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DITCHING TESTS WITH A 1/10-SIZE MODEL
OF THE ARMY A-20A AIRPLANE

I - CALM-WATER TESTS IN NACA TANK NO. 2

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MEMORANDUM REPORT

for the

Army Air Forces, Materiel Command

DITCHING TESTS WITH A 1/10-SIZE MODEL

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INTRODUCTION

The tests reported herein are the first in a series of tests requested by the Army Air Forces to determine the behavior of landplanes when they are forced to land on the water. (The emergency landing of a landplane on water is called "ditching.") The tests are being made in NACA tank no. 2 with scale dynamic models (models having scale weight and scale moment of inertia about all axes) in a manner similar to that of reference 1.

PROCEDURE

Construction of Models

A scale dynamic model¹ of the Army A-20A airplane was constructed of balsa wood and other light materials commonly used in the making of model aircraft capable of flying. Photographs of the model are shown in figures 1(a), 1(b), and 1(c).

¹The wing was inadvertently made somewhat larger than it should have been but, because the lift curve obtained for the model was approximately correct, the wing was not altered to the correct size.

In the tests of reference 1 and in subsequent tests made by them, the British found that models of the type used in the present tests can be made to approximate the motions of the full-size airplane provided the structural damage that occurs in an actual ditching is simulated.

Because of the low Reynolds number at which the tests were to be run a slat was added in front of the wing to prevent its stalling at angles of attack below the angle of stall of the full-size airplane. The height of the wing of this airplane is such that the slot thus formed did not appear to be an appreciable factor in the hydrodynamic performance of the model.

The balsa-wood model, of course, had more buoyancy than the actual airplane would have and consequently the model would float indefinitely whereas the airplane might sink quickly. The hydrostatic characteristics were therefore not properly simulated in the tests; a proper simulation of these characteristics would require the construction of a model whose density and porosity were to scale and that would undergo structural damage similar to that of the airplane, thus allowing entrance of water at the same rate that it would enter the airplane.

Apparatus and Test Methods

After the model had been balanced statically and aerodynamically, it was attached to the towing carriage in such a manner that it could be launched at the desired speed without applying appreciable disturbing moments. A photograph of a model on the launching gear is shown in figure 2.

Motion-picture photographs of the landing runs were made from two camera positions on the side of the tank. Visual observations of the lengths of the landing runs were also made. A third motion-picture camera was used to record the motion of the model from the time it was launched until it struck the water. From the photographs taken with this camera, sinking speeds and attitudes were determined. The model generally landed in an attitude within 1° of the attitude at which it was launched.

The maximum longitudinal decelerations under various conditions were measured with an NACA V-G recorder altered to fit the model. This accelerometer was located in a watertight compartment which was approximately at the location of the pilot's compartment. Since this instrument records only the value of the maximum deceleration, no indication was obtained of the duration or the time of occurrence of the deceleration measured.

Test Conditions

Variation of parameters under control of pilot.-

Load, landing speed, sinking speed, attitude, and flap position are all to some extent under the control of the pilot. Although these variables are interdependent, varying conditions of wind and power make available a range of values for any combination of these variables - e.g., by varying the power a range of landing and sinking speeds can be obtained for a single combination of attitude, flap position, and load.

In order to simplify the tests, all tests were made with one gross load corresponding to 21,500 pounds full-size gross weight. The center of gravity of the model was located at 28.13 percent of the mean aerodynamic chord; the vertical location was 4.14 inches (41.4 in. full size) above the bottom of the fuselage. Ditchings of this airplane at higher gross weights will probably be made very infrequently and ditchings at lower gross weights should be less severe.

The inclusion of power-operated propellers on the model would have introduced difficulties that would have slowed down the testing tremendously. In order to simulate the full-size landings that would be made at the slow landing speeds associated with head winds or the use of power, the model was launched at speeds below those at which it would be fully air-borne.

This method tended to give sinking speeds that would be greater than would necessarily be obtained at the low landing speeds, and the results are perhaps slightly more conservative at these landing speeds. However, the model was launched very near the water and measurements of the sinking speeds obtained showed that they varied from 2 to 6 feet per second full size, a range that might be expected in actual landings.

Some tests were made to investigate the effect of increased sinking speeds. In these tests the model was launched from greater heights above the water at speeds below those at which the model would be fully air-borne; and in these tests sinking speeds greater than would normally be expected in practice were reached.

Tests were made with the fuselage reference line of the model at attitudes of 10° , 6° , and 2° with respect to the water surface. The 10° attitude approximates a normal tail-down landing condition and the 2° attitude approximates a three-wheel landing condition. The tests with the 6° attitude were made to check for any unusual effects that might occur at intermediate attitudes.

Tests were made with flaps up and with flaps down 40° . Some of the tests with flaps down were made with flaps fastened rigidly down (called "fixed"). However, when the flaps were fixed down, they frequently broke loose from the model; and, because of the manner in which the flaps are fastened on the actual airplane, it is believed that they will frequently break away when this airplane is ditched. In the tests the breaking away of the flaps was usually simulated by fastening the flaps down by friction (called "semi-fixed") in such a manner that when they were struck heavily by water they were forced up.

Variations in form of model.- In reference 1, it had been found that propellers had little effect on ditching characteristics of models. Propellers were therefore not provided in the present tests. However, since it was assumed that the worst effect that could be obtained from propellers would probably be in a case where the propellers would be locked with one blade of each extending vertically downward, some attempts were made to check this effect. Tests were made with both wooden and soft aluminum blades simulating this condition. The wooden blades did not break and had a detrimental effect on the ditching; the aluminum blades bent backwards and formed small planing surfaces that were beneficial. Because neither of these conditions seemed to be a very good simulation of full-size conditions, these tests were considered inconclusive.

The failure of the bomb-bay doors, the lower rear gun hatch, and the bombardier's sighting window were each simulated by cutting openings in the fuselage.

All these openings are shown in the photograph of figure 3. One test at the 10° attitude was also made in which these openings were covered with shellacked paper. In this test the paper in the location of the bombardier's window did not break through but the paper over the other two openings did.

No sensible difference was noted between the behavior of the model in this test and its behavior when the openings were not covered. The covering was therefore not applied for other tests. Although it seemed probable that the bulkhead aft of the bomb bay would fail if the bomb-bay doors failed, a few tests were made with this bulkhead in place, as well as with the one forward of the bomb bay, in order to be sure that the configuration that would give the most severe ditchings was tested.

Because some of the A-20 airplanes have gun blisters near the nose of the fuselage in a position where they might affect ditching characteristics, these blisters were simulated in the model, as shown in figure 4, for one series of tests.

RESULTS

General Behavior

Diving did not occur in the landing runs even when large amounts of structural failure were simulated. Such pitching as did occur was not violent. The model usually ran in a straight line until a fairly low speed was reached when it would turn to one side. The turning that occurred was not considered to be violent. However, this tendency to turn produced inconsistencies in the lengths of landing runs.

A series of photographs showing the behavior of the model in two ditchings is shown in figure 5. The model with simulated damage had the bomb-bay doors, the bombardier's sighting window, and the rear hatch removed. In the photographs of the ditching of the complete model, the model appeared to dive at the end of the run. The behavior was not violent because the forward speed by this time was very low.

An interesting feature in the behavior of the model is shown in figure 6. This series of photographs shows

the complete model ditched at an attitude of 2°. Almost immediately after touching the water the tail was "sucked in" and the model assumed a high attitude. This behavior was characteristic when the complete model was ditched at the low attitude.

The results of the tests are summarized in tables I and II where lengths of landing runs and maximum accelerations are given. The lengths of landing runs given represent the average of several landings in most cases.

Effects of varying parameters under control of pilot.-
The effects of varying those parameters over which the pilot has some degree of control are listed as follows:

<u>Parameter</u>	<u>Effect of Varying Parameter</u>
Landing speed	Average and maximum decelerations tended to increase with increase in landing speed.
Sinking speed	Increasing sinking speed by increments to 20 feet per second full scale caused no appreciable change in the lengths of landing runs.
Attitude	Increasing attitude tended to decrease average and maximum decelerations but the decrease in maximum decelerations was small.
Flap position	Effect on average deceleration was somewhat inconsistent but for a given landing speed there was generally not enough effect to be significant when the flaps were semifixed. There was a tendency for the average decelerations to be decreased in a low-attitude landing when the flaps were fixed down.

Effects of varying amounts of structural damage.-
The effects of structural damage, simulated as described, were as shown in the following: