NACA

RESEARCH MEMORANDUM

for the

Air Materiel Command, Army Air Forces

FREE-SPINNING AND TUMBLING TESTS OF A $\frac{1}{16}$-SCALE MODEL OF THE McDONNELL XP-85 AIRPLANE

By

Walter J. Klinar

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

MAR 6 1947

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

for the

Air Materiel Command, Army Air Forces

FREE-SPINNING AND TUMBLING TESTS OF A $\frac{1}{16}$-SCALE MODEL OF THE McDONNELL XP-85 AIRPLANE

By Walter J. Klinar

SUMMARY

Tests have been performed in the Langley 20-foot free-spinning tunnel to determine the spin and recovery characteristics and the tumbling tendencies of a $\frac{1}{16}$-scale model of the McDonnell XP-85 airplane. The erect spin and recovery characteristics of the model were determined with the following tails installed on the model: "X" tail only, X tail plus center vertical tail, and X tail plus 50-percent rudder area incorporated into the vertical fins on the upper vee. In addition, other tail modifications were made to the model in an attempt to improve the spin-recovery characteristics. The spinning investigation also included inverted spin tests and spin-recovery-parachute tests. For the tumbling tests, the X tail only was installed on the model.

The test results showed that with either of the three tail arrangements, the model usually spun in flat attitudes with oscillations about the lateral and longitudinal axes. In general, full reversal of the rudder pedals did not stop the spinning rotation. To make the model satisfactorily meet the spin-recovery requirements, it was found that installation of either a very large ventral fin (17.9 square feet, full scale) below the tail or a somewhat smaller ventral fin and rudder (12.4 square feet, total full-scale area) with a rudder throw of at least $\pm 22^{\circ}$ was required.

Either a 21.3-foot tail parachute or a 6.4-foot wing-tip parachute (drag coefficient approximately 0.70) appears necessary as an emergency spin-recovery device during demonstration spins.

The model did not exhibit any tumbling tendencies at the nromal loading.

INTRODUCTION

As requested by the Air Materiel Command, Army Air Forces, an investigation of the spin and recovery characteristics of the McDonnell XP-85 airplane has been conducted with a $\frac{1}{16}$-scale model in the Langley 20-foot free-spinning tunnel. A brief series of tumbling tests was also conducted on the model. The XP-85 airplane is a parasite fighter and is designed to be carried within a bomb bay of the B-36 airplane. The XP-85 airplane has a landing hook attached to the fuselage nose and is equipped with leading-edge flaps. The wing of the airplane is swept back and the tail is "X" shaped.

The erect spin and recovery characteristics of the model were determined for the normal loading with the following tails installed: X tail only, X tail plus center vertical tail, and X tail plus 50-percent rudder area incorporated into the vertical fins on the upper vee (upper arms of the X tail). Various other tail modifications including ventral fins and tail fillets were investigated in an attempt to improve the model's spin-recovery characteristics. Spin tests with the leading-edge flaps deflected, inverted spin tests, and tests to determine the effect of emergency spin-recovery tail and wing-tip parachutes were performed. Inasmuch as the XP-85 is equipped with a pilot-ejection seat, pilot-escape tests on the model were not deemed necessary.

Tumbling tests were made with the model in the normal loading with the X tail only installed.

Tests with the model loaded to simulate a revised normal loading (McDonnell Aircraft Corp. telegram to AMC Engineering Liaison Officer, NACA, dated July 17, 1946, containing additional information on model received after model was ballasted) were not considered necessary, as it was felt that test results for this loading would be similar to the results obtained for the normal loading.

SYMBOLS

b	wing span, feet
S	wing area, square feet
$\bar{c}$	mean aerodynamic chord, feet
$x/\bar{c}$	ratio of distance of center of gravity rearward of leading edge of mean aerodynamic chord to mean aerodynamic chord
$z/\bar{c}$	ratio of distance between center of gravity and fuselage center line to mean aerodynamic chord (positive when center of gravity is below the fuselage center line)
m	mass of airplane, slugs
I_X, I_Y, I_Z	moments of inertia about X, Y, and Z body axes, respectively, slug-feet^2
$\frac{I_X - I_Y}{mb^2}$	inertia yawing-moment parameter
$\frac{I_Y - I_Z}{mb^2}$	inertia rolling-moment parameter
$\frac{I_Z - I_X}{mb^2}$	inertia pitching-moment parameter
ρ	air density, slug per cubic foot
μ	relative density of airplane $\left(\frac{m}{\rho Sb}\right)$
α	angle between fuselage center line and vertical (approximately equal to absolute value of angle of attack at plane of symmetry), degrees
ϕ	angle between span axis and horizontal, degrees
V	full-scale true rate of descent, feet per second
Ω	full-scale angular velocity about spin axis, revolutions per second

σ helix angle, angle between flight path and vertical, degrees (For the tests of this model, the average absolute value of the helix angle was approximately 1°.)

β approximate angle of sideslip at center of gravity, degrees (Sideslip is inward when inner wing is down by an amount greater than the helix angle.)

APPARATUS AND METHODS

Model

The $\frac{1}{16}$-scale model of the McDonnell XP-85 airplane used for the tests was built by the contractor. The model was checked for dimensional accuracy and prepared for testing by the Langley Laboratory. Prior to the time tests were started a few design changes were made to the XP-85 airplane. These changes were incorporated into the model and were as follows: wing moved forward 4.89 inches (full scale), dihedral of wing changed from -8° to -4°, size of upper vee tails increased, and the incidence of both upper and lower vee tails changed from 0° to -5°. After tests were nearly completed, the Laboratory was informed by Mr. W. J. Blatz, McDonnell representative, that the following additional changes had been made to the XP-85 airplane: wing root incidence changed from 1° to 2°, wing tip incidence changed from 1° to -3°, and wing moved rearward 1.3 inches (full scale). None of these latter changes were incorporated into the model as it was felt that they would not alter the model's spin-recovery characteristics. A three-view drawing of the model as tested with the center vertical and X tails installed is shown in figure 1. The dimensional characteristics of the airplane as represented by the model as tested in the free-spinning tunnel are given in table I.

A photograph of the model is shown in figure 2. Figure 3 shows the model with the outboard leading edge of the wing pivoted downward to form the leading-edge flaps. A sketch of the X tail with 50 percent rudder area incorporated into the vertical fins on the upper vee is shown in figure 4. Sketches of the various other tail modifications are shown in figures 5 to 10.

The model was ballasted with lead weights to obtain dynamic similarity to the airplane at an altitude of 15,000 feet

(ρ = 0.001496 slug per cubic foot). The weight, moments of inertia, and center-of-gravity location of the airplane used in ballasting the model were obtained from data furnished by the McDonnell Aircraft Corporation, Report No. 417, serial 5, March 28, 1946, with corrections made at the Langley Laboratory for the forward movement of the wing and the increase in size of the upper vee tails.

A remote-control mechanism was installed in the model to actuate the controls or open the parachute for recovery tests. Sufficient moments were exerted on the control surfaces during recovery tests to reverse the controls fully and rapidly.

The model parachutes used were of the flat circular type, made of silk, and had a drag coefficient of approximately 0.70 (based upon the canopy area measured with the parachute spread out on a flat surface).

WIND TUNNEL AND TESTING TECHNIQUE

The tests were performed in the Langley 20-foot free-spinning tunnel, the operation of which is generally similar to that described in reference 1 for the Langley 15-foot free-spinning tunnel, except that the model-launching technique for the spin tests has been changed. With the controls set in the desired position, the model is launched by hand with rotation into the vertically rising air stream. After a number of turns in the established spin, recovery attempt is made by moving one or more controls by means of the remote-control mechanism. After recovery, the model dives into a safety net.

Spin tests.- The spin data presented have been converted to corresponding full-scale values by the methods described in reference 1. A photograph of the model during a spin is shown in figure 11.

In accordance with standard spin-tunnel procedure, tests were performed to determine the spin and recovery characteristics of the model for the normal spinning control configuration (stick full back, ailerons neutral, and right rudder pedal full forward in a right spin) and for various other aileron-rudevator combinations. Recovery was generally attempted by rapid reversal of the rudder pedals from full with to full against the spin. Tests were also performed to evaluate the possible adverse effects on recovery of small deviations from the normal control configuration for spinning.

For these tests, the stick was set at two-thirds of its full back deflection and the ailerons were set at one-third of full deflection in the direction conducive to slower recoveries (against the spin for the XP-85 model). Recovery from this spin was attempted by rapidly reversing the rudder pedals from full with to two-thirds against the spin. This particular control configuration and manipulation is referred to as the "criterion spin."

Turns for recovery are measured from the time the controls are moved to the time the spin rotation ceases. The criterion for a satisfactory recovery from a spin for the model had been adopted as two turns or less. Recovery characteristics of the model may be considered satisfactory, however, if recovery attempted from the criterion spin in the manner previously described requires $2\frac{1}{4}$ turns.

For recovery attempts in which the model struck the safety net before recovery could be effected because of the wandering or oscillatory motion of the model, or because of an unusually high rate of descent, the number of turns from the time the controls were moved to the time the model struck the safety net were recorded. This number indicated that the model required more turns to recover from the spin than shown, as for example >3. A >3-turn recovery, however, does not necessarily indicate an improvement when compared to a >7-turn recovery. Recovery attempts for those conditions in which the model failed to recover in less than 10 turns is indicated by ∞. If the model recovered without control movement when launched in a spinning attitude with the controls set for the spin, the condition was recorded as "no spin."

The testing technique for determining the optimum size of, and the towline length for, spin-recovery parachutes is described in detail in reference 2. The parachute pack and towline were attached to the model in such a manner as to have no effect on the steady spin before being opened. For the tail parachute tests, the parachute towline was attached to the top rear of the fuselage and the parachute was packed below the upper vee tail on the inboard side of the fuselage (right side in a right spin). The parachute was opened for the recovery attempt by actuating the remote-control mechanism. The testing technique for wing-tip parachutes was essentially the same as that for the tail parachutes except that the parachute pack and towline were attached to the outer wing tip (left wing tip in a right spin) on the upper surface. It is recommended that, for full-scale wing-tip parachute installations that the parachute be packed within the wing structure. All parachutes should be provided with a positive means of ejection. For the current tests, the controls were not moved during recovery so that recovery was due entirely to the effect of opening the parachute.

Tumbling tests.- In order to determine the tumbling tendencies of the model, the model was launched into the tunnel with an initial pitching rotation about the lateral axis. The number of turns the model took before it ceased rotating was observed, as was the behavior of the model after it ceased rotating.

Moving pictures were taken of the tumbling tests so that a study of the model motion could be made. As has been previously stated, the tumbling tests were conducted with the X tail only installed on the model. The controls were so set on the model to simulate the airplane with the rudder pedals at neutral and the stick laterally neutral, full right, and full left for the following longitudinal stick positions: full back, neutral, and full forward.

PRECISION

The spin results presented herein are believed to be the true values given by the model within the following limits:

α, deg	±1
ϕ, deg	±1
V, percent	±5
Ω, percent	±2
Turns for recovery	$\pm1/4$ turn when obtained from motion picture records $\pm1/2$ turn when obtained by visual estimate

The preceding limits may have been exceeded for certain spins in which it was difficult to control the model in the tunnel because of the high rate of descent or because of the wandering or oscillatory nature of the spin.

Comparison between model and airplane spin results (references 1 and 3) indicates that spin-tunnel results are not always in complete agreement with airplane spin results. In general, the models spun at a somewhat higher rate of descent and at from 5° to 10° more outward sideslip than did the corresponding airplanes. The comparison made in reference 3 for 20 airplanes showed that 80 percent of the models predicted satisfactorily the number of turns required for recovery from the spin for the corresponding airplanes, and that 10 percent overestimated and 10 percent underestimated the number of turns required.

Because of the impracticability of ballasting the model exactly and because of inadvertent damage to the model during the tests, the measured weight and mass distribution of the model varied from the true scaled-down values within the following limits:

Weight, percent	0 to 1 high
Center-of-gravity location, percent $\bar{c}$	1 rearward to 2 rearward of normal
Moments of inertia: I_X, percent	2 high to 4 high
Moments of inertia: I_Y, percent	5 high to 8 high
Moments of inertia: I_Z, percent	3 high to 6 high

The accuracy of measuring the weight and mass distribution of the model are believed to be within the following limits:

Weight, percent	±1
Center-of-gravity location, percent $\bar{c}$	±1
Moments of inertia, percent	±5

Controls were set with an accuracy of $\pm1^\circ$.

TEST CONDITIONS

Tests were performed for the model conditions listed on table II. The greater majority of the tests were conducted with the X tail only installed on the model inasmuch as Mr. D. S. Lewis of the McDonnell Aircraft Corporation had indicated that the airplane would probably be built without the center vertical tail installed. When the center tail was installed the rudder pedals operated the rudder on this tail in addition to the rudevators. Tests were run with 50-percent rudder area incorporated into the vertical fins on the upper vee tail at the request of Mr. M. Asper, also of the McDonnell Aircraft Corporation. All tests were conducted with the cockpit closed and the landing hook retracted. The configuration of the model as tested in the clean condition was as follows: flaps retracted, landing hook retracted, and cockpit closed.

Mass characteristics and mass parameters for the normal loading, revised normal loading, and other loading conditions possible on the airplane and for the actual loading tested on the model are listed on table III. The mass distribution parameters for the loadings possible on the XP-85 airplane and for the loading tested on the model are plotted in figure 12. As discussed in reference 4, figure 12 can be used as an aid in predicting the relative effectiveness of the controls on the recovery characteristics of the model.

The maximum control deflections used in the tests were:

Rudder mounted on center tail, deg	15 right, 15 left
Rudevators, deg	45 up, 30 down
Ailerons, deg	20 up, 20 down
Flaps, deg	30 down

For tests with 50 percent of the vertical fins on the upper vee used as rudders, maximum deflections of 30° right and 30° left were used, and for tests with a ventral fin and rudder added to the model (modification 14), the maximum rudder deflections used were 22° right and 22° left.

The intermediate control deflections used for the spin tests were:

Stick two-thirds back, full right rudder pedal:	
Left upper rudevator and right lower rudevator, deg	35 up
Right upper rudevator and left lower rudevator, deg	5 up
Stick two-thirds back, two-thirds left rudder pedal:	
Left upper rudevator and right lower rudevator, deg	10 up
Right upper rudevator and left lower rudevator, deg	30 up
Ailerons one-third deflected, deg	7 up, 7 down
Rudder on center vertical tail two-thirds deflected, deg	10
Rudders on fins on upper vee two-thirds deflected, deg	20
Rudder on modification number 14	22 right, 15 left 15 right, 15 left 15 right, 10 left

The rudevator deflections for various stick and rudder pedal positions are shown on figure 13.

RESULTS AND DISCUSSION

The results of the spin tests of the model are presented in charts 1 to 3 and tables IV and V. The model data are presented in terms of the full-scale values for the airplane at a test altitude of 15,000 feet. Results of right and left spins were quite similar and results for right spins are arbitrarily presented (airplane turning to pilot's right). Table VI contains the tumbling test results.

Spin Tests - Normal Loading

Clean condition.- The test results obtained with the XP-85 model with the normal loading and in the clean condition are presented in charts 1 and 2. The model loading condition is represented by point 1 on table III and figure 12.

Similar results were obtained with either the X tail alone, X tail plus center vertical tail, or X tail with 50-percent rudder area incorporated into the vertical fins on the upper vee installed on the model. For the normal control configuration for spinning (stick full back and laterally neutral, and right rudder pedal full forward in a right spin), the model spun at flat attitudes with oscillations about the lateral and longitudinal axes. Fully reversing the rudder pedals did not satisfactorily terminate the spin, in fact, the effect of moving the controls was usually so slight that the model generally continued spinning. Simulating the stick-forward position or setting the ailerons against the spin had little effect on the spin or recovery characteristics of the model. Test results indicated that normal control manipulation for recovery (full rudder pedal reversal followed by movement of the stick forward) would also be ineffective.

With the ailerons set full with the spin (stick right in a right spin) and the stick set longitudinally neutral or full back the model did not spin, but went into a tight vertical roll. When the ailerons were moved from neutral to full with the spin for recovery, however, the model did not recover satisfactorily. Based on these results, it appears that if an incipient spin is obtained, immediate setting of the ailerons full with the spin will probably prevent the fully developed spin. If, however, a fully developed spin is obtained with the ailerons set at neutral or against the spin, moving the ailerons to full with the spin will probably not cause the airplane to recover satisfactorily because of the excessive time required in changing from a flat to a steep attitude.

Flaps deflected.- Results obtained for tests with the leading-edge flaps deflected on the model are presented on chart 2. Deflecting the flaps had no effect on the steady spin characteristics. Although no recoveries were attempted during these tests, it appeared that the model's recovery characteristics would not be altered by deflecting the flaps inasmuch as the steady spin data with flaps extended and with flaps retracted were very much similar.

Inverted spins.- The test results obtained for the inverted spin tests are presented on chart 3. The order used on the charts for presenting the data for inverted spins is different from that used for erect spins. For inverted spins, "controls crossed" (right rudder pedal forward and stick to the pilot's left when the airplane is spinning to the pilot's right) for the developed spin is plotted to the right of the chart and "stick back" is plotted at the bottom. When the controls are crossed in the developed spin, the ailerons aid the rolling motion; when the controls are together, the ailerons oppose the rolling motion. The angle of wing tilt on the chart is given as up or down relative to the ground.

Results obtained for inverted spins were similar to those obtained for the erect spins. The model did not recover when the ailerons were neutral or when the controls were together, and the model did not spin when the controls were crossed.

Spin Tests - Revised Normal Loading

No tests were conducted with the model ballasted to simulate the airplane at the revised normal loading. As is shown in table III, the differences between the normal loading and the revised normal loading are small except for the variation in center-of-gravity position. Past spin-tunnel experience has shown, however, that for models having high relative densities (the relative density of XP-85 at 15,000 feet is 44.9), moderate variations in the center of gravity have little effect on model spin and recovery characteristics. Consequently, it is to be expected that similar results would have been obtained for both the normal loading and the revised normal loading.

Tail Modifications

Various tail modifications were tested in an attempt to improve the recovery characteristics of the model in erect spins. The modifications are tabulated in table IV and are classified as "ineffective," "slightly effective," or "very effective." The tail configurations to which the modifications were made are also indicated in table IV.

Most of the modifications indicated in table IV were classified as ineffective either because the rudevators would not terminate the spin at all or because too many turns were required. In fact, for certain ventral fin modifications tested, the spin sometimes flattened after the rudevators were reversed from with to against the spin, and in some instances the model would not spin for rudevator with settings (although a large number of turns was required before the launching rotation ceased) but the model continued to spin when rudevators were placed against the spin.

With relatively large thin ventral fins installed on the model (modifications 12 and 15), the model did not spin for the criterion spin control setting when the rudevators were either with or against the spin, but a large number of turns were required before the launching rotation ceased. These modifications were termed as slightly effective for it appears that if the corresponding airplane with either of these modifications should get into a spin at a given control setting, satisfactory recovery would probably not be possible.

Two of the modifications tested led to satisfactory spin and recovery characteristics and are classified as very effective in table IV. With a very large ventral fin installed on the model (modification number 16, approximate full-scale area 17.9 square feet), the model did not spin at the criterion spin control setting (rudevators either with or against the spin) and the original spinning rotation imparted to the model on launching was damped out rapidly. Accordingly, this size ventral fin appeared to be very effective and necessary to insure satisfactory spin recovery characteristics for the airplane with the design rudevators. It was found that the ventral fin area required to make the model satisfactorily meet the spin requirements could be reduced somewhat provided a portion of the ventral fin was used as a rudder. With such a modification installed on the model (modification 14, total full-scale area 12.4 square feet) and for a maximum rudder throw of $\pm 22^{\circ}$, a spin was obtained at the criterion spin control setting and the spin was satisfactorily terminated (2 turns) by reversal of the rudder only. With the same modification installed on the model and a maximum rudder throw of only $\pm15^{\circ}$, however, satisfactory recoveries were not obtained.

Thus, in order to insure satisfactory recoveries from spins obtained on the airplane, it appears that installation of a very large ventral fin (modification 16) or the installation of a somewhat smaller ventral fin and rudder (modification 14) with a rudder throw of at least $\pm22^{\circ}$ is necessary.

Spin-Recovery Parachutes

The results of tests performed with spin-recovery parachutes attached to either the tail of the model or to the outboard wing of the model are presented in table V. The model was in the normal loading and the X tail was installed for these tests.

With the spin-recovery parachute attached to the tail, satisfactory recovery was obtained by opening the equivalent of a 21.3-foot- (full scale) diameter parachute with a 0.7-foot towline. Satisfactory recovery was also obtained by opening the equivalent of a 6.4-foot- (full scale) diameter parachute attached by the shroud lines to the outboard wing tip. The drag coefficient measured for the tail and wing-tip parachutes was approximately 0.70.

The turns for recovery presented in table V were measured from the time the parachute was opened to when the model assumed a nearly vertical (unstalled) attitude. For the tail parachute tests, the model usually made from 1 to 3 turns about the parachute axis after assuming a vertical attitude before the rotation stopped. When the wing-tip parachutes were opened, the model would steepen up to a vertical attitude after the spin rotation had slowed down, and would then usually begin turning about the outboard wing tip and parachute axis in an inverted attitude. On the full-scale airplane, the parachute should be freed immediately after the airplane assumes a vertical attitude in order to prevent the airplane from taking additional turns about the parachute axis.

Tumbling Tests

The tumbling tests were conducted with the model in the normal loading and with the X tail only installed. The test results presented on table VI show that the model had no tumbling tendencies at the loading tested. Inasmuch as the tumbling rotation imparted to the model on launching and the pitching oscillations encountered by the model after the tumbling had ceased were damped out rapidly, it appeared that a rearward movement of the center of gravity even by as much as 10 percent of the mean aerodynamic chord would probably not appreciably alter the model's tumbling characteristics. Forward movements in the center of gravity would probably make the model's resistance to tumbling even greater.

CONCLUSIONS

Based on the results of tests of a $\frac{1}{16}$-scale model of the XP-85 airplane, the following conclusions regarding the spin and recovery and the tumbling characteristics of the airplane at a test altitude of 15,000 feet have been made:

1. The airplane will spin at flat attitudes with oscillations about the lateral and longitudinal axes. The fully developed spin will not be terminated satisfactorily by normal control manipulation for recovery. Setting ailerons full with the spin during the incipient phase will probably prevent the attainment of a developed spin.

2. The spin and recovery characteristics of the airplane with the "X" tail installed will not be affected by either adding a center vertical tail and rudder or by incorporating 50-percent rudder area into the vertical fins on the upper vee.

3. Deflecting the leading-edge flaps will not affect the airplane spin characteristics nor improve the airplane recovery characteristics.

4. Recoveries from inverted spins will be unsatisfactory.

5. Either the installation of a very large ventral fin (17.9 square feet, full scale) or the installation of a somewhat smaller ventral fin and rudder (12.4 square feet, total full-scale area) with a rudder throw of at least $\pm 22^{\circ}$ appears necessary to insure satisfactory recovery characteristics.

6. A 21.3-foot tail parachute or a 6.4-foot wing-tip parachute (drag coefficient 0.70) will be effective for emergency recoveries from demonstration spins.

7. The airplane will not tumble.

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

Walter J. Klinar
Walter J. Klinar
Aeronautical Engineer

Approved: Thomas A. Harris
for Hartley A. Soulé
Chief of Stability Research Division

MEL

REFERENCES

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

2. Seidman, Oscar, and Kamm, Robert W.: Antispin-Tail-Parachute Installations. NACA RB, Feb. 1943.

3. Seidman, Oscar, and Neihouse, A. I.: Comparison of Free-Spinning Wind-Tunnel Results with Corresponding Full-Scale Spin Results. NACA MR, Dec. 7, 1938.

4. Neihouse, A. I.: A Mass-Distribution Criterion for Predicting the Effect of Control Manipulation on the Recovery from a Spin. NACA ARR, Aug. 1942.

TABLE I.- DIMENSIONAL CHARACTERISTICS OF THE XP-85 AIRPLANE AS REPRESENTED BY THE $\frac{1}{16}$-SCALE MODEL AS TESTED IN THE FREE-SPINNING TUNNEL

Length over all, ft	15.0
Normal gross weight, lb	4552
Normal center-of-gravity location, percent $\bar{c}$	21.6
Wing:	
Span, ft	21.12
Area, sq ft	100
Section, root	NACA 65-010
Section, tip	NACA 65-010
Root-chord incidence, deg	1
Tip-chord incidence, deg	1
Aspect ratio	4.41
Sweepback at 25 percent chord, deg	34
Dihedral of wing, deg	-4
Mean aerodynamic chord, in.	61.91
Leading edge $\bar{c}$ aft leading-edge root chord, in.	41.36
Leading-edge flaps:	
Location of hinge line, percent chord	15
Span, percent of b/2	40.3
Ailerons:	
Total area, sq ft	3.00
Location of hinge line, percent chord	80
Span, percent of b/2	40.3
Tail surfaces:	
Area vertical fins on upper vee(total), sq ft	8.32
Area upper vee tail (less vertical fins), sq ft	20.40
Area lower vee tail, sq ft	11.67
Center vertical tail area, sq ft	7.55
Total projected horizontal area upper vee, sq ft	14.40
Total projected horizontal area lower vee, sq ft	8.22
Distance from normal center of gravity to the 1/4 root chord of the upper vee, ft	4.97
Distance from normal center of gravity to the 1/4 root chord of the lower vee, ft	5.74
Incidence of vee tail, deg	-5
Dihedral of vee tails, deg	45
Location of hinge line of rudevators and rudder aft of the leading edge, percent chord	70
Airfoil section	NACA 66-009

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE II.- CONDITIONS TESTED ON THE $\frac{1}{16}$-SCALE

MODEL OF THE McDONNELL XP-85 AIRPLANE

[Normal loading; spins to pilot's right]

Type of test	Leading-edge flap position	Tail configuration installed				Method employed in recovery	Data presented
		a	b	c	Modifications		
Erect spin	Retracted	x				Reversal of rudder and rudevators	Chart 1
Do-----	----do----		x			Reversal of rudevators and movement of ailerons from neutral to with the spin	Chart 1
Do-----	30° deflected	x				--------------------------	Chart 2
Do-----	Retracted			x		Reversal of rudders and rudevators	Chart 2
Inverted spin	----do----		x			Reversal of rudevators	Chart 3
Erect spin	----do----	x	x	x	x	Reversal of rudders and rudevators	Table IV
Do-----	----do----		x			Tail and wing-tip parachutes	Table V
Tumbling	----do----		x			--------------------------	Table VI

[a]X tail plus center vertical tail.
[b]X tail only.
[c]X tail plus 50 percent rudder area incorporated into vertical fins on the upper vee (fig. 4).

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE III.- MASS CHARACTERISTICS AND INERTIA PARAMETERS FOR VARIOUS LOADINGS POSSIBLE ON THE XP-85 AIRPLANE AND FOR THE LOADING TESTED ON THE $\frac{1}{16}$-SCALE MODEL

[Model values converted to corresponding full-scale values]

No.	Loading	Weight (lb)	μ		Center-of-gravity location		Moments of inertia about center of gravity			Inertia parameters		
			Sea level	15,000 feet	$x/\bar{c}$	$z/\bar{c}$	I_X (slug/ft^2)	I_Y (slug/ft^2)	I_Z (slug/ft^2)	$\frac{I_X - I_Y}{mb^2}$	$\frac{I_Y - I_Z}{mb^2}$	$\frac{I_Z - I_X}{mb^2}$
	Airplane values											
1	Normal loading	4552	28.20	44.90	0.216	-0.013	740	1199	1509	-73.8×10^{-4}	-49.9×10^{-4}	123.7×10^{-4}
2	Revised normal loading	4777	29.6	47.1	.267	-.050	925	1485	1736	-85.8	-38.4	124.2
3	Center of gravity 8.4 percent $\bar{c}$ forward of normal	3904	24.20	38.54	.132	.013	708	1010	1319	-56.6	-57.9	114.5
4	Center of gravity 6.3 percent $\bar{c}$ rearward of normal	3738	23.20	36.94	.279	-.049	700	1072	1409	-72.7	-65.9	138.6
5	Fuel, guns, and ammunition removed from normal loading	3090	19.20	30.57	.185	-.022	676	928	1257	-59.6	-77.7	137.3
	Model values at beginning of tests											
1	Normal gross weight	4571	28.40	45.22	0.222	-0.028	758	1256	1552	-79.5	-47.3	126.8

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE IV.- EFFECTIVENESS OF THE TAIL MODIFICATIONS TESTED ON THE $\frac{1}{16}$-SCALE MODEL OF THE XP-85 AIRPLANE

Effectiveness of modification	Modification number	Figure number	Description of modification	Airfoil section and section thickness (full scale)	Tail installed		
					a	b	c
Ineffective	1	5	Small flat sheets added in the horizontal plane and between the upper and lower vee tails	Flat sheet 1 inch thick	x		
Ineffective	2	5	Large flat sheets added in the horizontal plane and between the upper and lower vee tails	Flat sheet 1 inch thick	x		
Ineffective	3	6	Triangular fins added ahead of lower vee tails and in chord planes of the lower vee tails	Flat sheet 1 inch thick	x		
Ineffective	4	6	Rectangular fins added ahead of lower vee tails and in chord planes of the lower vee tails	Flat sheet 1 inch thick	x		
Ineffective	5	6	Span of lower vee tails increased	Flat sheet 1 inch thick		x	
Ineffective	6	7	Triangular ventral fin (approximate full-scale area = 7.30 sq ft)	Flat sheet 1 inch thick		x	
Ineffective	7	7	Modification no. 6 plus 100 percent increase in the rudevator chords	Flat sheet 1 inch thick		x	
Ineffective	8	7	Rectangular ventral fin (approximate full-scale area = 10.36 sq ft)	Flat sheet 1 inch thick	x		
Ineffective	9	8	Triangular ventral fin (approximate full-scale area = 9.26 sq ft)	Flat sheet 1 inch thick		x	
Ineffective	10	9	Triangular ventral fin (approximate full-scale area = 6.02 sq ft)	Flat sheet 1 inch thick		x	x
Ineffective	11	9	Rounded ventral fin (approximate full-scale area = 7.32 sq ft)	Flat sheet 1 inch thick		x	x
Ineffective	12	9	Rounded ventral fin (approximate full-scale area = 10.00 sq ft)	Faired airfoil section - maximum thickness equals approximately 8 percent chord at its 50 percent chord station		x	x
Ineffective	13	10	Rounded ventral fin (approximate full-scale area = 12.42 sq ft)	NACA 65-009		x	
Ineffective	14	10	Modification no. 13 with 40 percent rudder area (rudder throw = ±15°)	NACA 65-009		x	
Slightly effective	15	8	Triangular ventral fin (approximate full-scale area = 10.30 sq ft)	Flat sheet 1 inch thick		x	
Slightly effective	12	9	Rounded ventral fin (approximate full-scale area = 10.00 sq ft)	Flat sheet 1 inch thick		x	x
Very effective	14	10	Modification no. 13 with 40 percent rudder area (rudder throw = ±22°)	NACA 65-009		x	
Very effective	16	10	Rounded ventral fin (approximate full-scale area = 17.94 sq ft)	NACA 65-009		x	

[a]X tail plus center vertical tail.
[b]X tail only.
[c]X tail plus 50 percent rudder area incorporated into the vertical fins on the upper vee (fig. 4).

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE V.- SPIN-RECOVERY-PARACHUTE DATA OBTAINED WITH THE $\frac{1}{16}$-SCALE MODEL OF THE XP-85 AIRPLANE (X TAIL INSTALLED)

[Normal loading; flaps retracted; recovery attempted by opening the parachute with the rudder pedals full with the spin; right erect spins; model values converted to full-scale values; parachute drag coefficient approximately 0.70]

Parachute diameter (ft)	Towline length (ft)	Turns for recovery from aileron neutral, stick-full-back spins. V = 216 fps.
Tail parachutes		
12.0	21.0	3, 4, $4\frac{1}{2}$
13.3	21.0	$5\frac{1}{2}$, ∞, ∞
14.7	21.0	$1\frac{1}{2}$, $2\frac{3}{4}$, $4\frac{1}{4}$
14.7	35.0	1, $3\frac{1}{2}$, $5\frac{1}{2}$
16.0	35.0	$1\frac{1}{2}$, $2\frac{1}{4}$, 9
16.0	21.0	$2\frac{1}{2}$, $3\frac{1}{4}$, 4
16.0	.7	$1\frac{3}{4}$, $2\frac{3}{4}$, 4
21.3	21.0	$1\frac{3}{4}$, $2\frac{1}{4}$, 3
21.3	.7	2, 2, $2\frac{1}{4}$
Wing-tip parachutes		
13.3	0.	$\frac{1}{2}$, 1, 1
8.0	0.	$\frac{3}{4}$, $\frac{3}{4}$, 1
6.4	0.	1, $1\frac{1}{4}$, $1\frac{1}{4}$
5.3	0.	$\frac{1}{2}$, $1\frac{1}{2}$, $2\frac{3}{4}$
4.7	0.	2, $2\frac{1}{2}$, 3
4.0	0.	$1\frac{3}{4}$, 2, 2
2.5	3.5	5, >5, 6

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE VI.- TUMBLING TESTS OF THE $\frac{1}{16}$-SCALE MODEL OF

THE XP-85 AIRPLANE (X TAIL INSTALLED)

[Normal loading; flaps retracted. Model given initial pitching rotation about lateral axis. Tunnel airspeed for all tests was 16[illegible] feet per second, full scale.]

Rudevator settings (deg) (a)	Aileron setting	Direction initial pitching rotation	Remarks
0	N	Positive	Stopped tumbling and either pitched into a dive or spiraled to the right
0	N	Negative	Stopped tumbling and either pitched into a dive or spiraled to the right
0	RAU, LAD	Positive	Stopped tumbling and either pitched into a dive or spiraled to the right
0	RAU, LAD	Negative	Stopped tumbling and either pitched into a dive or spiraled to the right
0	RAD, LAU	Positive	Stopped tumbling and either pitched into a dive or spiraled to the left
0	RAD, LAU	Negative	Stopped tumbling and either pitched into a dive or spiraled to the left
30 up	RAD, LAU	Positive	Stopped tumbling and spiraled to the left
30 up	RAD, LAU	Negative	Stopped tumbling and either pitched into a dive or spiraled to the left
30 up	N	Positive	Stopped tumbling and pitched into a dive
30 up	N	Negative	Stopped tumbling and pitched into a dive
30 up	RAU, LAD	Positive	Stopped tumbling and spiraled to the right
30 up	RAU, LAD	Negative	Stopped tumbling and spiraled to the right
15 down	RAU, LAD	Positive	Stopped tumbling and either pitched into a dive or spiraled to the right
15 down	RAU, LAD	Negative	Stopped tumbling and either pitched into a dive or spiraled to the right
15 down	N	Positive	Stopped tumbling and either pitched into a dive or spiraled to the right or left
15 down	N	Negative	Stopped tumbling and either pitched into a dive or spiraled to the right or left
15 down	RAD, LAU	Positive	Stopped tumbling and either pitched into a dive or spiraled to the left
15 down	RAD, LAU	Negative	Stopped tumbling and either pitched into a dive or spiraled to the left

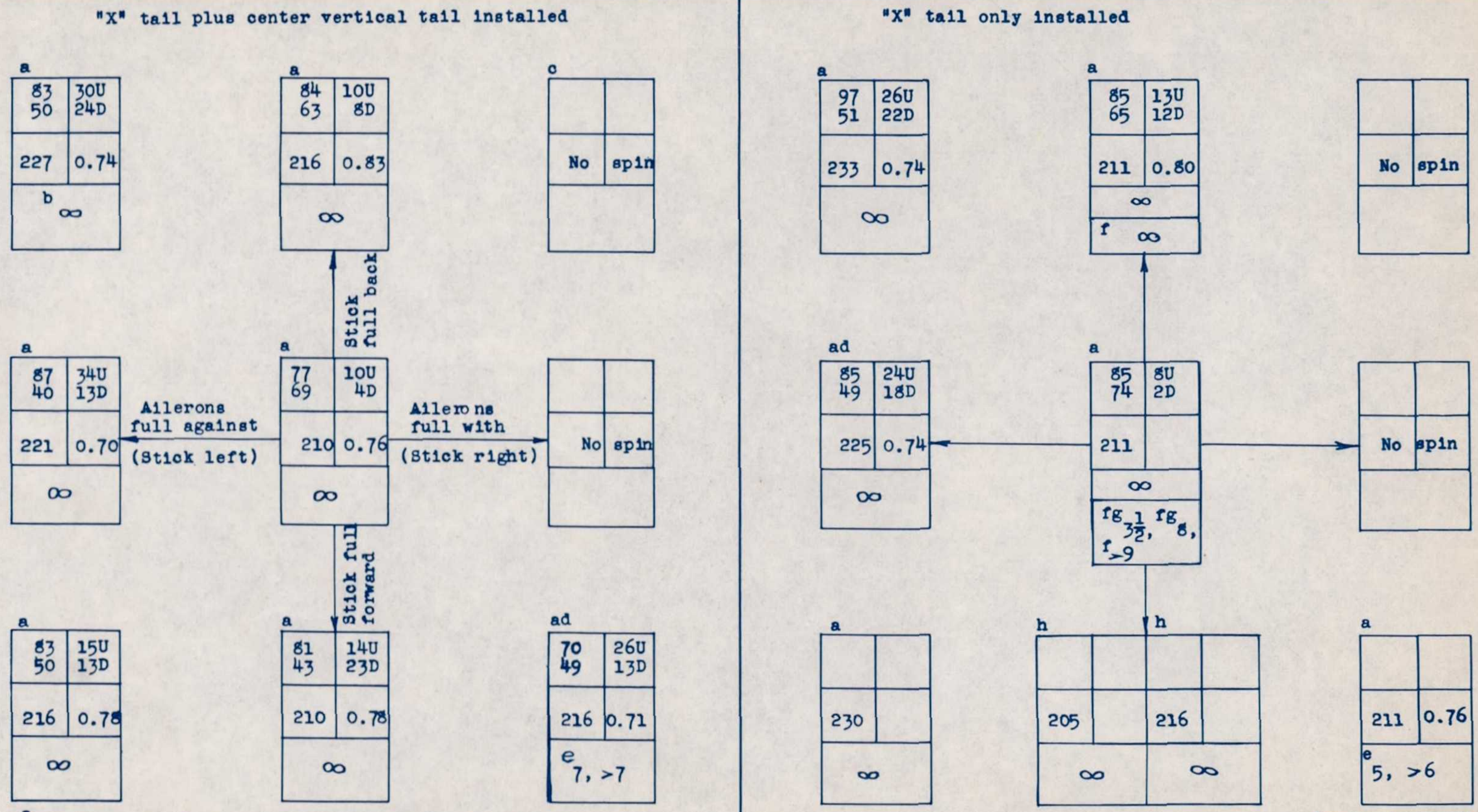
[a]Settings tested are for the rudder pedals set at neutral and the stick neutral, full back and full forward.

N Ailerons neutral.
RAD Right aileron down.
RAU Right aileron up.
LAD Left aileron down.
LAU Left aileron up.

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

CHART 1.- SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{16}$-SCALE MODEL OF THE McDONNELL XP-85 AIRPLANE (WITH AND WITHOUT THE CENTER VERTICAL TAIL INSTALLED)

[Normal loading; flaps retracted; recovery attempted by rapid full reversal of the rudder pedals (recovery attempted from, and steady-spin data presented for, rudder pedals full with the spin); right erect spins]



[a]Oscillatory spin, average or range of values given.
[b]∞ means that model required more than 10 turns for recovery.
[c]"No spin" means model does not spin - goes into a tight vertical roll.
[d]Wandering spin.
[e]Model goes into an inverted spin upon recovery.
[f]Ailerons moved from neutral to full with the spin for the recovery.
[g]Model goes into a vertical roll upon recovery.
[h]Two types of spin.

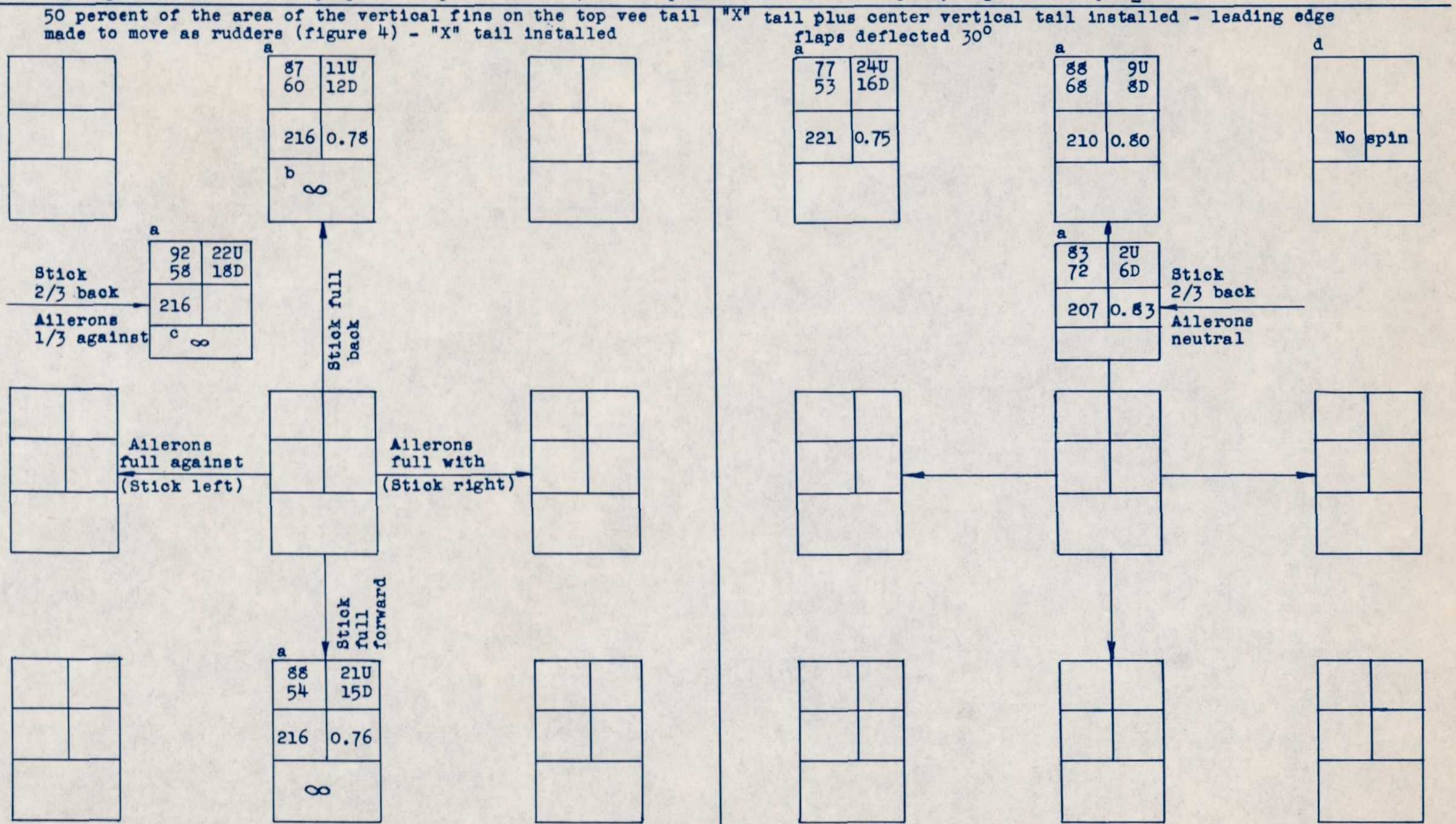
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	ϕ (deg)
V (fps)	Ω (rps)
Turns for recovery	

CHART 2.- EFFECT OF INCORPORATING RUDDER AREA INTO THE VERTICAL FINS ON THE TOP VEE TAIL, AND EFFECT OF DEFLECTING THE LEADING-EDGE FLAPS ON THE SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{16}$-SCALE MODEL OF THE McDONNELL XP-85 AIRPLANE

[Normal loading; flaps retracted unless otherwise noted; recovery attempted by rapid full reversal of the rudder pedals (recovery attempted from, and steady-spin data presented for, rudder pedals full with the spin); right erect spins]



aOscillatory spin, average or range of values given.
b∞ means model requires more than 10 turns for recovery.
cRudders and rudevators reversed from full with to 2/3 against the spin.
d"No spin" means model does not spin - dives out of spin after initial launching rotation is expended.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

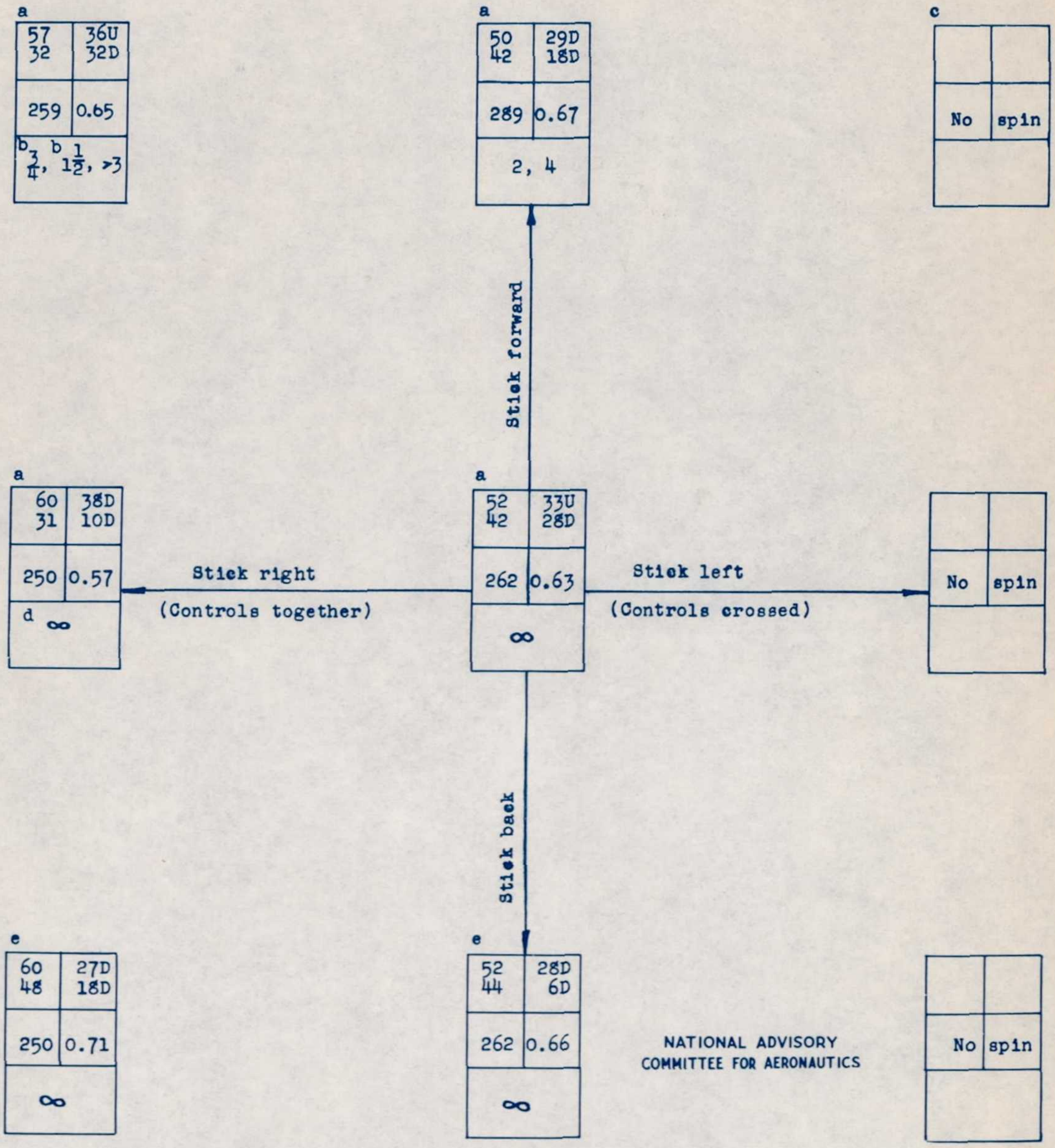
Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down

α (deg)	ϕ (deg)
V (fps)	Ω (rps)
Turns for recovery	

CHART 3.- INVERTED SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{16}$-SCALE MODEL OF THE McDONNELL XP-85 AIRPLANE

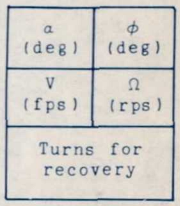
[Normal loading; flaps retracted; recovery attempted by full rapid reversal of the rudder pedals (recovery attempted from, and steady-spin data presented for, rudder pedals full with the spin); spins to pilot's right]

"X" tail installed



[a] Oscillatory spin with a whip to the turning motion, average or range of values given.
[b] Model goes into a spin in the other direction upon recovery.
[c] "No spin" means model does not spin - goes into a vertical roll.
[d] ∞ means model required more than 10 turns for recovery.
[e] Oscillatory spin, average or range of values given.

Model values converted to corresponding full-scale values.
U inner wing up
D inner wing down



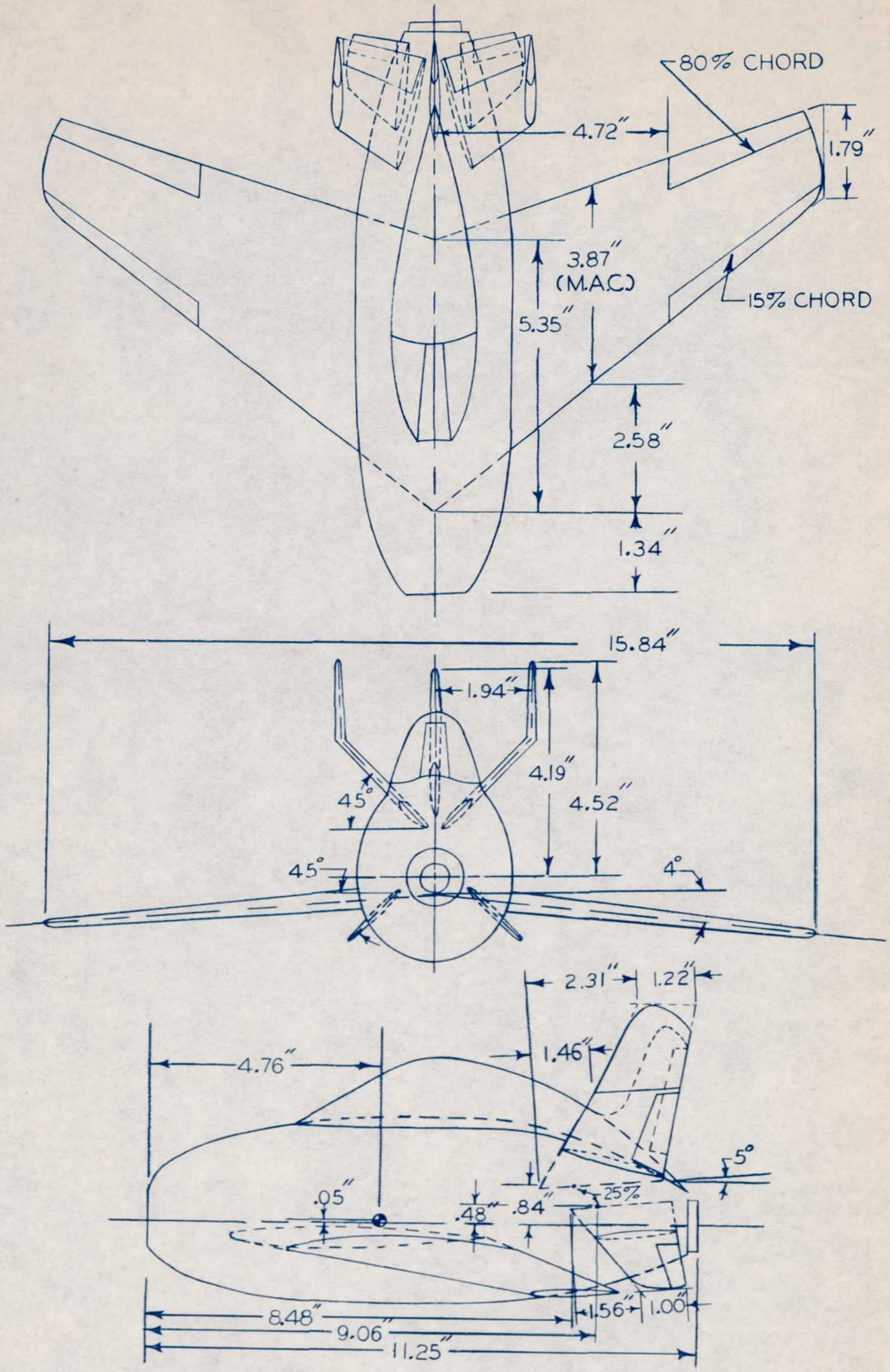


FIGURE 1.- DRAWING OF THE 1/16-SCALE MODEL OF THE XP-85 AIRPLANE TESTED IN THE FREE-SPINNING TUNNEL. C.G. INDICATED FOR NORMAL LOADING.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

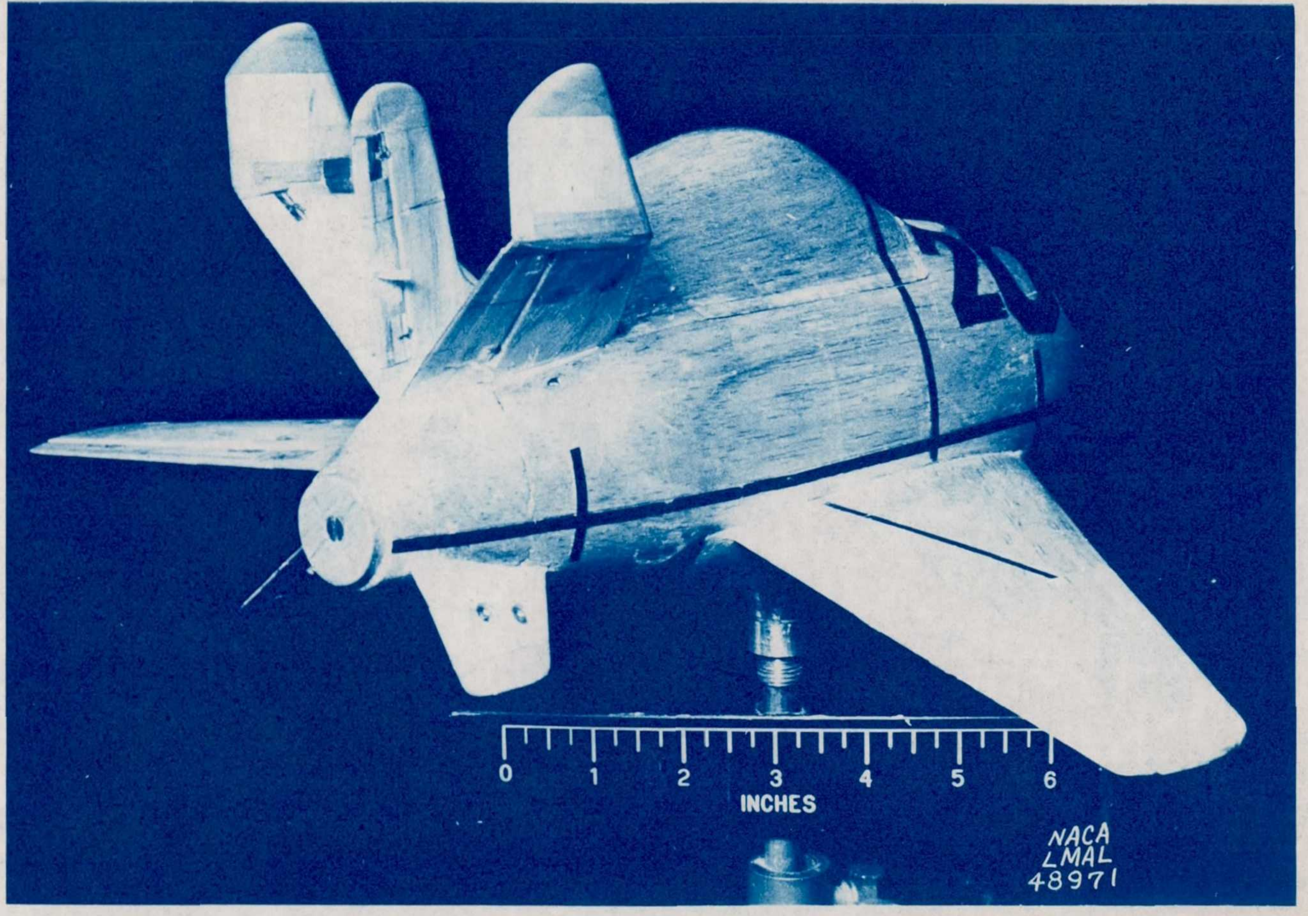


Figure 2.- The $\frac{1}{16}$-scale model of the McDonnell XP-85 airplane in the clean condition.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
LANGLEY MEMORIAL AERONAUTICAL LABORATORY - LANGLEY FIELD, VA.

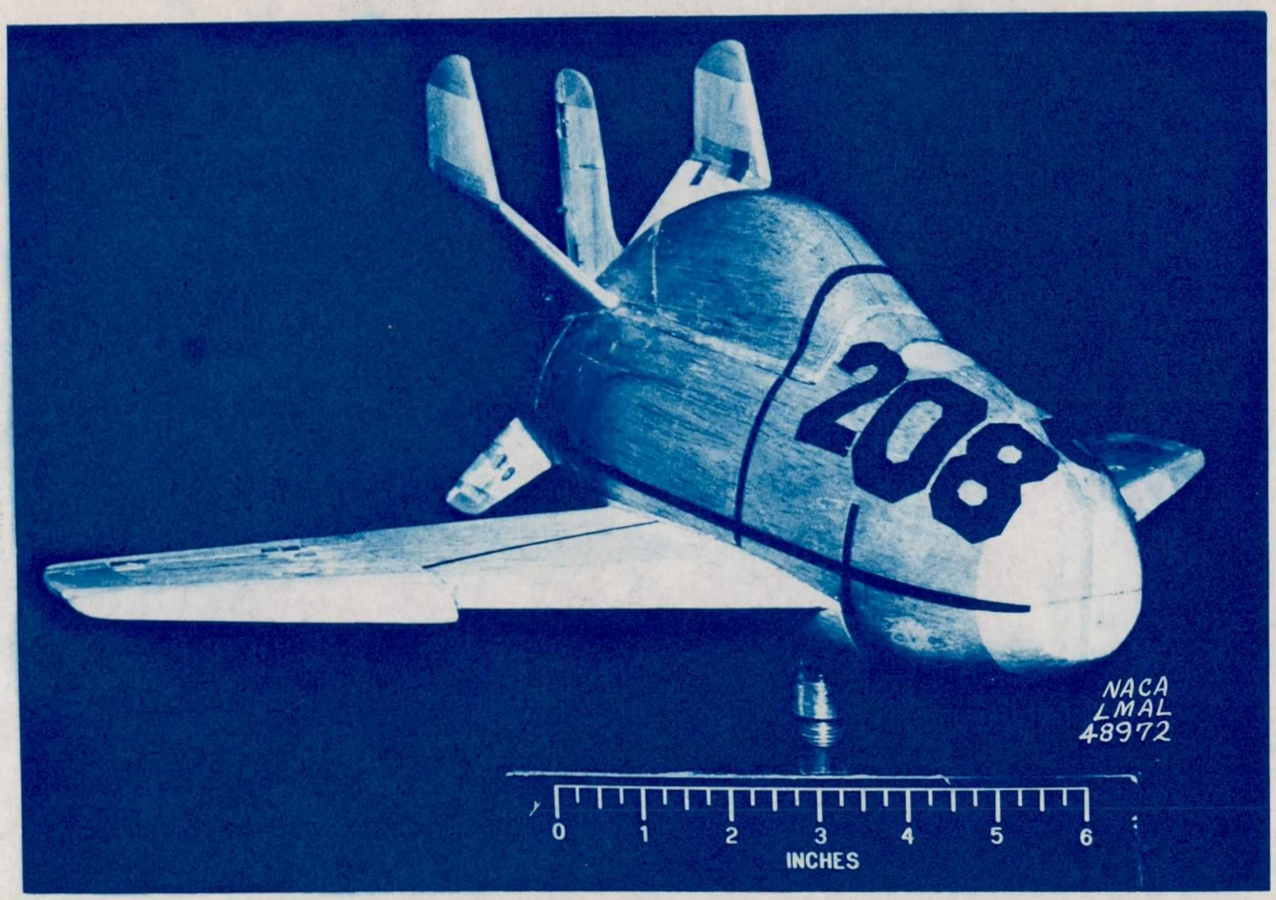


Figure 3.- The $\frac{1}{16}$-scale model of the McDonnell XP-85 airplane with the leading edge flaps deflected.

