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RESEARCH MEMORANDUM

WIND-TUNNEL INVESTIGATION OF THE STABILITY OF JETTISONED NOSE SECTIONS OF THE D-558 AIRPLANE - PHASES I AND II

By

Stanley H. Scher

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

An investigation of the stability of models of the jettisonable nose sections of the D-558 airplanes, Phase I and Phase II, has been conducted in the Langley 20-foot free-spinning tunnel. The effects of center-of-gravity location and of stabilizing fins of various sizes were determined. Brief tests were also made to determine the effects of covering the air-duct openings on the Phase I model and of opening stabilizing parachutes on the Phase II model. Included in the report are the results of additional free-spinning-tunnel tests which were made on a $\frac{1}{2}$-scale model of a nose section of the RM-11 missile, which is a test vehicle that the National Advisory Committee for Aeronautics plans to use in investigating some of the high-speed aspects of the nose-jettison problem.

Both of the D-558 model nose sections tumbled end over end about an approximately horizontal axis. The installation of suitable stabilizing fins on each model, together with sufficient forward location of the center of gravity, prevented the tumbling motion and caused the model to damp any applied rotation and to descend in a stable nose-down attitude. The test results obtained with the model of the RM-11 nose indicated similar favorable effects of forward center-of-gravity locations and of installing stabilizing fins.

INTRODUCTION

The NACA is conducting an investigation of the problem of safe pilot escape from the Douglas D-558 airplanes. Because of the danger associated with jumping from an airplane at high speeds, it is planned that, if it should become necessary, the pilot would escape from the airplane by jettisoning the complete nose of the airplane with a break-away point just aft of the pilot. After this nose section had decelerated to a safe airspeed, the pilot would leave the nose section and open his personal parachute for a normal emergency landing. In order to obtain data on the low-speed stability and motion of the nose section when it is falling freely, an investigation has been undertaken in the Langley 20-foot free-spinning tunnel with a $\frac{1}{14}$-scale model of the D-558, Phase I, nose section and a $\frac{1}{12}$-scale model of the Phase II nose section. In the investigation means for stabilizing the nose section were studied. The results of this investigation are presented herein. In addition, for comparison with the D-558 test results, data are also presented from an investigation in the free-spinning tunnel with a $\frac{1}{2}$-scale model of the jettisonable nose section of the RM-11 missile to determine means for stabilizing it at low speed. The RM-11 missile is being used by the NACA as a test vehicle in a study of the high-speed aspects of the nose-jettison problem.

In the tests, the models simulated the respective nose sections during their descent toward the ground, after having been jettisoned from and having cleared the remaining structural parts of the aircraft. The tests included dropping the models at various attitudes into the vertically rising air stream as well as launching the models at various attitudes with rotation applied about a vertical (spin) axis or about a horizontal (tumbling) axis. The effects on stability of moving the center of gravity forward and of installing fins on the models were investigated. Brief tests were made in which the air-duct openings of the Phase I model were covered, and brief tests were also made in which stabilizing parachutes were attached to the Phase II model. The drag coefficients of the D-558 nose models at 0° angle of attack were determined from drag measurements made on a strain-gage balance mounted in the tunnel, and from the results of these tests the terminal velocity of each airplane nose section when in a stable nose-down attitude was estimated.

SYMBOLS

L	length of nose section (all fractions of this distance are measured from the front end of nose section)
I_X, I_Y, I_Z	full-scale values of moments of inertia about X (longitudinal), Y (lateral), and Z (normal) body axes, respectively, slug-feet^2
C_D	drag coefficient of nose section $\left(\frac{\text{Drag}}{\frac{1}{2}\rho V^2 F}\right)$
ρ	air density, slugs per cubic foot
V	airspeed, feet per second
F	projected frontal area of nose section, square feet

V_T full-scale terminal velocity of nose section, feet per second $\left(\sqrt{\frac{2W}{C_D \rho F}}\right)$

W full-scale weight of nose section, pounds

APPARATUS AND METHODS

Models

A $\frac{1}{14}$-scale model of the jettisonable nose section of the D-558 airplane, Phase I, a $\frac{1}{12}$-scale model of the jettisonable nose section of the D-558 airplane, Phase II, and a $\frac{1}{2}$-scale model of the jettisonable nose section of the RM-11 test vehicle were constructed and prepared for testing at the Langley Laboratory. Photographs of the D-558 models are shown as figures 1 and 2, and dimensional sketches are shown in figures 3 and 4. The various fins tested on the D-558 models are shown in figures 5 and 6. A sketch of the model of the nose section of the RM-11 test vehicle showing the fins tested on the model is shown in figure 7. The stabilizing parachutes tested on the D-558, Phase II, model were the box types shown in figures 8 and 9 as well as the ordinary flat type.

The D-558 models were ballasted with lead weights to approximate dynamic similarity to the nose sections of the respective airplanes at an altitude of 15,000 feet (ρ = 0.001496 slug per cubic foot). The weight and center-of-gravity locations for the original loadings of the D-558 nose sections were obtained from data furnished by the contractor. Based on the weight and center-of-gravity locations and on preliminary moment-of-inertia information which had also been furnished by the contractor, the moments of inertia of the D-558 models as tested are believed to have been such that the airplane nose sections were adequately represented for the purpose of the present tests.

For the RM-11 nose tests, the primary purpose was to determine the fin area and the center-of-gravity location necessary for stable descent, and no attempt was made to ballast the model for any particular moment-of-inertia distribution. The weight and center-of-gravity location, however, were determined for each test condition. The measured weights as determined were assumed to correspond to a test altitude of 15,000 feet, and the corresponding full-scale RM-11 nose section weights at sea level were then determined.

Wind Tunnel and Testing Technique

The model tests were performed in the Langley 20-foot free-spinning tunnel, the operation of which is, in general, similar to that described in reference 1 for the Langley 15-foot free-spinning tunnel, except that models are now launched into the vertically rising air stream by hand rather than from a spindle. A photograph which shows the test section of the Langley 20-foot free-spinning tunnel with a typical spin-tunnel airplane model spinning in the tunnel is shown as figure 10. The tests included free-drop tests, in which the model was held at attitudes which ranged from 0° angle of attack (tip of nose pointed vertically down) to 180° angle of attack (tip of nose pointed vertically up) and was simply released into the tunnel, and tests in which the model was launched from the same attitudes with applied spinning rotation about a vertical axis or tumbling rotation about a horizontal axis.

For the parachute tests, the D-558, Phase II, nose section model was released into the air stream with the open parachute attached. In addition, for those tests in which flat-type parachutes were used, brief tests were made in which the parachute was packed on the back surface of the model and opened while the model was tumbling in descent.

The drag measurements on the D-558 models were made in order to determine the nose-down rate of descent of each airplane nose section at terminal velocity. The terminal velocity could not be determined through free-drop tests because in a stable nose-down attitude the terminal velocity of these models exceeded the maximum airspeed of the tunnel. For the drag measurement tests, the models were mounted on a strain-gage balance at 0° angle of attack to the air stream.

For all the free-flight tests, observations were made of the motions and rate of descent of the model. Motion pictures were also taken of the free model. All the values of rates of rotation and rates of descent as presented in this paper have been converted to full-scale values for the nose sections at an altitude of 15,000 feet.

TEST CONDITIONS

The mass characteristics of the D-558 models for the loadings tested are presented in tables I and II. The accuracy of measuring the weight and mass distribution of the models is believed to be within the following limits:

Weight, percent . . . . ±1
Center-of-gravity location, inch . . . . ±0.01
Moments of inertia, percent . . . . ±5

The loading and fin arrangements tested on the D-558 models are presented in tables III and IV. The center of gravity, weight, and fin arrangements tested on the RM-11 model are presented in table V.

