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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

FREE-SPINNING-TUNNEL INVESTIGATION TO DETERMINE THE EFFECT OF TWO NOSE DESIGNS ON SPIN AND RECOVERY CHARACTERISTICS OF A $\frac{1}{20}$-SCALE MODEL OF THE MCDONNELL XF3H-1 AIRPLANE

TED NO. NACA DE 343

By Jack H. Wilson

Langley Aeronautical Laboratory
Langley Field, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
WASHINGTON
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FREE-SPINNING-TUNNEL INVESTIGATION TO DETERMINE THE EFFECT OF TWO NOSE DESIGNS ON SPIN AND RECOVERY CHARACTERISTICS OF A $\frac{1}{20}$-SCALE MODEL OF THE MCDONNELL XF3H-1 AIRPLANE

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SUMMARY

An investigation has been conducted in the Langley 20-foot free-spinning tunnel on a $\frac{1}{20}$-scale model to determine the effect of two alternate nose designs on the spin and recovery characteristics of the McDonnell XF3H-1 airplane.

The results of the investigation indicated that, in order to insure satisfactory recovery from any developed spin obtained in the airplane with either of the two alternate nose designs, it may be necessary to use ailerons deflected with the spin (stick right in a right spin) in conjunction with rudder reversal, as was the case for the original nose design.

INTRODUCTION

In accordance with the request of the Bureau of Aeronautics, Department of the Navy, tests have been performed in the Langley 20-foot free-spinning tunnel to determine the effect of two alternate nose designs on the spin and recovery characteristics of a $\frac{1}{20}$-scale model

[redacted]

of the McDonnell XF3H-1 airplane. Tests performed previously on the model with the original long sharp-pointed nose, installed as reported in reference 1, had indicated that use of ailerons might be necessary in conjunction with rudder reversal to insure recovery. Reference 1 also indicated a favorable effect on the model when the sharp nose of the fuselage was cut off. Inasmuch as a shorter blunter nose was under consideration for the production airplane, it was desired to determine if such a nose installation would give satisfactory recovery by normal use of controls (full rudder reversal followed by movement of elevator down).

SYMBOLS

b	wing span, feet
S	wing area, square feet
c	wing or elevator chord at any station along span
$\bar{c}$	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 reference line to mean aerodynamic chord (positive when center of gravity is below fuselage reference 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, slugs per cubic foot
μ	relative density of airplane, $\left(\frac{m}{\rho Sb}\right)$
α	angle between fuselage reference 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 3°.)

APPARATUS AND METHODS

Model

The $\frac{1}{20}$-scale model of the McDonnell XF3H-1 used for the tests of reference 1 was modified so that the original nose could be replaced by either of the two alternate nose shapes. The model was ballasted to maintain dynamic similarity to the airplane at an altitude of 19,000 feet (ρ = 0.001311 slug/cu ft). A three-view drawing of the model with the original nose installed is shown as figure 1. A comparison drawing of the original nose and the two alternate nose designs (noses 1 and 2) is shown as figure 2. The dimensional characteristics of the airplane are presented in table I.

Wind Tunnel and Testing Technique

The technique used for obtaining and converting data was the same as that used for the original XF3H-1 model tests (see reference 1).

PRECISION

The precision of the measurements made and of the data presented is believed to be the same as that listed in reference 1 except for the following model values which varied from the true scaled-down values within the following limits:

Weight	0 to 2 high
Center-of-gravity location, percent $\bar{c}$	0 to 2 rearward

TEST CONDITIONS

The mass characteristics and inertia parameters for loadings possible on the airplane and for the loading of the model during tests are shown in table II Tests of the model at the design gross-weight loading with either of the two alternate nose designs were made only for erect spins with flaps, landing gear, and slats retracted and with the horizontal tail set at an incidence of 0°.

As a means of expediting tests of the model, the spoilers, wing-tip skids, and wing stall-control vanes which are part of the basic design were not installed on the model for these tests since reference 1 indicated little effect of these items on the model spin and recovery characteristics.

The control deflections used in these tests were the same as those reported in reference 1.

RESULTS AND DISCUSSION

The results of the spin tests with the two alternate nose designs are presented in charts 1 and 2. The model data are presented in terms of the full-scale values for the airplane at a test altitude of 19,000 feet. Right and left spins were similar so that data for right spins only are arbitrarily presented in the charts.

Design Gross-Weight Loading

The results of erect-spin tests with either of the two alternate nose designs installed on the model indicated that with the elevator up and ailerons with the spin, the model spins were steep and recoveries were rapid by rudder reversal alone. With the elevator up and ailerons at neutral or against the spin two conditions were possible. Either the model motion was so oscillatory that the model would not spin or a relatively steep oscillatory spin was obtained from which recovery was not always satisfactory either by rudder reversal alone or by simultaneous reversal of rudder and elevator.

Reference 1 indicated the possibility of an additional condition with the original long nose installed on the XF3H-1 design - a flat-type oscillatory spin. The results of the present investigation indicate that, although installation of either of the alternate nose designs on the airplane eliminated the flat-type oscillatory spin, recovery by normal spin-recovery technique (full rudder reversal followed one-half turn later by movement of the elevator down) still would not always insure satisfactory recovery, and aileron movement with the spin might be required, as was the case for the long pointed nose design reported in reference 1. The elimination of the flat-type spin by installation of either of the alternate nose designs indicates a favorable effect of the installation of a shorter nose section. There is a possibility, however, that the difference between the results obtained for the original long nose design and the alternate shorter nose design might be due to scale effect. Because of the low Reynolds number of spin-tunnel tests, and since the drag coefficient increases with a decrease in Reynolds number, a corresponding much higher drag coefficient at high angles of attack on the nose section may lead to a flatter spin on the model than on the airplane. The results of reference 1 and of the current investigation indicate that with either of the three nose designs installed on the airplane, the recommended recovery technique will be the same.

Recommended Recovery Technique

Based on the results obtained with the model with either of the two alternate nose designs installed, the following recommendations similar to those of reference 1 are made as to recovery technique for erect spins. The rudder should be reversed briskly from full-with the spin to full-against the spin simultaneously with movement of the stick to with the spin laterally; approximately one-half turn later the stick should be moved forward longitudinally. Care should be exercised to avoid excessive rates of acceleration in the recovery dive.

CONCLUDING REMARKS

Results of tests of a $\frac{1}{20}$-scale model of the McDonnell XF3H-1 airplane to determine the spin and recovery characteristics of the airplane with either of two alternate nose designs installed at a spin altitude of 19,000 feet indicate that the motion of the airplane may be oscillatory in roll, yaw, and pitch and that the oscillation may become so violent that the airplane will oscillate out of the spin. On the other hand, an oscillatory spin may be maintained from which satisfactory recovery will be obtained provided the following technique is used:

brisk rudder reversal simultaneous with movement of the ailerons to with the spin (stick right in a right spin); one-half turn later, the stick should be moved forward longitudinally.

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Jack H. Wilson per am
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Aeronautical Research Scientist

Approved: Thomas A. Harris
Thomas A. Harris
Chief of Stability Research Division

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REFERENCE

1. Berman, Theodore: Free-Spinning-Tunnel Tests of a $\frac{1}{20}$-Scale Model of the McDonnell XF3H-1 Airplane - TED No. NACA DE 343. NACA RM SL50I12, Bur. Aero., 1950.