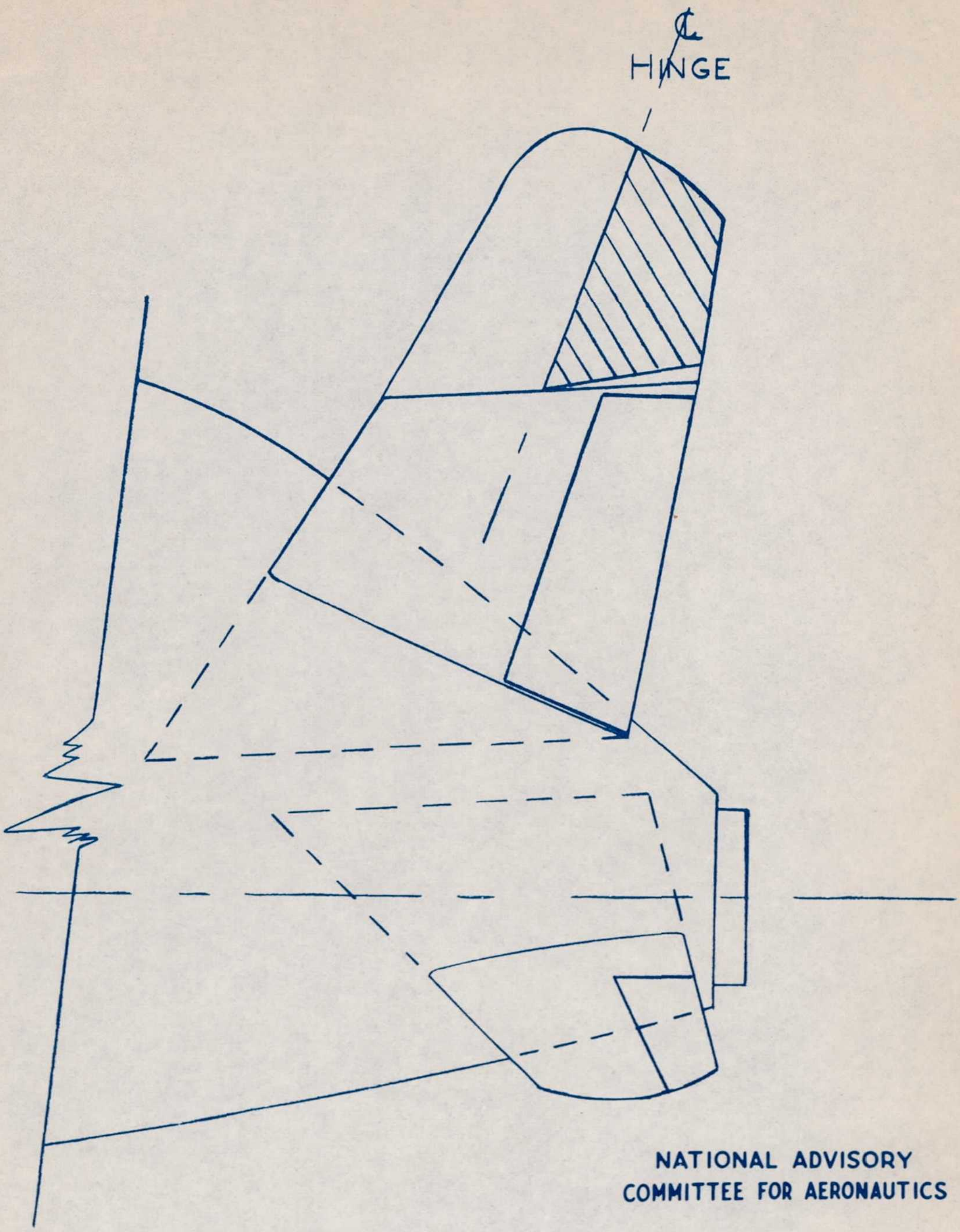
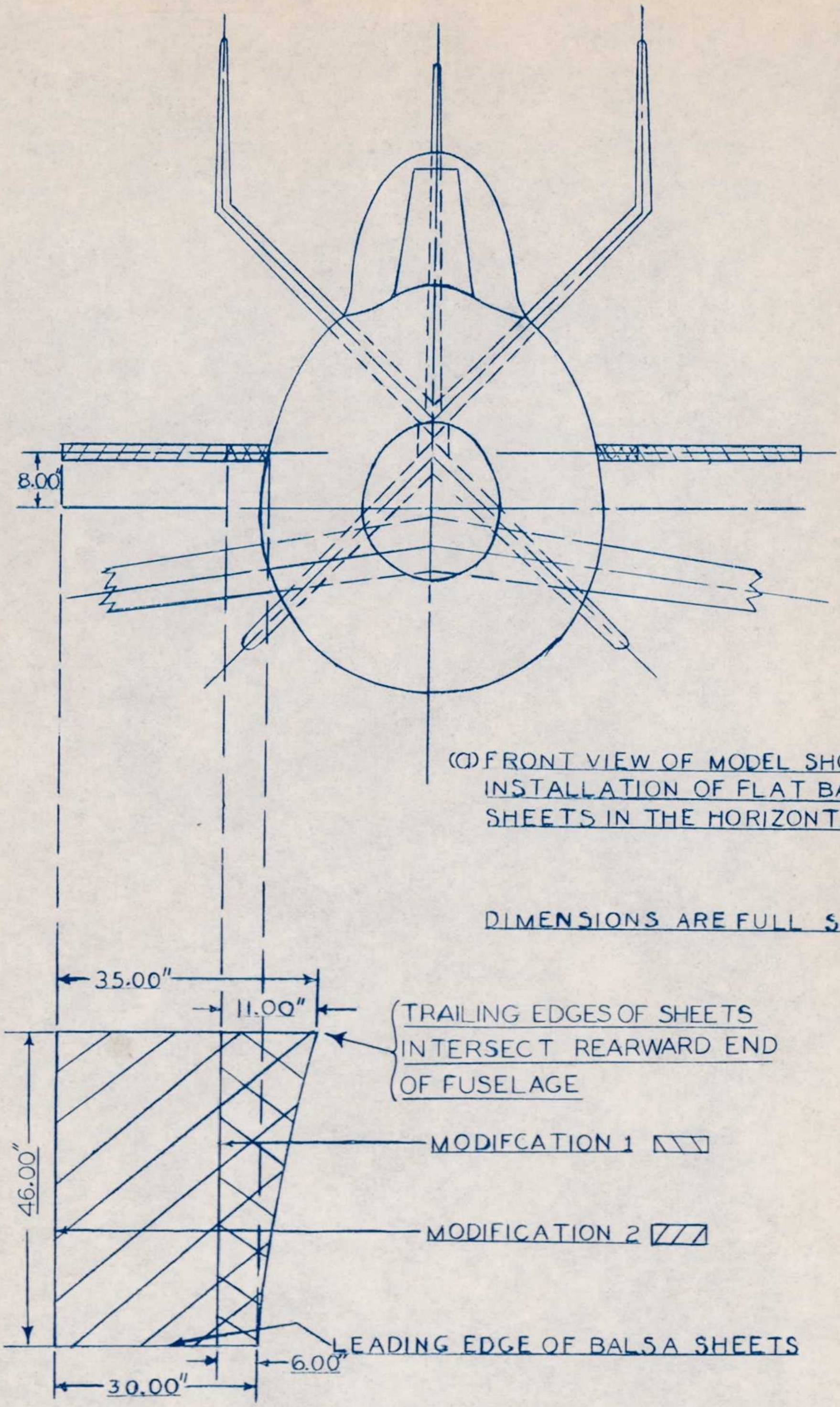


FIGURE 4.- RUDDERS ADDED TO FINS ON THE UPPER VEE TAILS AT THE 50 PERCENT CHORD LINE ON THE 1/16-SCALE MODEL OF THE XP-85 AIRPLANE.



(a) FRONT VIEW OF MODEL SHOWING INSTALLATION OF FLAT BALSA SHEETS IN THE HORIZONTAL PLANE

DIMENSIONS ARE FULL SCALE

(b) PLAN VIEW OF BALSA SHEETS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

FIGURE 5.–HORIZONTALLY MOUNTED BALSA SHEETS TESTED ON THE 1/16-SCALE MODEL OF THE XP-85 AIRPLANE

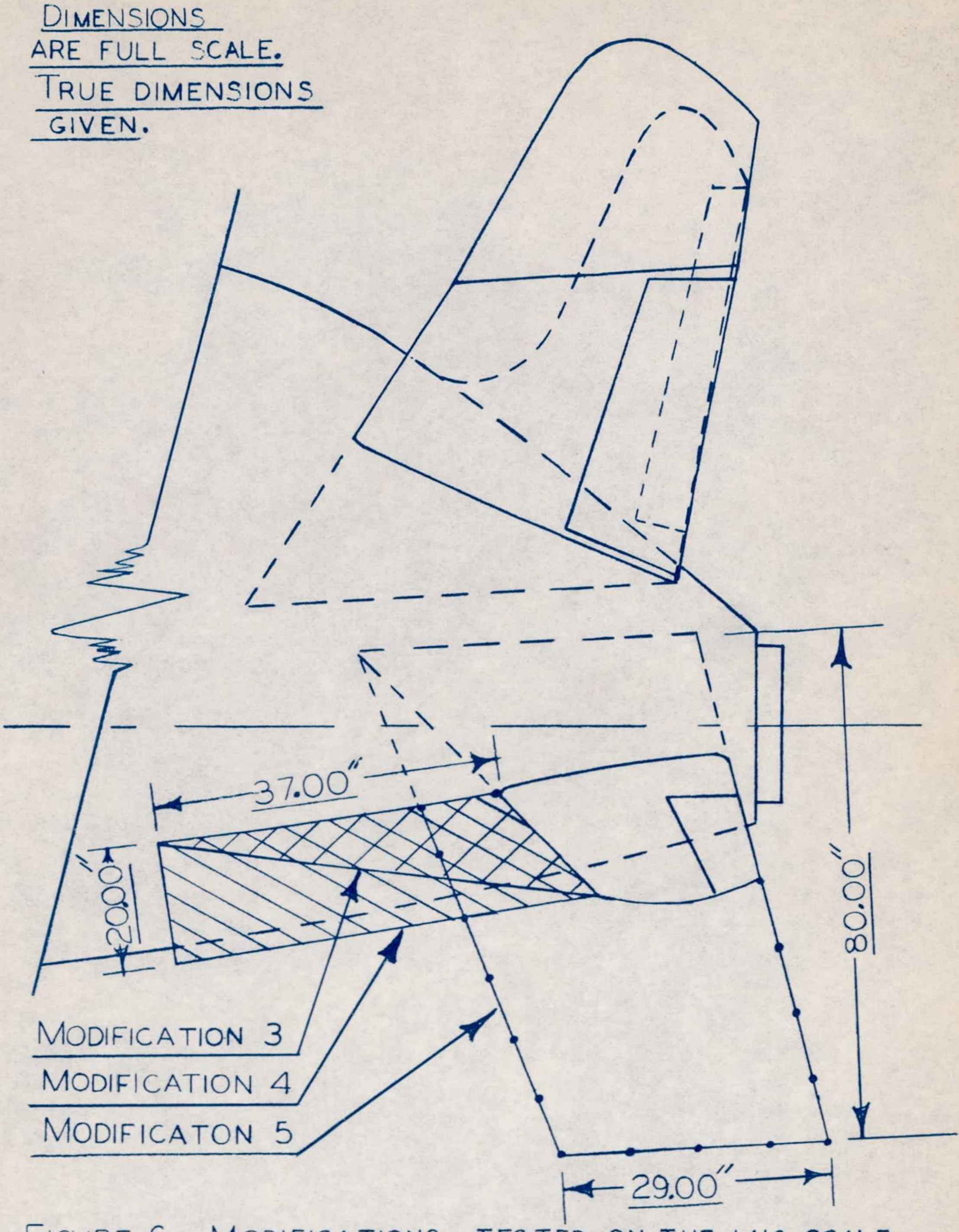


FIGURE 6. - MODIFICATIONS TESTED ON THE 1/16-SCALE MODEL OF THE XP-85 AIRPLANE. MODIFICATIONS SHOWN ABOVE ARE ADDED IN CHORD PLANES OF THE LOWER VEE TAILS.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