RESULTS AND DISCUSSION

D-558 Airplane Nose Section Models

Original loading, no fins.- The results of the tests made with the D-558 nose section models are presented in tables III and IV. When either the Phase I or the Phase II nose section model in its original loading with no fins was launched for the free-drop tests, it usually went immediately into a tumbling motion although sometimes it floated for a few seconds in its initial attitude before going into the tumbling motion. When launched with applied spinning rotation, it occasionally rotated in a flat attitude in what appeared to be a spinning condition, but after a few turns this condition was damped and the tumbling motion began. When launched with applied tumbling rotation, the model continued to tumble. The Phase II model in its original configuration is shown tumbling in the moving-picture strips in figure 11.

The particular tumbling conditions obtained during the model tests represent each airplane nose section while descending toward the ground at a relatively low speed after equilibrium has been obtained. The full-scale average rates of vertical descent and of tumbling rotation were 273 feet per second and 5.1 radians per second, respectively, for the Phase I nose section, and 253 feet per second and 3.6 radians per second, respectively, for the Phase II nose section. C_D during the tumbling was 1.5 for the Phase I model and 1.05 for the Phase II model. For each nose section, the axis of the tumbling rotation appeared to be approximately through the center of gravity. This rotation about the center of gravity would impart to the pilot a centripetal acceleration with lines of action in a radial direction from the center of gravity to various parts of the pilot's body. At his head during a low-speed tumble this acceleration would be approximately 2.5g for the Phase I nose section and approximately 1g for the Phase II nose section. Assuming that the rate of tumbling varies directly with the speed at which the nose section travels through the air and that the nose section was jettisoned from the airplane at a high speed and went immediately into a tumbling motion, it is probable that much higher acceleration forces would result which would be very dangerous to a man in the pilot's seat. For example, at a Mach number of 1.0 at 15,000 feet altitude (airspeed 1060 feet per second) the Phase II nose section might tumble at a rate of approximately 15 radians per second, which would cause a centripetal force of approximately 15g at the pilot's head.

Effect of air-duct openings.- Brief tests were made during which the air-duct openings of the Phase I nose section were covered and the results did not indicate any change in the tendency of the model to tumble while descending.

Effects of fins and center-of-gravity location.- Each model was modified from its original condition by forward movements of the center of gravity and by the installation of various-sized stabilizing fins. The results of these tests are presented in tables III and IV. For the Phase I model, moving the center of gravity forward from 0.571L to 0.509L and installing fins no. I-2 prevented the model from tumbling and made it descend in a stable nose-down attitude (table III). For the Phase II model, the same effect was achieved by moving its center of gravity forward from 0.692L to 0.624L and installing fins no. II-4 (table IV). The moving-picture strips in figure 12 show the Phase II model as an applied rotation damped out and the model subsequently descended in a stable nose-down attitude.

Stabilizing parachutes.- The results of the tests made with stabilizing parachutes on the D-558, Phase II, nose section model are presented in table VI. The results indicate the unsuitability of flat-type parachutes as stabilizing agents for the D-558 nose section. The results also indicate that when box-type parachutes A or B (figs. 8 and 9) with 2-foot-square holes cut in the 8-foot-square tops were attached to the model both model and parachute descended in a stable manner. The parachute tests were very brief, inasmuch as it was felt that the use of parachutes to stabilize the nose section immediately after it is jettisoned from the airplane introduces additional problems. One problem is that the parachute may fail to stabilize the nose section until after dangerous tumbling has taken place. Another problem is that a severe parachute shock load would develop, and there is also a possibility of fouling of the parachute on the rest of the airplane before it can open fully. It was felt that adding fins and moving the center of gravity forward provided a more practicable means of preventing tumbling and stabilizing the motion of the airplane nose section.

RM-11 Test-Vehicle Nose Section Model

The test results presented in table V for the RM-11 nose section model are in general agreement with those obtained for the D-558 nose section models, in that they again indicate the favorable effect of forward center-of-gravity locations and of installing stabilizing fins on bodies simulating airplane nose sections. When the center of gravity was at 0.58L and the intermediate size fins shown in figure 7 were installed on the model, it descended in a stable nose-down attitude.

CONCLUSIONS

Based on the results of tests made in the Langley 20-foot free-spinning tunnel with $\frac{1}{14}$- and $\frac{1}{12}$-scale models of the jettisonable nose sections of the D-558 airplane, Phases I and II, respectively, the following conclusions are made regarding the stability of the D-558 airplane nose sections if they are jettisoned from the airplanes:

1. Either nose section will tumble end over end about an approximately horizontal axis as it descends toward the earth. If the nose is jettisoned while the airplane is traveling at a high rate of speed, the centripetal acceleration which would result from the tumbling motion might be very dangerous to the pilot enclosed within the nose section.

2. The nose sections will descend in a stable nose-down attitude if the center of gravity is moved sufficiently forward and if suitable stabilizing fins are added at the base of the nose sections.

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

REFERENCE

1. Zimmerman, C. H.: Preliminary Tests in the N.A.C.A. Free-Spinning Wind Tunnel. NACA Rep. No. 557, 1936.

TABLE I.– FULL-SCALE VALUES OF MASS CHARACTERISTICS FOR THE LOADING ARRANGEMENTS TESTED ON THE $\frac{1}{14}$-SCALE MODEL OF THE JETTISONABLE NOSE SECTION OF THE DOUGLAS D-558, PHASE I, AIRPLANE

Loading	Weight (lb)	Moments of inertia about the center of gravity		
		I_X (slug-ft^2)	I_Y (slug-ft^2)	I_Z (slug-ft^2)
Original (center of gravity at 0.571L)	1076	46	147	147
Overweight 251 lb (center of gravity at 0.509L)	1327	62	227	227

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TABLE II.— FULL-SCALE VALUES OF MASS CHARACTERISTICS FOR THE LOADING ARRANGEMENTS TESTED ON THE $\frac{1}{12}$-SCALE MODEL OF THE JETTISONABLE NOSE SECTION OF THE DOUGLAS D-558, PHASE II, AIRPLANE

Loading	Weight (lb)	Moments of inertia about the center of gravity		
		I_X (slug-ft^2)	I_Y (slug-ft^2)	I_Z (slug-ft^2)
Original (center of gravity at 0.692L)	766	33	108	108
Center of gravity at 0.650L	766	33	126	126
Center of gravity at 0.624L	771	31	127	127
Overweight 148 lb (center of gravity at 0.548L)	914	34	187	187
Overweight 150 lb (center of gravity at 0.611L)	916	35	169	169

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TABLE III.– LOADING AND FIN ARRANGEMENTS AND RESULTS OF TESTS OF THE $\frac{1}{14}$–SCALE MODEL OF THE JETTISONABLE NOSE SECTION OF THE D–558, PHASE I, AIRPLANE TESTED IN THE FREE–SPINNING TUNNEL

Loading	Fins (See fig. 5.)	Description of motion of model during descent
Original (center of gravity at 0.571L)	None	Model tumbled end over end about an approximately horizontal axis; average rate of descent was 273 ft/sec (186 mph) and average rate of tumble was 5.1 radians/sec (full–scale values); C_D = 1.5
Do ------	I-1	Model trimmed with nose at angle of about 20° down from horizontal and traveled forward across tunnel
Do ------	I–2	Do.
Overweight 251 lb (center of gravity at 0.509L)	I–2	Model lost any applied rotation and descended in nose–down stable attitude; C_D = 0.40, V_T = approximately 586 ft/sec (400 mph)

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TABLE IV.– LOADING AND FIN ARRANGEMENTS AND RESULTS OF TESTS OF THE $\frac{1}{12}$–SCALE MODEL OF THE JETTISONABLE NOSE SECTION OF THE D-558, PHASE II, AIRPLANE TESTED IN THE FREE-SPINNING TUNNEL