TABLE I.- DIMENSIONAL CHARACTERISTICS OF THE MCDONNELL XF3H-1 AIRPLANE

Length over all, feet:	
Original nose	59.4
Nose number 1	56.7
Nose number 2	56.1
Wing:	
Span, feet	35.3
Area, square feet	415.0
Sweepback at c/4, degrees	45
Incidence, degrees	2
Dihedral, degrees	0
Section (parallel to plane of symmetry):	
Root	NACA 0009-1.16 38/1.14 Modified
Tip	NACA 0007-1.16 38/1.14 Modified
Aspect ratio	3.0
Mean aerodynamic chord, inches	146.4
Leading edge of $\bar{c}$ rearward of leading edge of root chord, inches	104.2
Ailerons:	
Area, square feet (rearward of hinge)	17.4
Span, percent b/2	0.267
Hinge-line location, percent c	0.800
Horizontal tail:	
Total area, square feet	70.0
Span, feet	14.5
Sweepback at c/4, degrees	45
Elevator area rearward of hinge line, square feet	11.5
Distance from normal center of gravity to elevator hinge line at root, feet	25.14
Dihedral, degrees	0
Incidence, degrees	5.5 up, 15 down

TABLE I.- DIMENSIONAL CHARACTERISTICS OF THE MCDONNELL XF3H-1 AIRPLANE - Concluded

Vertical tail:	
Total area, square feet	45.4
Sweepback at c/4, degrees	45
Rudder area rearward of hinge line, square feet	11.3
Distance from normal center of gravity to rudder hinge line at root of rudder, feet	24.1
Unshielded rudder volume coefficient	0
Tail-damping ratio	0.0114
Tail-damping power factor	0

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TABLE II.- MASS CHARACTERISTICS AND INERTIA PARAMETERS FOR LOADING CONDITIONS POSSIBLE ON THE McDONNELL XF3H-1 AIRPLANE AND FOR THE LOADING TESTED ON THE $\frac{1}{20}$-SCALE MODEL

[Model values converted to corresponding full-scale values; moments of inertia are given about center of gravity.]

Number	Loading	Weight (lb)	μ		Center-of-gravity location		Moments of Inertia (slug-feet^2)			Mass Parameters		
			Sea level	19,000 ft	$x/\bar{c}$	$z/\bar{c}$	I_X	I_Y	I_Z	$\frac{I_X - I_Y}{mb^2}$	$\frac{I_Y - I_Z}{mb^2}$	$\frac{I_Z - I_X}{mb^2}$
Airplane Values												
1	Design gross weight	18,366	16.4	29.7	0.286	0.008	13,488	53,625	62,733	-565×10^{-4}	-128×10^{-4}	693×10^{-4}
2	Overload gross weight	20,256	18.1	32.8	.277	.012	15,192	54,244	65,067	-498	-138	636
3	Combat gross weight	18,468	16.5	29.9	.286	.007	13,463	53,698	62,839	-563	-128	691
Model Values												
1	Design gross weight	18,645	16.6	30.2	.300	.010	13,319	54,379	63,643	-569	-128	697