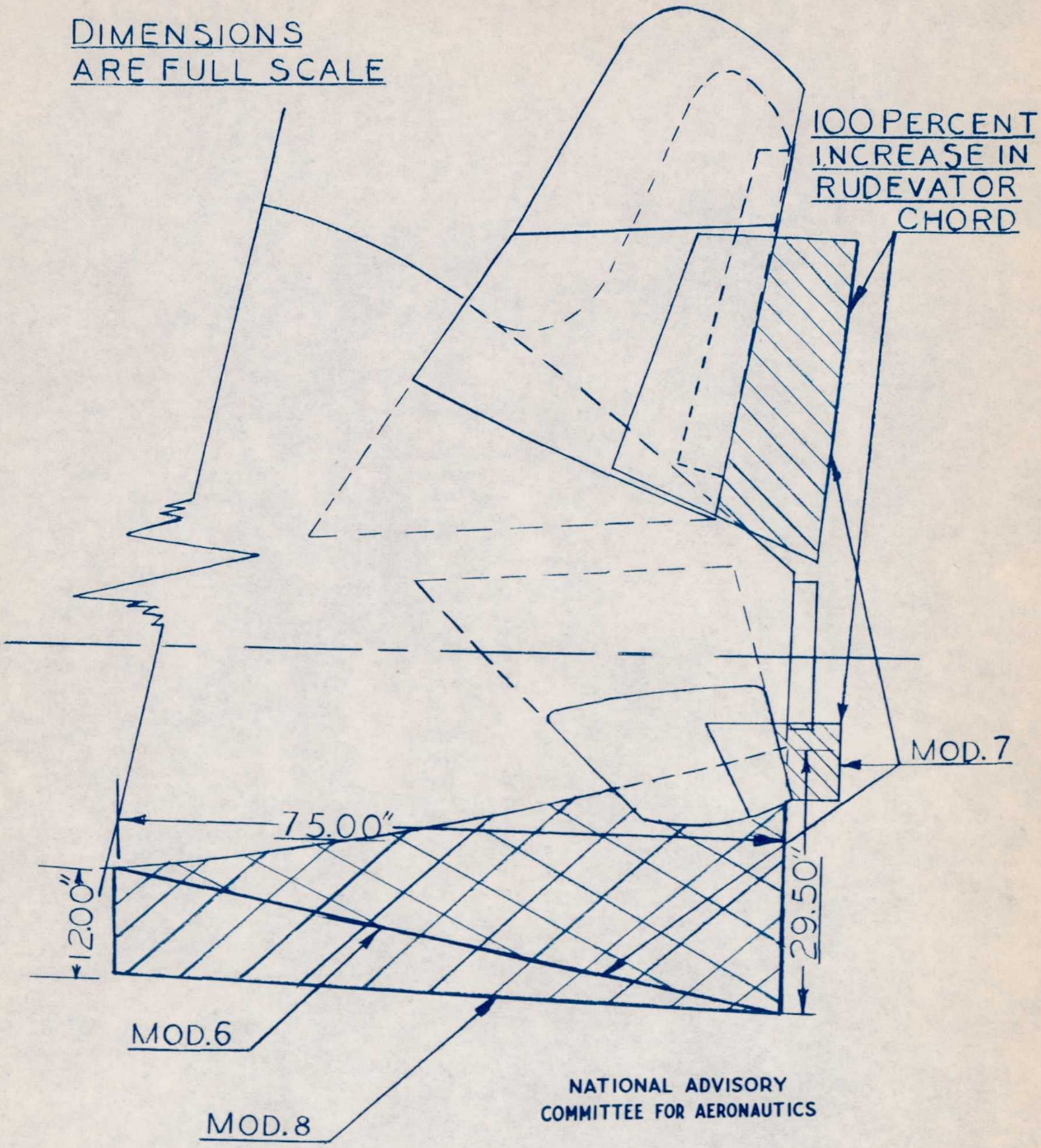


FIGURE 7.- VENTRAL FINS TESTED ON THE 1/16-SCALE MODEL OF THE XP-85 AIRPLANE

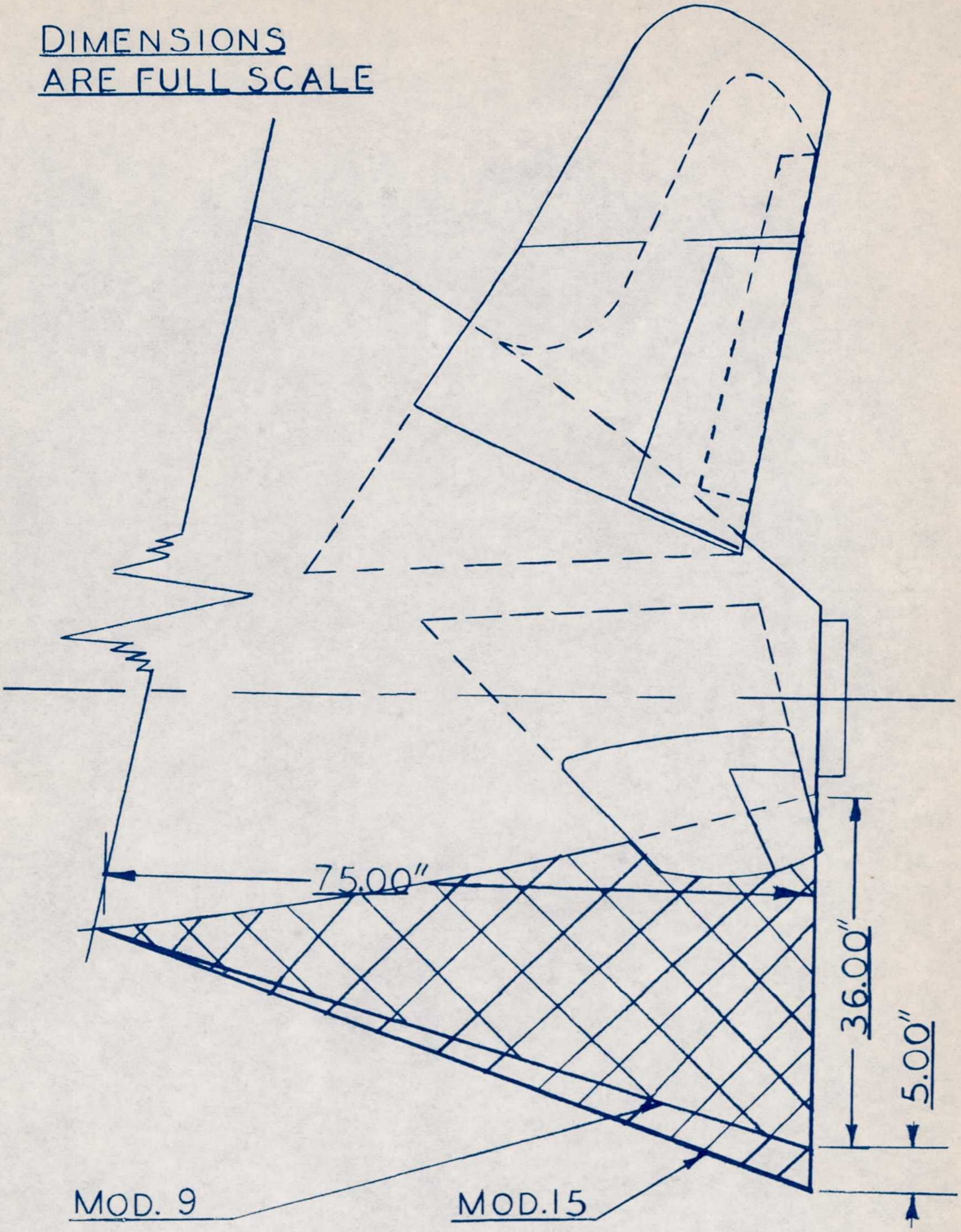


FIGURE 8. - VENTRAL FINS TESTED ON THE 1/16-SCALE MODEL OF THE XP-85 AIRPLANE

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

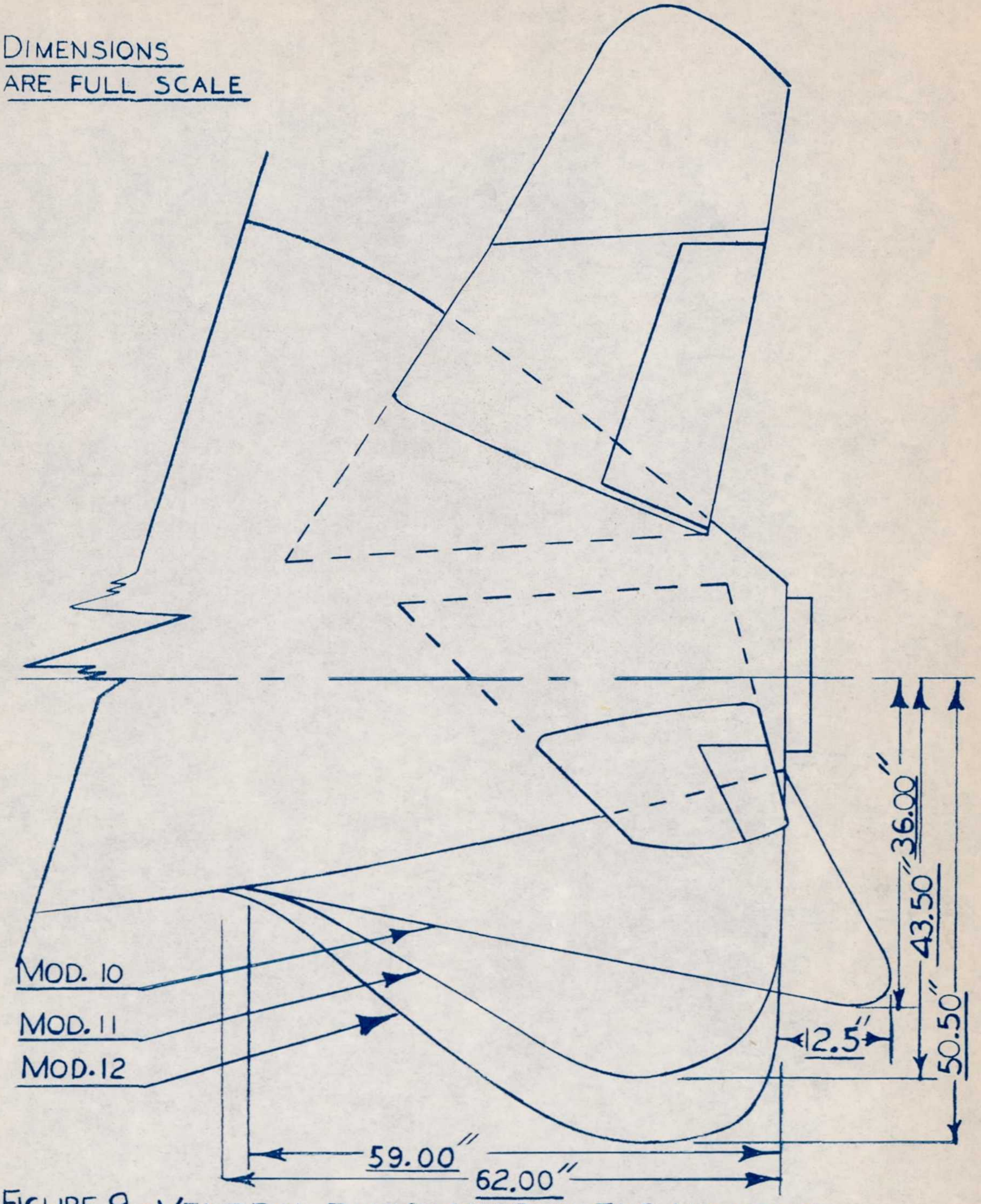


FIGURE 9.- VENTRAL FINS TESTED ON THE 1/16-SCALE MODEL OF THE XP-85 AIRPLANE.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