Loading	Fins (See fig. 6.)	Description of motion of model during descent
Original (center of gravity at 0.692L)	None	Model tumbled end over end about an approximately horizontal axis; average rate of descent was 253 ft/sec (172.5 mph) and average rate of tumble was 3.62 radians/sec (full-scale values); C_D = 1.05
Center of gravity at 0.650L	-----do-----	Similar to results obtained with center of gravity at 0.692L and no fins, except average rate of tumble was slightly lower
Center of gravity at 0.624L	-----do-----	Do.
Overweight 148 lb (center of gravity at 0.548L)	-----do-----	Model sometimes oscillated in arc of about ±100° from nose-down attitude; model sometimes tumbled
Original (center of gravity at 0.692L)	II-1	Model sometimes tumbled, sometimes went briefly into an apparent flat spinning condition, sometimes trimmed with nose at angle of about 20° down from horizontal and traveled forward across tunnel
Do-------	II-2	Same as results obtained with center of gravity at 0.692L and fins II-1; also model sometimes oscillated in arc of about ±90° from nose-down attitude
Do-------	II-3	Same as results obtained with center of gravity at 0.692L and fins II-1; also model sometimes rolled about various model axes

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TABLE IV.- LOADING AND FIN ARRANGEMENTS AND RESULTS OF TESTS

OF THE $\frac{1}{12}$-SCALE MODEL - Concluded

Loading	Fins (See fig. 6.)	Description of motion of model during descent
Original (center of gravity at 0.692L)	II-4	Model sometimes tumbled, sometimes trimmed with nose at angle of about 20° down from horizontal and traveled forward across tunnel; once, model descended in nose-down stable attitude
Center of gravity at 0.624L	II-1	Model sometimes oscillated in arc of about ±90° from nose-down attitude; model sometimes trimmed with nose at angle of about 20° down from horizontal and traveled forward across tunnel
Center of gravity at 0.624L	II-3	Same as results obtained with center of gravity at 0.624L and fins II-1
Do--------	II-4	Model lost any applied rotation and descended in nose-down stable attitude; C_D = 0.25, V_T = approximately 520 ft/sec (354 mph)
Overweight 150 lb (center of gravity at 0.611L)	II-4	Same as results obtained with center of gravity at 0.624L and fins II-4, except V_T = approximately 569 ft/sec (387 mph)

[redacted]

TABLE V.— CENTER OF GRAVITY, WEIGHT, AND FIN ARRANGEMENTS AND RESULTS OF TESTS OF THE $\frac{1}{2}$-SCALE MODEL OF THE JETTISONABLE NOSE SECTION OF THE RM-11 TEST MISSILE TESTED IN THE FREE-SPINNING TUNNEL

Center-of-gravity location	Weight, (lb) (full-scale)	Fins (See fig. 7.)	Description of motion of model during descent
0.64L	4	None	Model rolled and oscillated about various axes
.55L	2.4	-----do-----	Do.
.49L	4	-----do-----	Model sometimes descended in fairly stable nose-down attitude; model sometimes trimmed with nose at about 20° down from horizontal and traveled forward across tunnel, occasionally making a portion of a turn about a vertical (tunnel) axis
.38L	7.7	-----do-----	Model sometimes went into a flat spin (nose about 20° down from horizontal) with a whipping motion; model sometimes descended in stable nose-down attitude
.31L	7.7	-----do-----	Do.
.71L	4	2 in. × 2 in. × 2.83 in.	Model trimmed with nose at angle of about 20° up from horizontal and traveled backward across tunnel
.64L	4	-----do-----	Model sometimes oscillated from nose-up 30° attitude to nose-down 60° attitude while turning slowly about a vertical axis; model sometimes descended in stable, nose-down attitude
.60L	2.4	-----do-----	Same as results obtained with center of gravity at 0.49L and no fins installed
.56L	2.4	-----do-----	Model descended in fairly stable nose-down attitude
.58L	2.4	3.38 in. × 3.38 in. × 4.78 in.	Model descended in nose-down stable attitude $C_D = 0.161$; before C_D
.60L	4	4 in. × 4 in. × 5.66 in.	Do.

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TABLE VI.- RESULTS OF TESTS OF THE JETTISONABLE NOSE SECTION OF THE D-558, PHASE II, AIRPLANE WITH STABILIZING PARACHUTES IN THE FREE-SPINNING TUNNEL

[Model in original loading; no fins installed on model]

Description of parachute (dimensions are full scale)	Length of towline, ft (full scale)	Point of towline attachment on model	Results of tests
Flat; 6-ft diameter	14.4	Rear center	Opening of parachute changed tumbling rotation of model to a flat rotation (nose down 30° from horizontal) about a vertical (tunnel) axis, with a periodic whipping motion as the model dangled from the open parachute; parachute canopy rotated in a continuous circle as nose section and parachute descended at a rate of 187 ft/sec, full scale
Do--------	4.0	---do---	Do.
Flat; 10-ft diameter	14.4	---do---	Model slightly more stable than with 6-ft-diameter parachute
Box type A; 8-ft-square top (See fig. 8.)	3.0	---do---	Model and parachute descended in fairly stable manner at rate of 146 ft/sec, full scale
Box type A with 2-ft-square hole in center of top	3.0	---do---	Model and parachute descended in very stable manner at rate of 175 ft/sec, full scale
Do---------	3.0	On top surface at 0.69L	Model pitched gently up and down (about 50° up and 35° down) from horizontal attitude as model and parachute descended at rate of 146 ft/sec, full scale
Box type B; 8-ft-square top (See fig. 9.) with 2-ft-square hole in center of top	5.0	Rear center	Model and parachute descended in very stable manner at rate of 187 ft/sec, full scale
Do--------	5.0	On top surface at 0.69L	Model and parachute turned slowly in opposite directions (winding up shroud lines) and descended at 146 ft/sec, full scale

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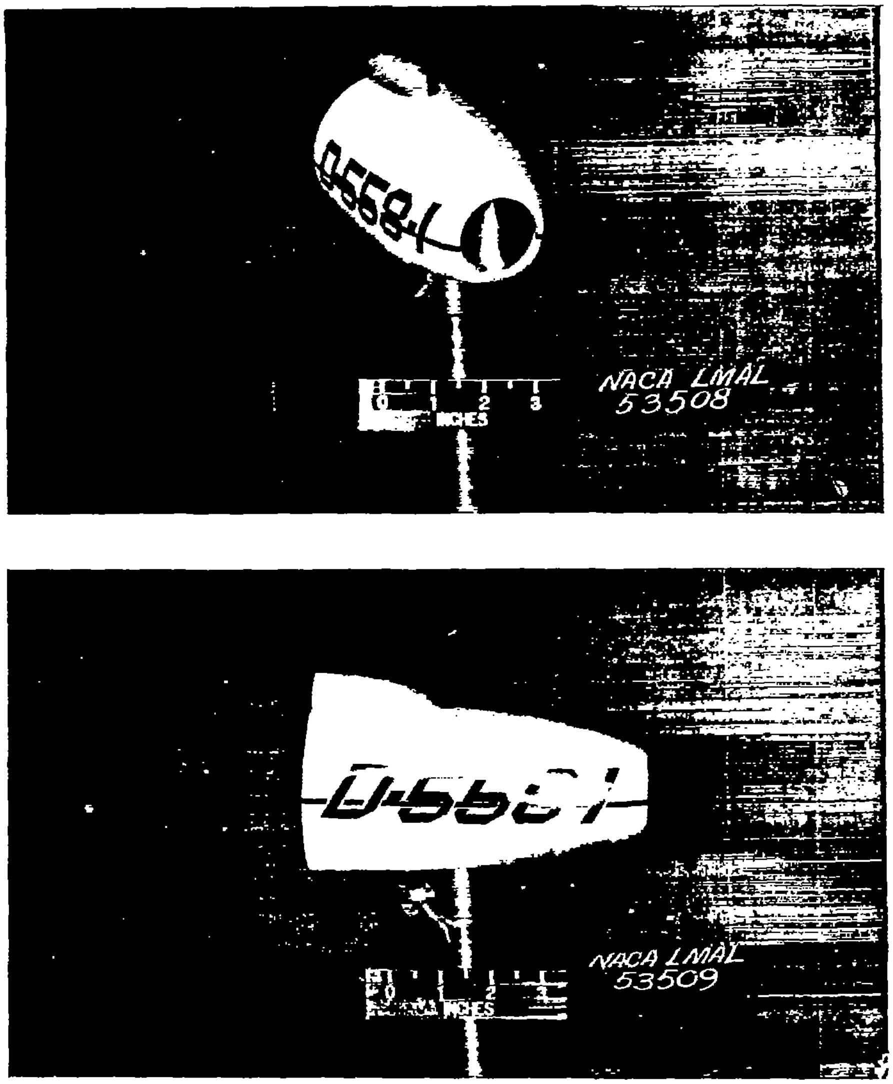

Figure 1.- Photographs of the $\frac{1}{14}$-scale model of the jettisonable nose section of the Douglas D-558, phase I, airplane tested in the free-spinning tunnel.

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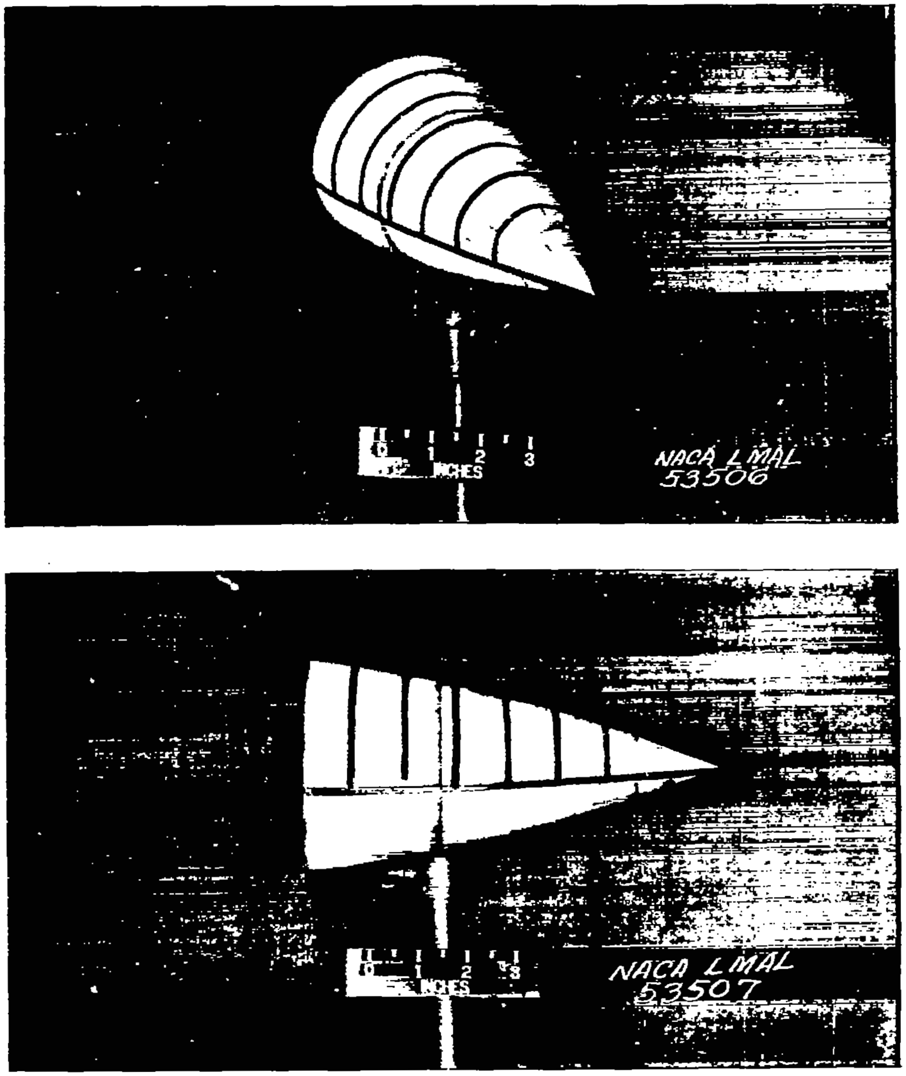

Figure 2.- Photographs of the $\frac{1}{12}$-scale model of the jettisonable nose section of the Douglas D-558, phase II, airplane tested in the free-spinning tunnel.

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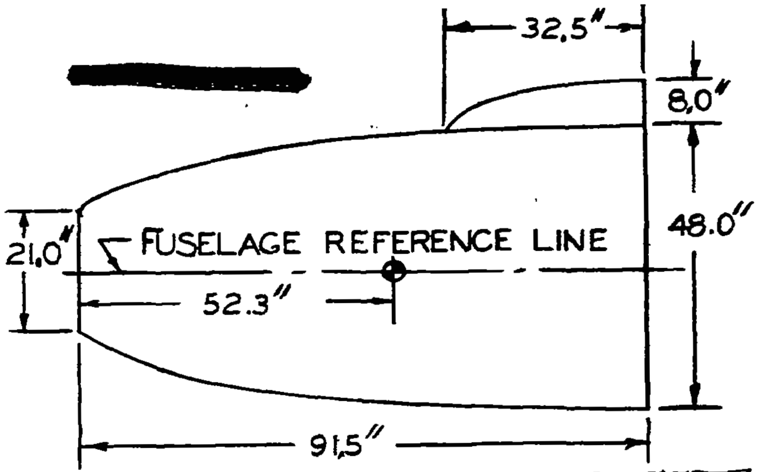

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FIGURE 3.-SKETCH OF THE $\frac{1}{14}$-SCALE MODEL OF THE JETTISONABLE NOSE SECTION OF THE DOUGLAS D-558, PHASE I, AIRPLANE TESTED IN THE FREE-SPINNING TUNNEL. CENTER OF GRAVITY IS SHOWN FOR THE ORIGINAL LOADING CONDITION. DIMENSIONS ARE FULL-SCALE VALUES. MODEL AIR DUCTS ARE NOT SHOWN.

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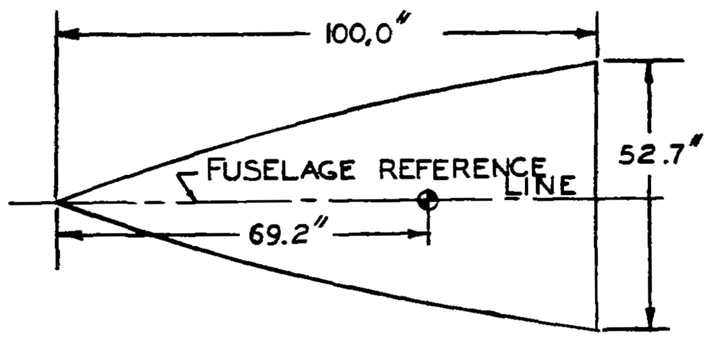

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FIGURE 4.-SKETCH OF THE $\frac{1}{12}$-SCALE MODEL OF THE JETTISONABLE NOSE SECTION OF THE DOUGLAS D-558, PHASE II, AIRPLANE TESTED IN THE FREE-SPINNING TUNNEL. CENTER OF GRAVITY IS SHOWN FOR THE ORIGINAL LOADING CONDITION DIMENSIONS ARE FULL-SCALE VALUES.

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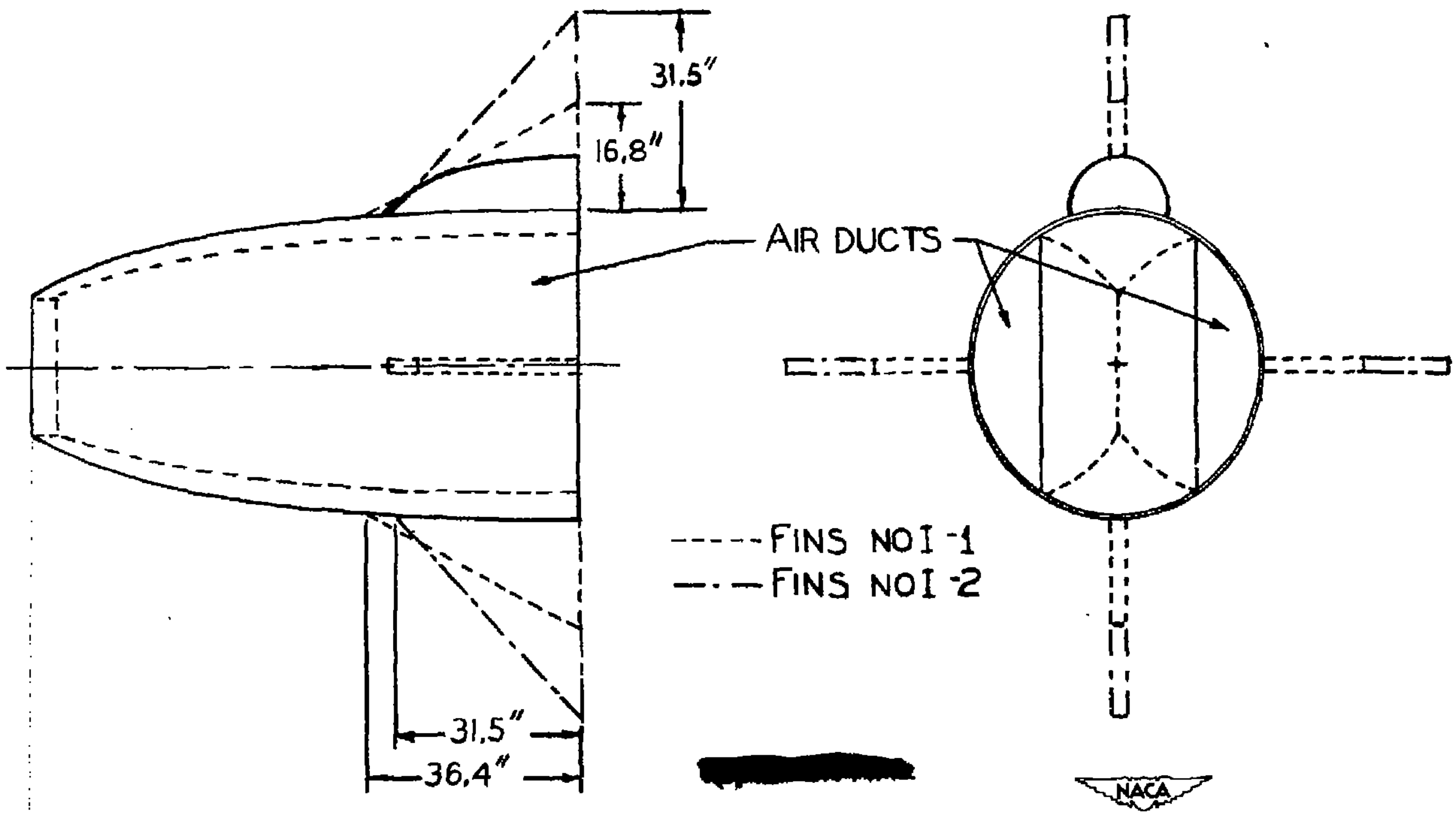

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FIGURE 5.-SKETCH SHOWING FINS TESTED ON THE $\frac{1}{14}$-SCALE MODEL OF THE JETTISONABLE NOSE SECTON OF THE DOUGLAS D-558, PHASE I, AIRPLANE. DIMENSIONS ARE FULL-SCALE VALUES.

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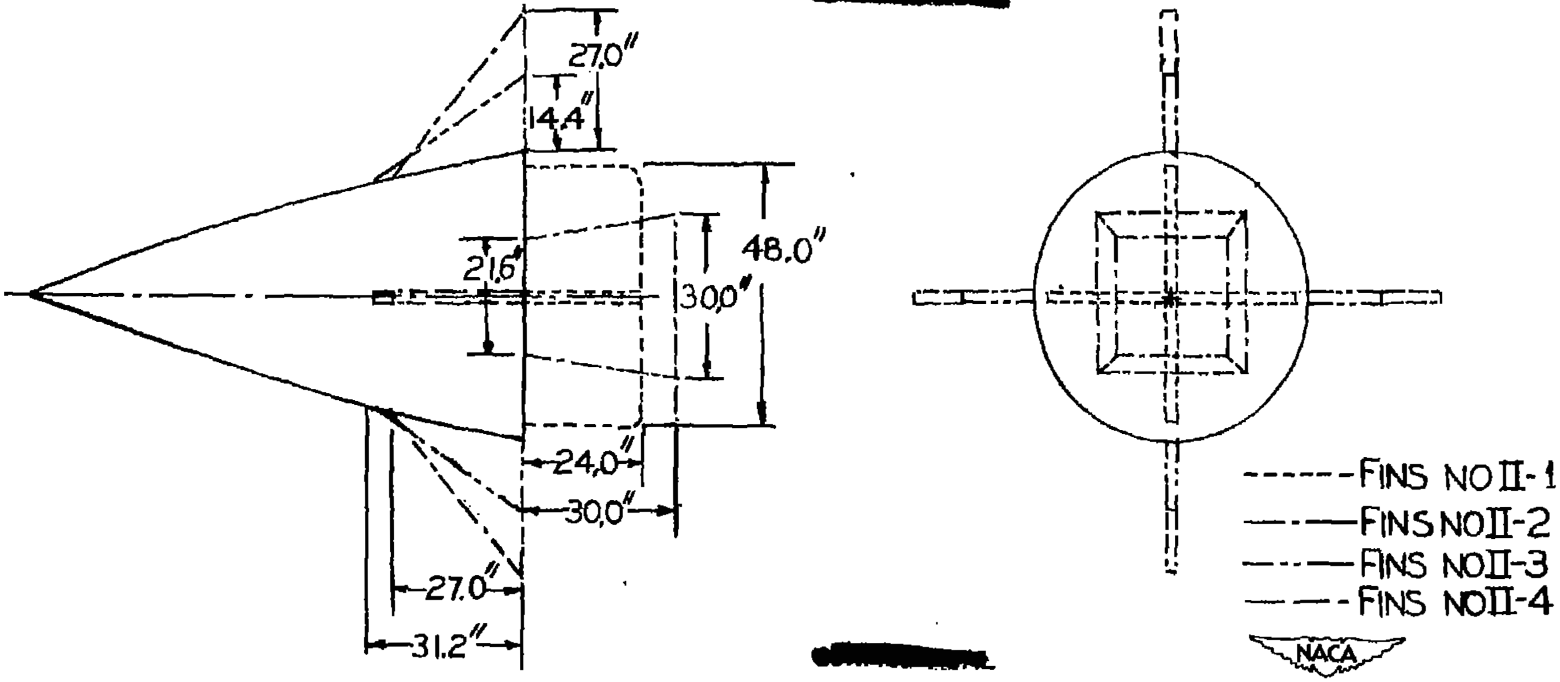

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FIGURE 6.- SKETCH SHOWING VARIOUS FINS TESTED ON THE $\frac{1}{12}$-SCALE MODEL OF THE JETTISONABLE NOSE SECTION OF THE DOUGLAS D-558, PHASE II, AIRPLANE. DIMENSIONS ARE FULL-SCALE VALUES.

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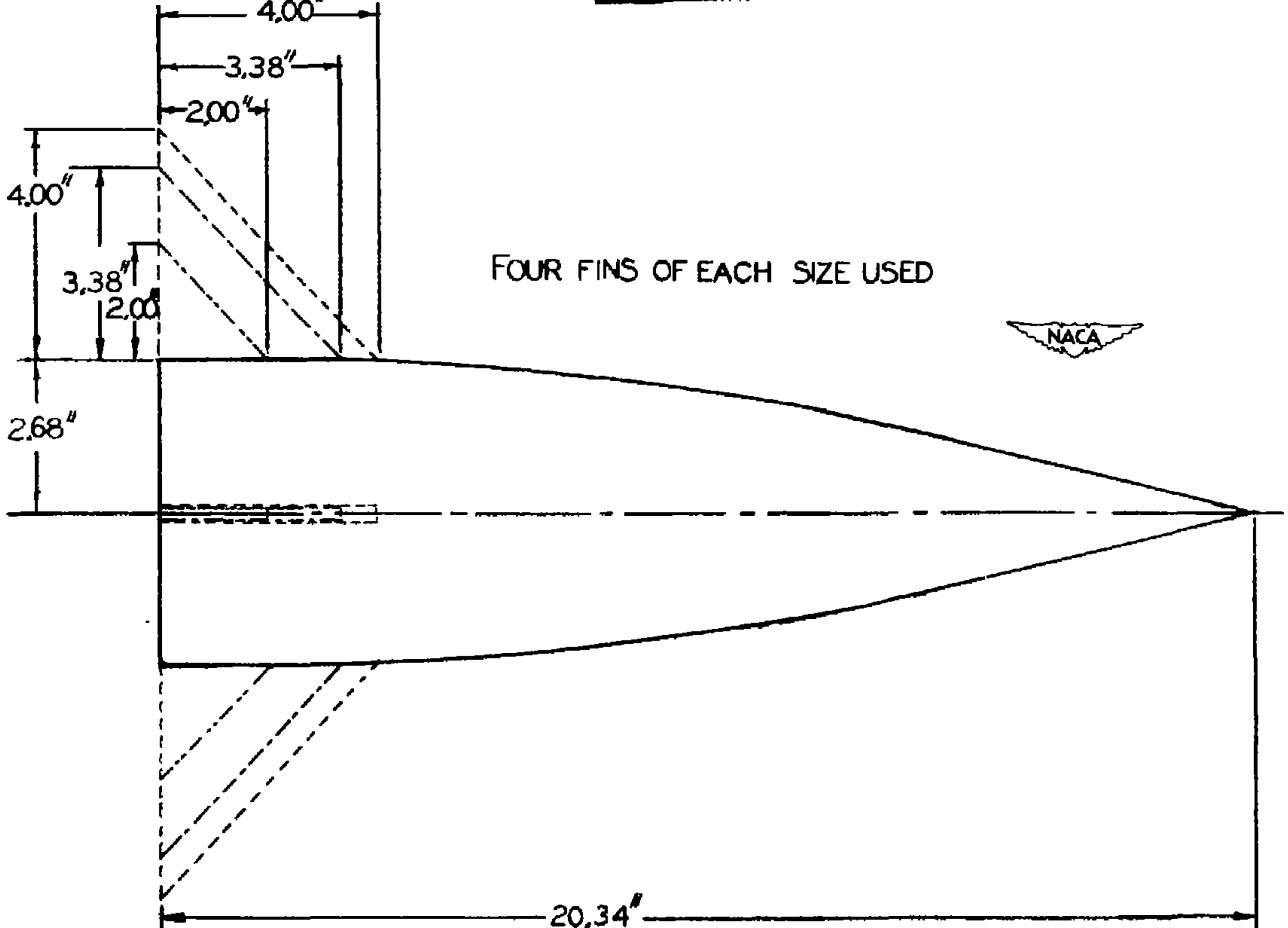

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FIGURE 7. - SKETCH OF THE $\frac{1}{2}$-SCALE MODEL OF THE NOSE SECTION OF THE RM-11 TEST VEHICLE TESTED IN THE FREE-SPINNING TUNNEL. VARIOUS FINS TESTED ON THE MODEL ARE SHOWN. DIMENSIONS SHOWN ARE MODEL VALUES.

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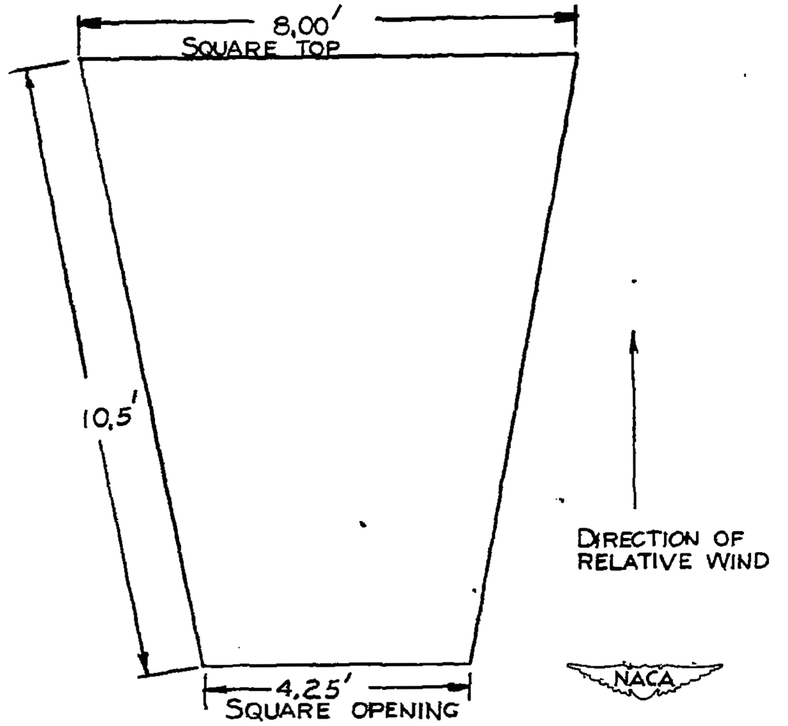

FIGURE 8.–SKETCH OF BOX-TYPE PARACHUTE A, USED AS STABILIZING PARACHUTE FOR THE $\frac{1}{12}$-SCALE MODEL OF THE D-558, PHASE II, AIRPLANE NOSE SECTION IN THE FREE-SPINNING TUNNEL. PARACHUTE IS SHOWN FULLY OPENED. EIGHT SHROUD LINES AVERAGING 10.6 FEET IN LENGTH WERE ATTACHED TO THE BOTTOM OF THE PARACHUTE AT THE CORNERS AND MIDWAY OF EACH SIDE. DIMENSIONS ARE FULL-SCALE.

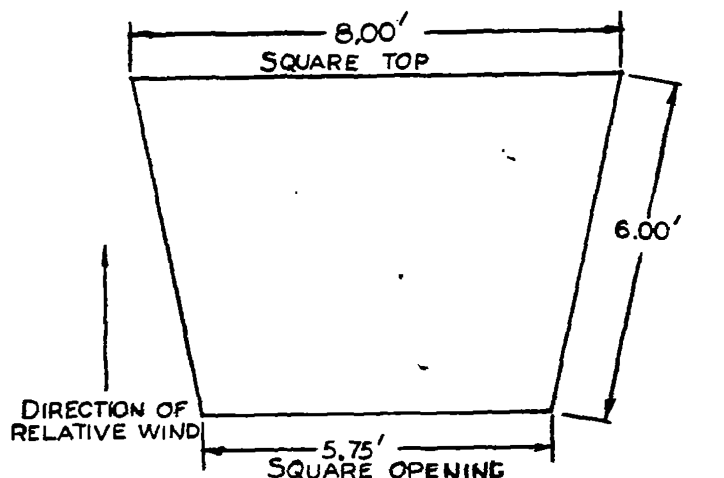

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FIGURE 9.-SKETCH OF BOX-TYPE PARACHUTE B, USED AS STABILIZING PARACHUTE FOR THE $\frac{1}{12}$-SCALE MODEL OF THE D-558, PHASE II, AIRPLANE NOSE SECTION IN THE FREE-SPINNING TUNNEL. PARACHUTE IS SHOWN FULLY OPENED. EIGHT SHROUD LINES AVERAGING 10.3 FEET IN LENGTH WERE ATTACHED TO THE BOTTOM OF THE PARACHUTE AT THE CORNERS AND MIDWAY OF EACH SIDE. DIMENSIONS ARE FULL-SCALE.

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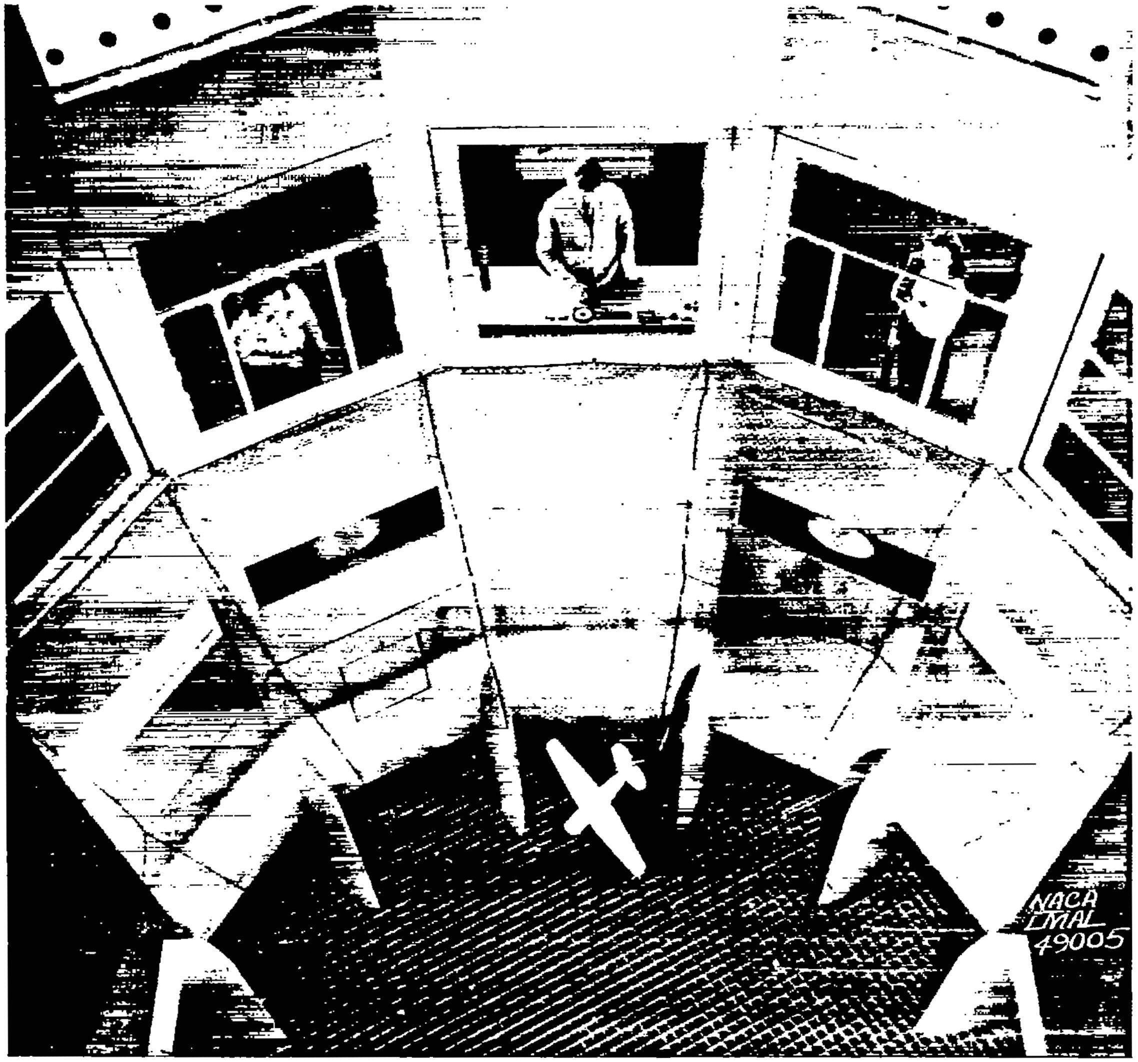

Figure 10.- Photograph showing the test section of the Langley 20-foot free-spinning tunnel. A typical spin-tunnel airplane model is shown spinning in the tunnel.

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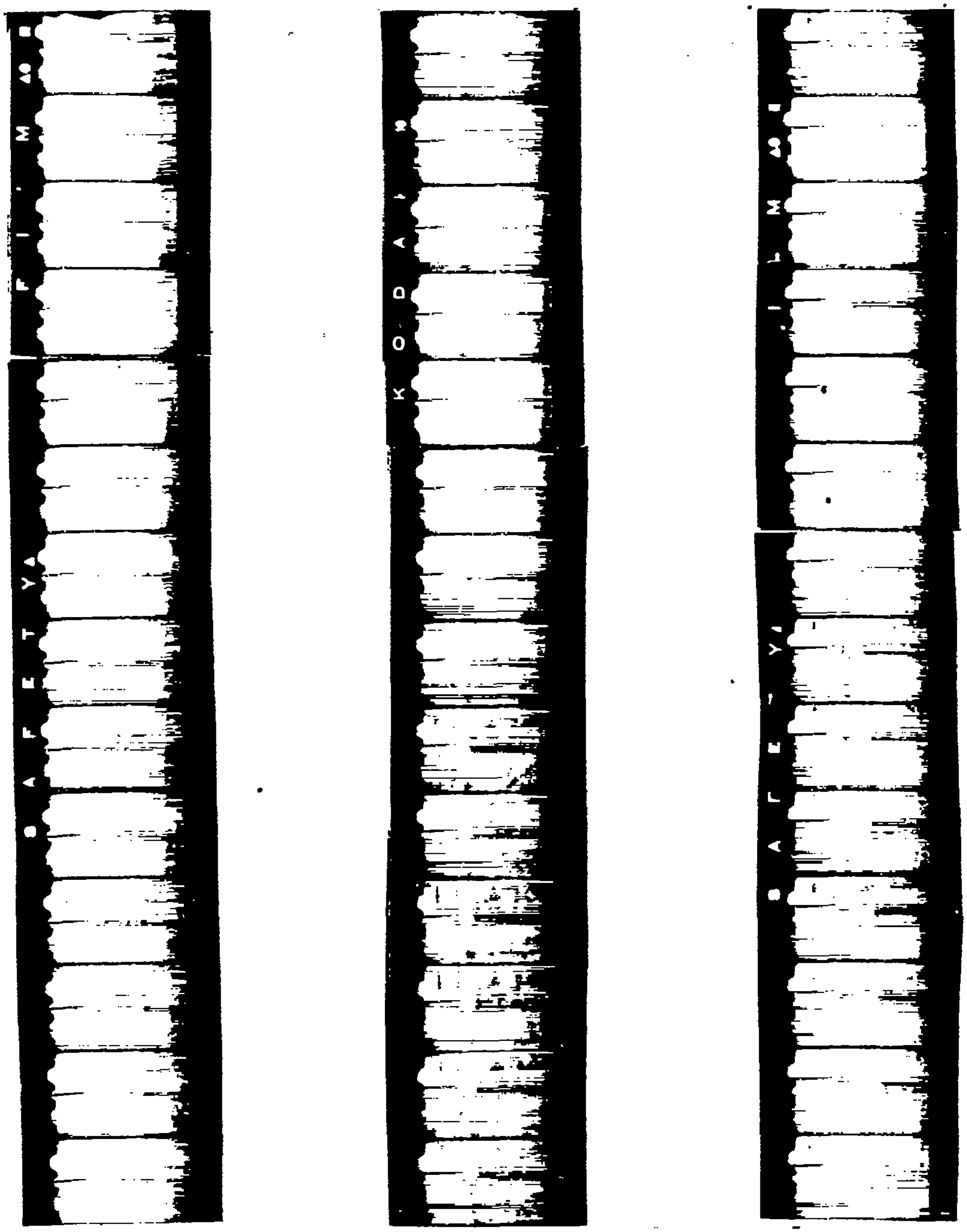

Figure 11.- Moving picture strip of tests of the $\frac{1}{12}$-scale model of the jettisonable nose section of the D-558, phase II, airplane in its original loading with no fins installed. The model is shown tumbling in the Langley 20-foot free-spinning tunnel.

Figure 11.- Concluded.

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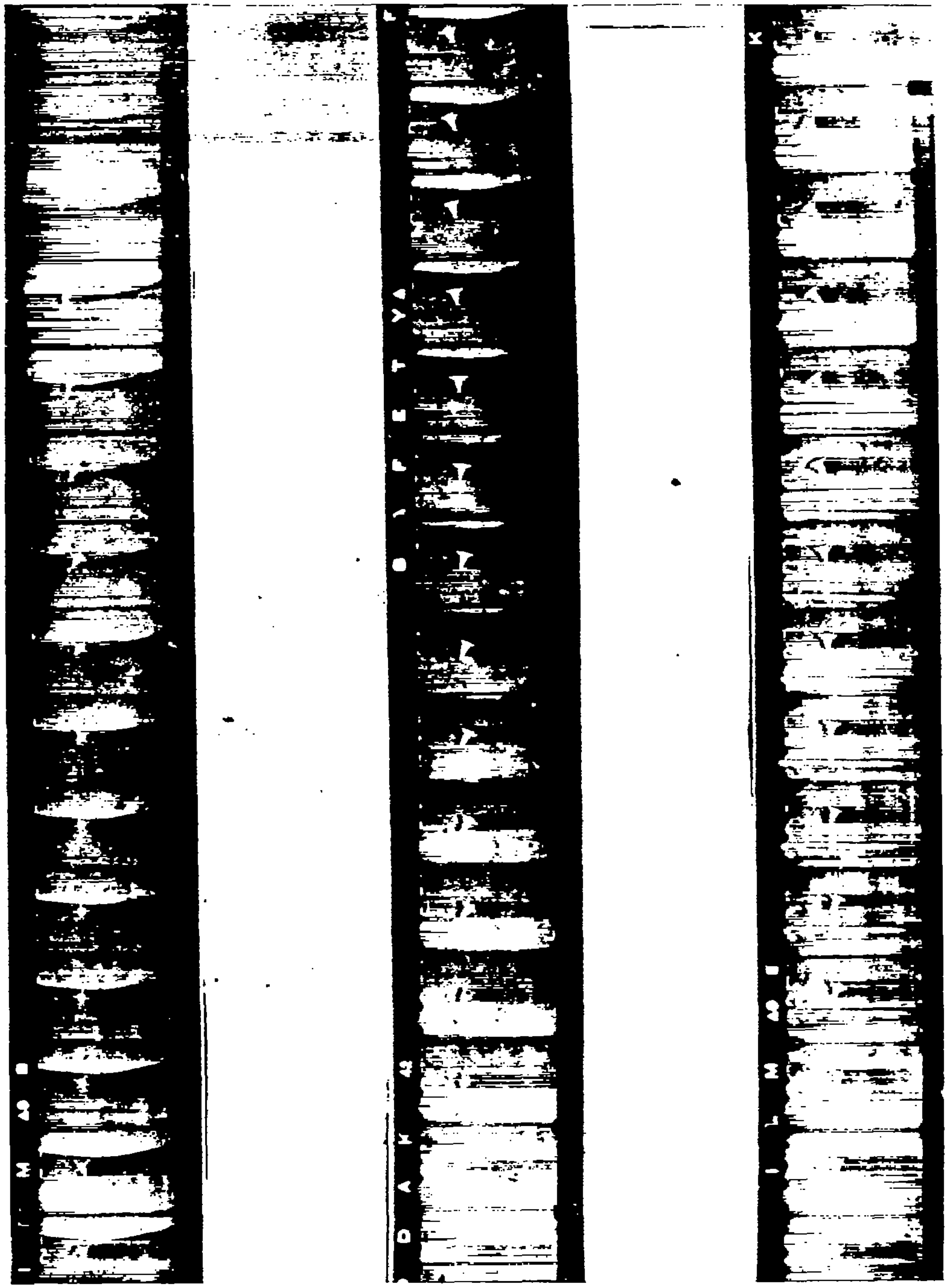

Figure 12.- Moving picture strip of tests of the $\frac{1}{12}$-scale model of the jettisonable nose section of the D-558, phase II, airplane with the center of gravity at 0.624L and fins II-4 installed. The model is shown damping applied rotation and descending in a stable nose-down attitude in the Langley 20-foot free-spinning tunnel.

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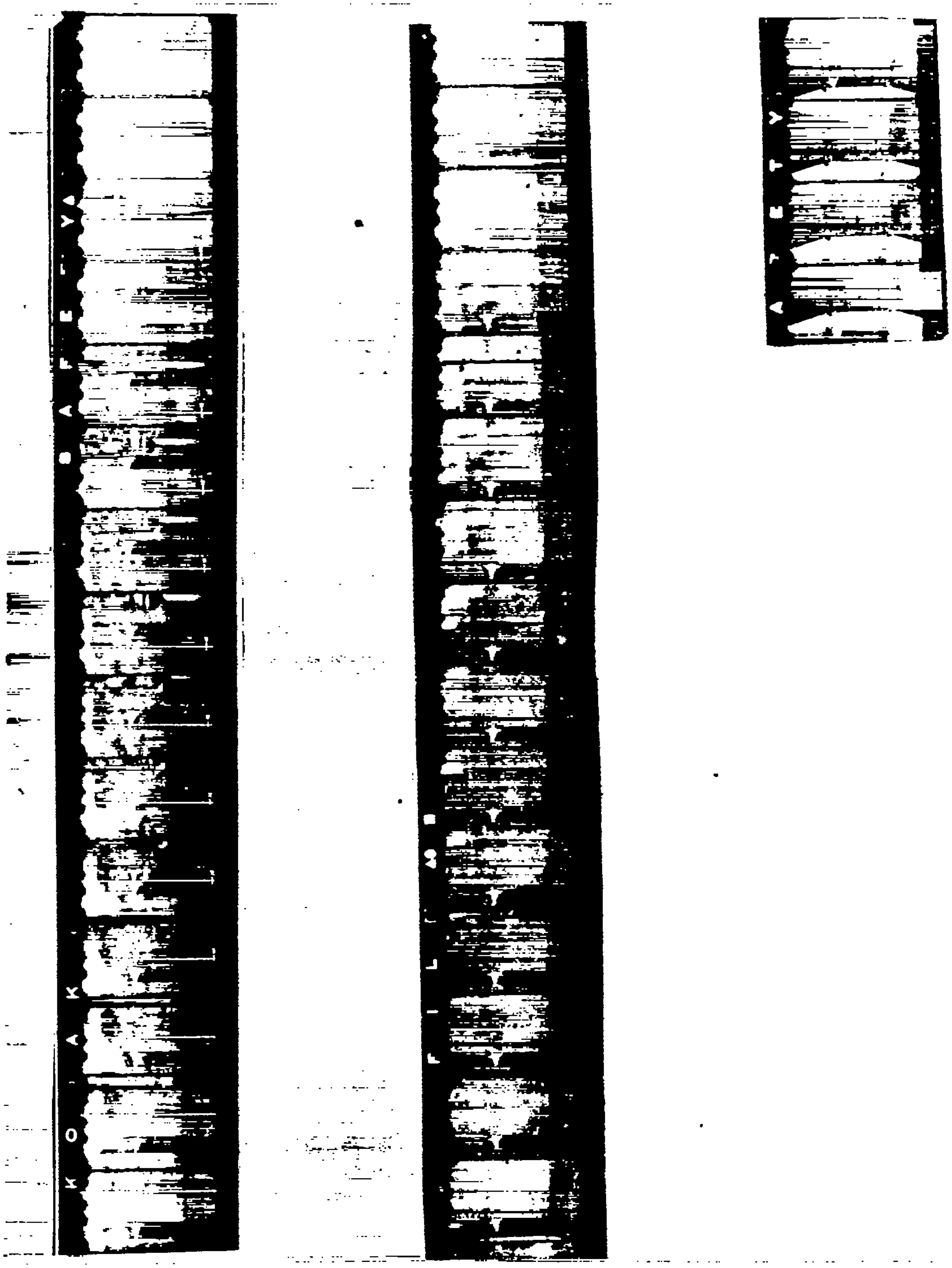

Figure 12.- Concluded.

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