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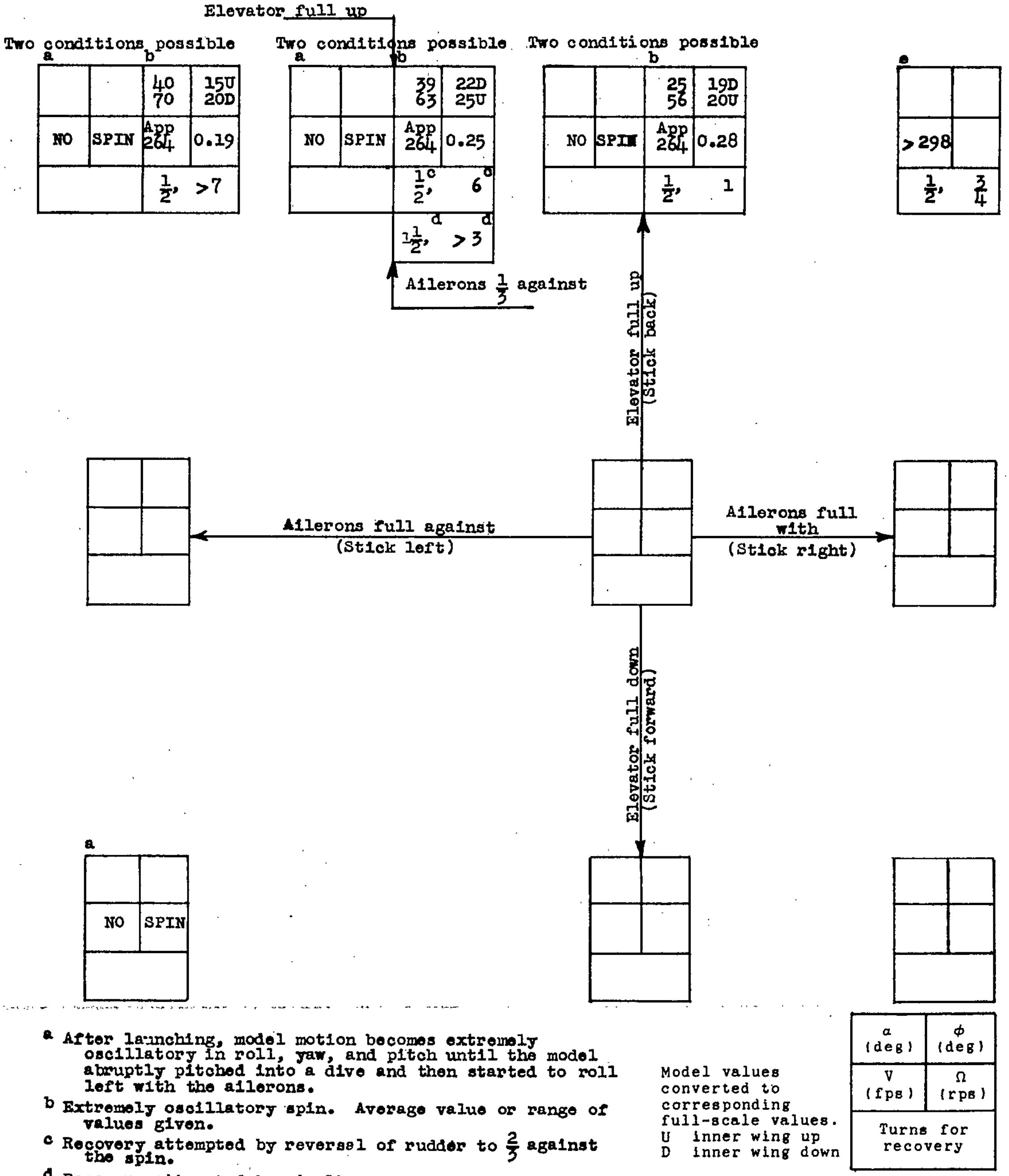
CHART 1.- SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{20}$-SCALE MODEL OF THE McDONNELL XF3H-1 AIRPLANE IN THE DESIGN GROSS-WEIGHT LOADING WITH NOSE NUMBER 1 INSTALLED ON THE MODEL

[Loading point 1 in table II; cockpit closed; landing gear and flaps retracted; recovery by rapid rudder reversal except as noted (recovery attempted from, and steady spin data presented for, rudder full-with spins); right erect spins]



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

[a] After launching, model motion becomes extremely oscillatory in roll, yaw, and pitch until the model abruptly pitched into a dive and then started to roll left with the ailerons.

[b] Extremely oscillatory spin. Average value or range of values given.

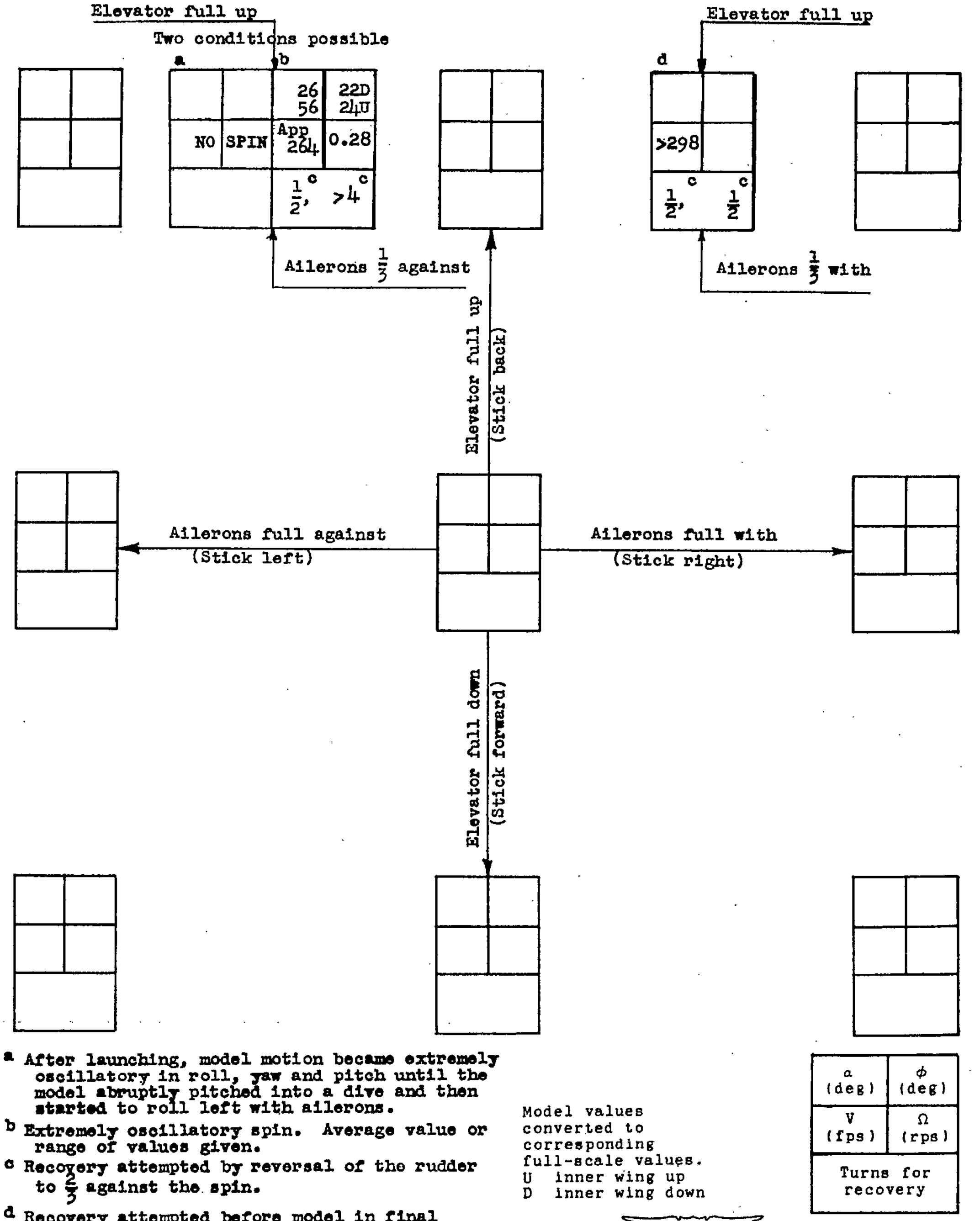
[c] Recovery attempted by reversal of rudder to $\frac{2}{3}$ against the spin.

[d] Recovery attempted by simultaneous movement of the rudder to $\frac{2}{3}$ against the spin and the elevator to $\frac{2}{3}$ down.

[e] Recovery attempted before model in steeper final attitude.

CHART 2.- SPIN AND RECOVERY CHARACTERISTICS OF THE $\frac{1}{20}$-SCALE MODEL OF THE McDONNELL XF3H-1 AIRPLANE IN THE DESIGN GROSS-WEIGHT LOADING WITH NOSE NUMBER 2 INSTALLED ON THE MODEL

[Loading point 1 on Table II; cockpit closed; landing gear and flaps retracted; recovery by full rudder reversal except as noted (recovery attempted from, and steady spin data presented for, rudder full-with spins); right erect spins]



[a] After launching, model motion became extremely oscillatory in roll, yaw and pitch until the model abruptly pitched into a dive and then started to roll left with ailerons.

[b] Extremely oscillatory spin. Average value or range of values given.

[c] Recovery attempted by reversal of the rudder to $\frac{2}{3}$ against the spin.

[d] Recovery attempted before model in final steeper attitude.

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

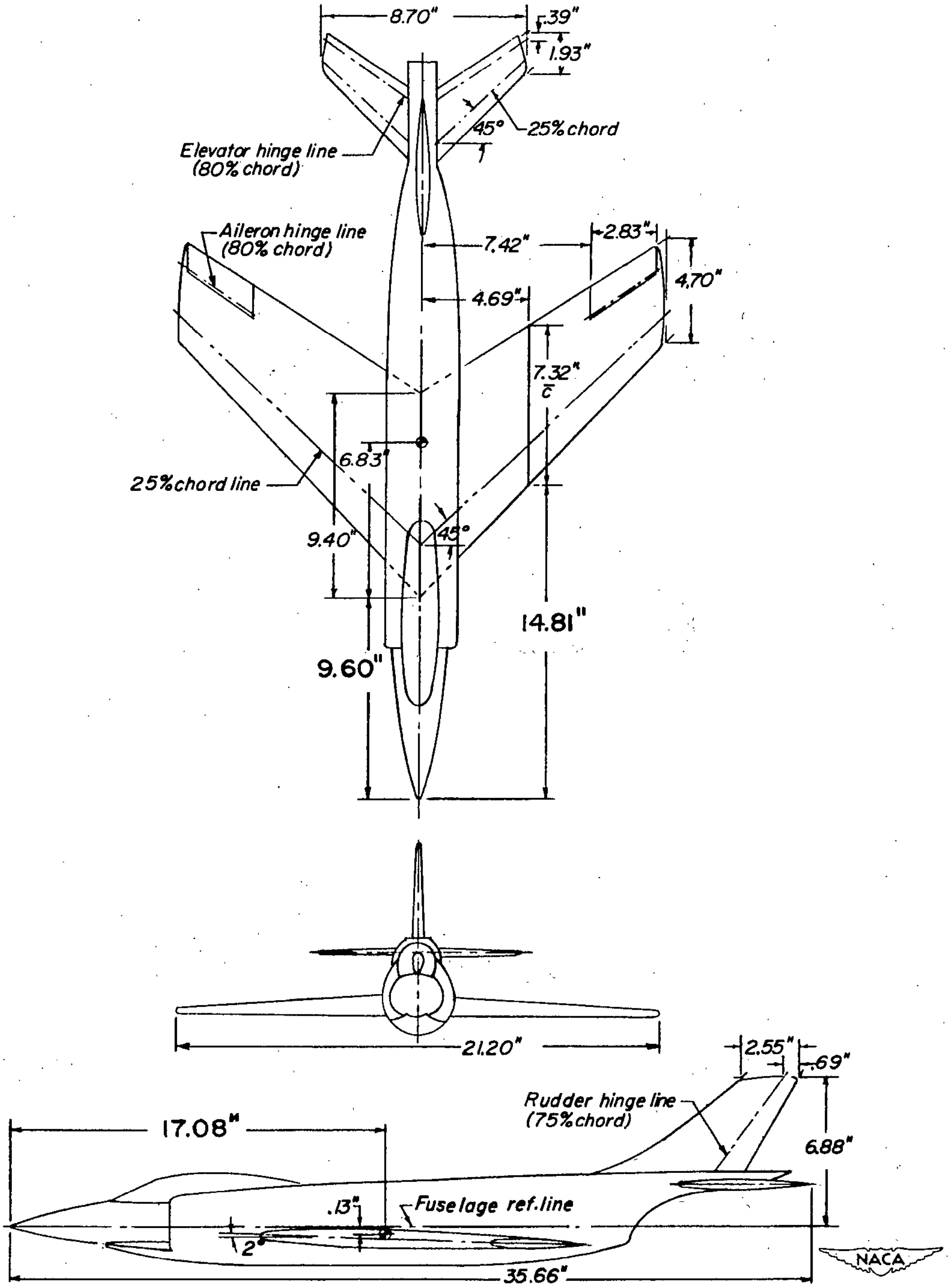


Figure 1.- Three-view drawing of the $\frac{1}{20}$ - scale model of the McDonnell XF3H-1 airplane with the original nose installed. Center-of-gravity location is shown for the design gross-weight condition. (Stall-control vanes and wing-tip skids are omitted.)

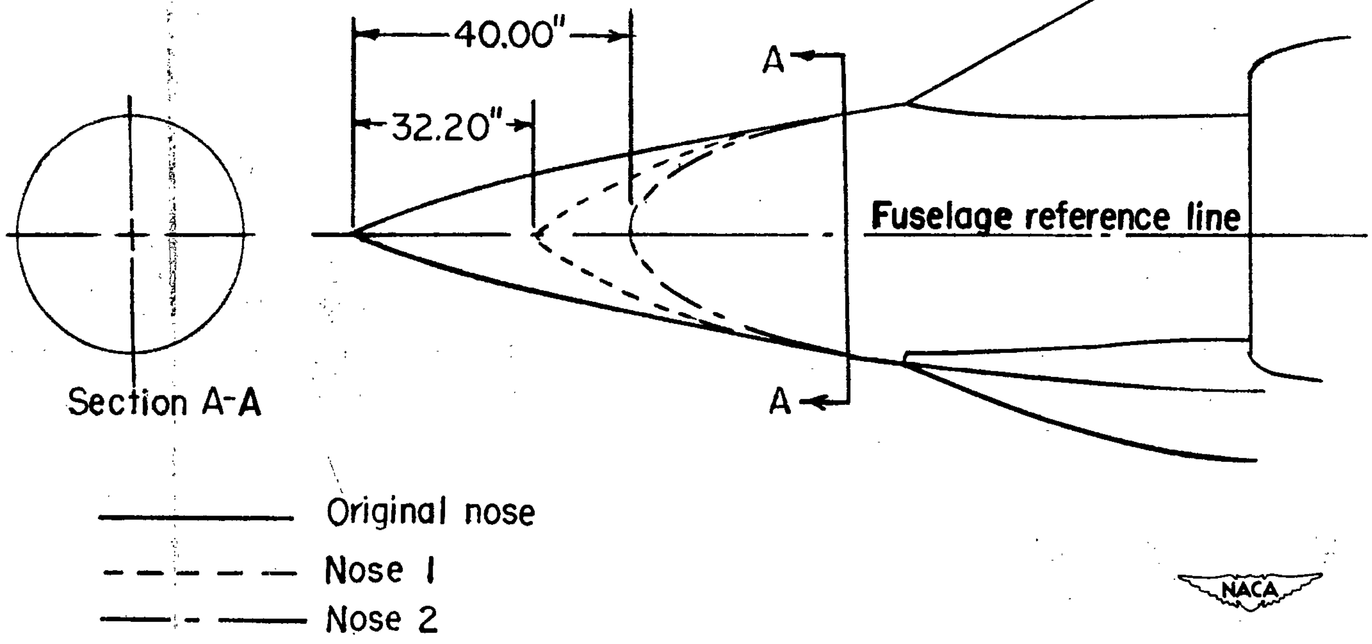


Figure 2.- Contours of original and alternate nose sections tested on $\frac{1}{20}$-scale model of the XF3H-1 airplane.

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