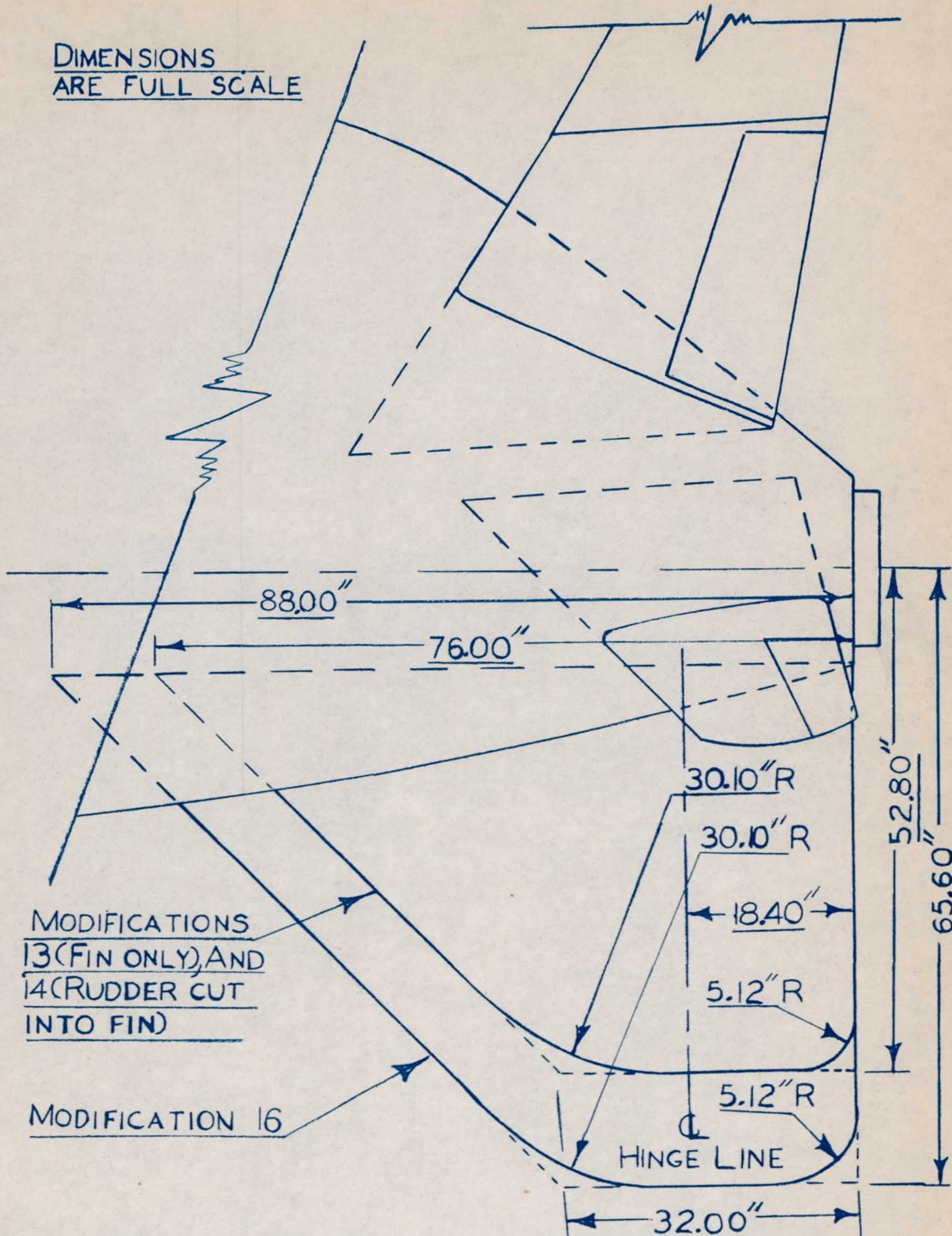


FIGURE 10.- VENTRAL FINS TESTED ON THE 1/16-SCALE MODEL OF THE XP-85 AIRPLANE.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

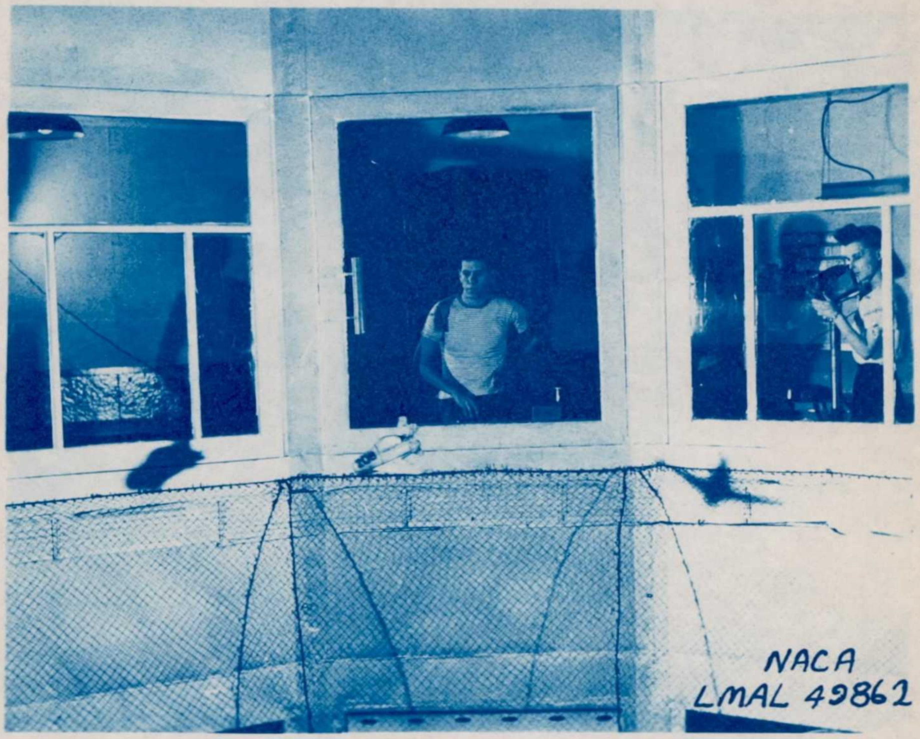


Figure 11.- Photograph of the $\frac{1}{16}$-scale model of the McDonnell XP-85 airplane spinning in the 20-foot free-spinning tunnel. Shadow of model at left shows approximate angle of attack and shadow of model at right shows approximate angle of wing tilt.

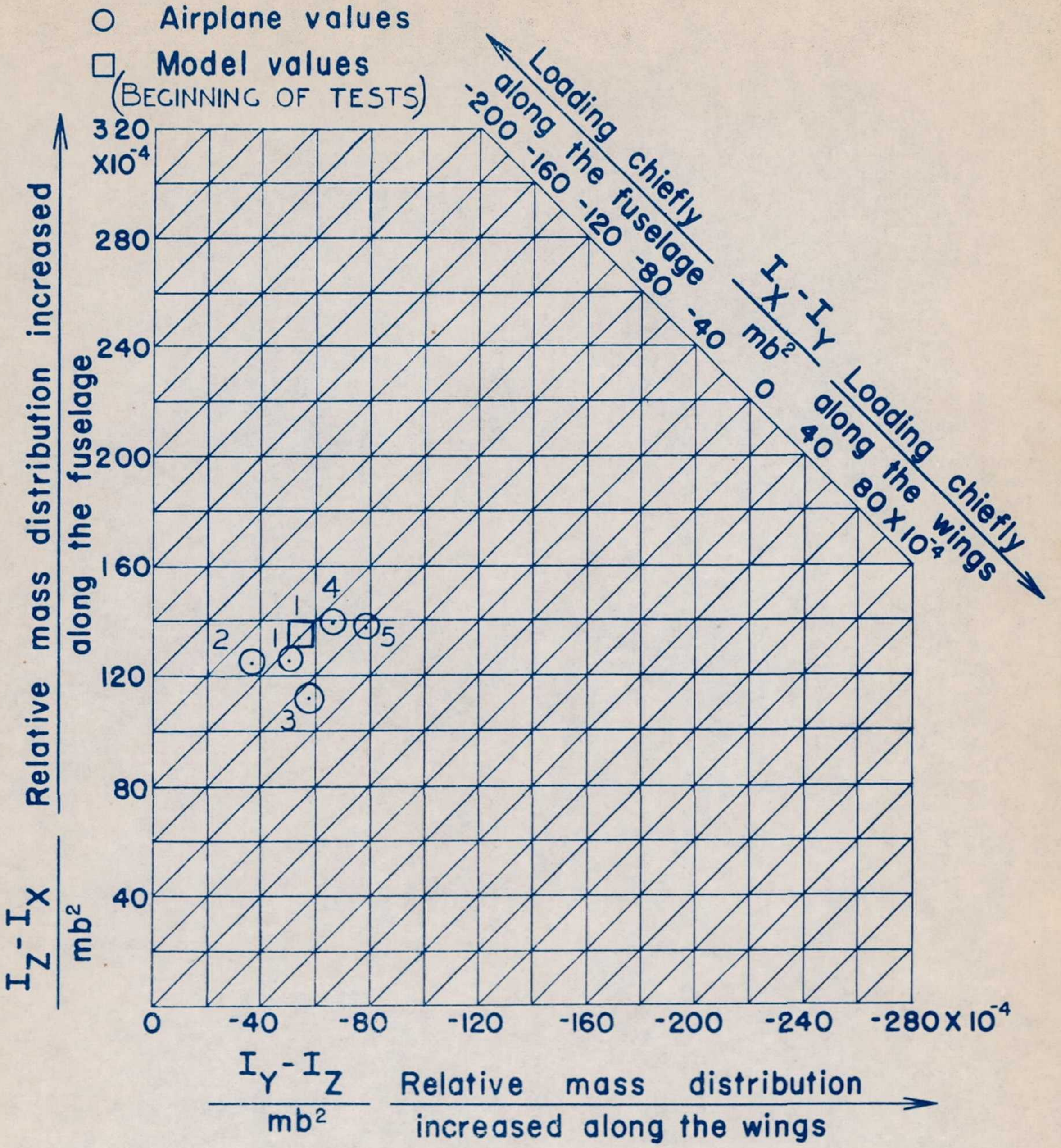


FIGURE 12.- MASS PARAMETERS FOR LOADINGS POSSIBLE ON THE XP-85 AIRPLANE AND FOR LOADING TESTED ON THE MODEL. (POINTS ARE FOR LOADINGS LISTED IN TABLE IV).

515

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

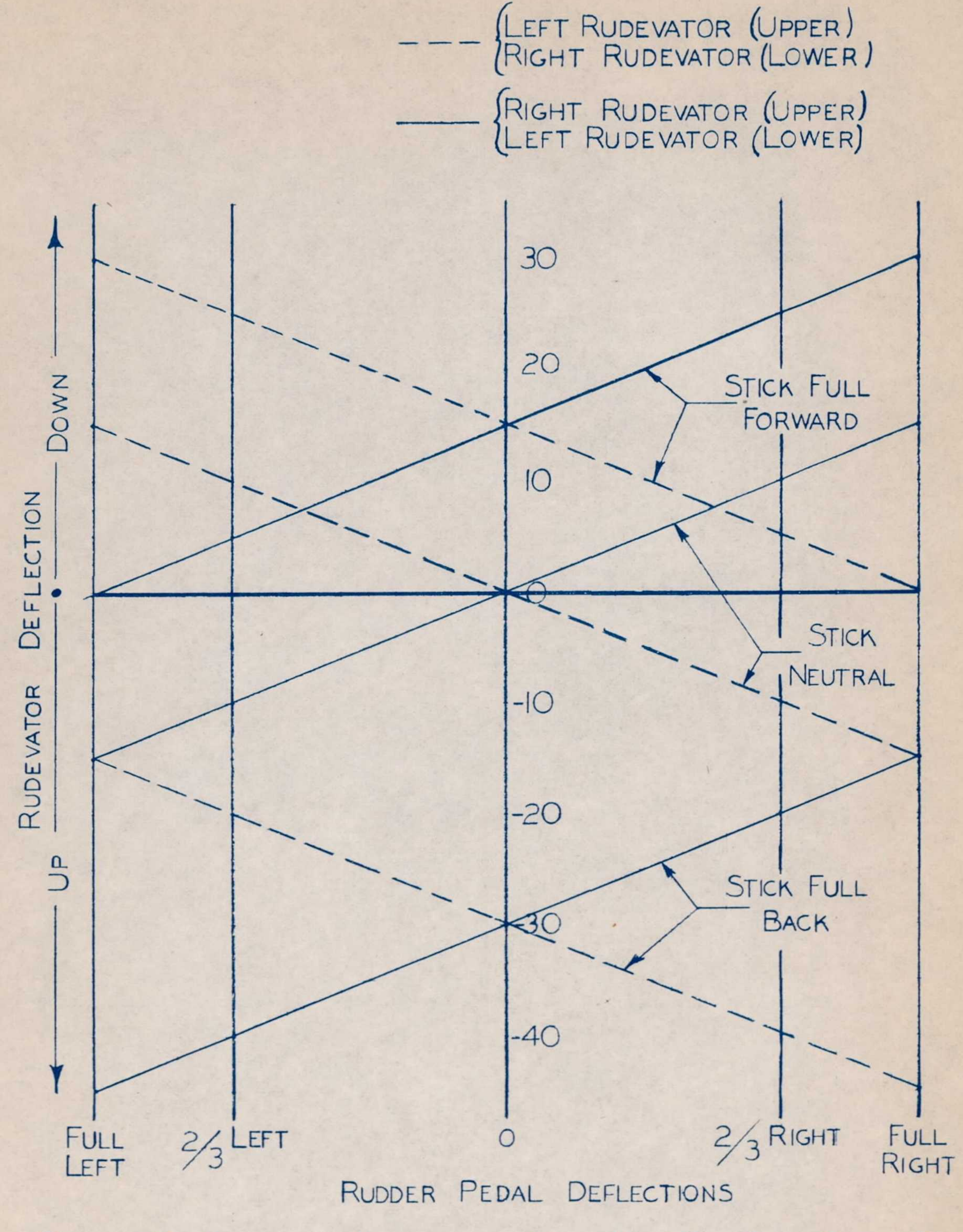


FIGURE 13.- RUDEVATOR DEFLECTIONS USED FOR THE SPIN TESTS OF THE 1/16-SCALE MODEL OF THE XP-85 AIRPLANE.

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS