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
AUG 17 1951

CLASSIFIED DOCUMENT

This document contains classified information affecting the National Defense of the United States within the meaning of the Espionage Act, USC 5031 and 38. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law.

Information so classified may be imparted only to persons in the military and naval services of the United States, appropriate civilian officers and employees of the Federal Government who have a legitimate interest therein, and to United States citizens of known loyalty and discretion who of necessity must be informed thereof.

DECLASSIFIED AFTER 12 YEARS

DOE DIP 5922

CLASSIFICATION CANCELLED
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.
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
c̅ mean aerodynamic chord, feet
x/c ratio of distance of center of gravity rearward of leading edge of mean aerodynamic chord to mean aerodynamic chord

z/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

Ix, Iy, Iz moments of inertia about X, Y, and Z body axes, respectively, slug-feet²

\[
\frac{I_x - I_y}{m} \quad \text{inertia yawing-moment parameter}
\]

\[
\frac{I_y - I_z}{m} \quad \text{inertia rolling-moment parameter}
\]

\[
\frac{I_z - I_x}{m} \quad \text{inertia pitching-moment parameter}
\]
\( \rho \)  
air density, slugs per cubic foot

\( \mu \)  
relative density of airplane, \( \left( \frac{m}{\rho_{SB}} \right) \)

\( \alpha \)  
angle between fuselage reference line and vertical  
(approximately equal to absolute value of angle of attack at plane of symmetry), degrees

\( \phi \)  
angle between span axis and horizontal, degrees

\( v \)  
full-scale true rate of descent, feet per second

\( \Omega \)  
full-scale angular velocity about spin axis, revolutions per second

\( \sigma \)  
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 30°.)

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 (\( \rho = 0.001311 \text{ slug/cu ft} \)). 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 .......................... 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.

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

Approved: Thomas A. Harris
Chief of Stability Research Division

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
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 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

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertical tail:</td>
<td></td>
</tr>
<tr>
<td>Total area, square feet</td>
<td>45.4</td>
</tr>
<tr>
<td>Sweepback at c/4, degrees</td>
<td>45</td>
</tr>
<tr>
<td>Rudder area rearward of hinge line, square feet</td>
<td>11.3</td>
</tr>
<tr>
<td>Distance from normal center of gravity to rudder hinge line at root of rudder, feet</td>
<td>24.1</td>
</tr>
<tr>
<td>Unshielded rudder volume coefficient</td>
<td>0</td>
</tr>
<tr>
<td>Tail-damping ratio</td>
<td>0.0114</td>
</tr>
<tr>
<td>Tail-damping power factor</td>
<td>0</td>
</tr>
</tbody>
</table>
### TABLE II. - MASS CHARACTERISTICS AND INERTIA PARAMETERS FOR LOADING CONDITIONS POSSIBLE ON THE MCDONNELL XF3H-1 AIRPLANE AND FOR THE LOADING TESTED ON THE 1/20-SCALE MODEL

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

<table>
<thead>
<tr>
<th>Number</th>
<th>Loading</th>
<th>Weight (lb)</th>
<th>( \alpha )</th>
<th>Center-of-gravity Location</th>
<th>Moments of Inertia (slug-feet(^2))</th>
<th>Mass Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sea level 19,000 ft</td>
<td>( x/\delta )</td>
<td>( y/\delta )</td>
<td>( I_x )</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Airplane Values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Design gross weight</td>
<td>18,366</td>
<td>16.4</td>
<td>29.7</td>
<td>0.286</td>
<td>0.008</td>
</tr>
<tr>
<td>2</td>
<td>Overload gross weight</td>
<td>20,256</td>
<td>18.1</td>
<td>32.8</td>
<td>0.277</td>
<td>0.012</td>
</tr>
<tr>
<td>3</td>
<td>Combat gross weight</td>
<td>18,468</td>
<td>16.5</td>
<td>29.9</td>
<td>0.286</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>Model Values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Design gross weight</td>
<td>18,645</td>
<td>16.6</td>
<td>30.2</td>
<td>0.300</td>
<td>0.010</td>
</tr>
</tbody>
</table>
CHART 1: SPIN AND RECOVERY CHARACTERISTICS OF THE 1/20-SCALE MODEL OF THE McDONNELL XPSH-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 spin.

Elevator full up

<table>
<thead>
<tr>
<th>Two conditions possible</th>
<th>Two conditions possible</th>
<th>Two conditions possible</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>10 70 150 200</td>
<td>70 150 200 220</td>
</tr>
<tr>
<td>NO SPIN</td>
<td>264 0.19</td>
<td>NO SPIN</td>
</tr>
<tr>
<td>b</td>
<td>23 220 250 270</td>
<td>220 250</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt; 7</td>
<td>12 3</td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>23 220 250 270</td>
<td>220 250</td>
</tr>
<tr>
<td>b</td>
<td>12 3</td>
<td></td>
</tr>
</tbody>
</table>

Ailerons 1/3 against

Ailerons full against (Stick left)

Ailerons full with (Stick right)

Elevator full 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 1/3 against the spin.

d Recovery attempted by simultaneous movement of the rudder to 1/3 against the spin and the elevator to 1/3 down.

e Recovery attempted after model in steeper final attitude.

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

Turns for recovery

Model values

<table>
<thead>
<tr>
<th>a (deg)</th>
<th>( \phi ) (deg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V (fps)</td>
<td>( \Omega ) (rps)</td>
</tr>
</tbody>
</table>

NACA
**Chart 2. Spin and Recovery Characteristics of the 1/2-Scale Model of the McDonnell XF5H-1 Airplane in the Design Gross-Weight Loading with Nose Number 2 Installed on the Model**

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.

- **D**: Extremely oscillatory spin. Average value or range of values given.
- **C**: Recovery attempted by reversal of the rudder to 9/4 against the spin.
- **D**: Recovery attempted before model in final steeper attitude.

<table>
<thead>
<tr>
<th>Elevator full up</th>
<th>26</th>
<th>56</th>
<th>App 220</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO SPIN</td>
<td>25</td>
<td>56</td>
<td>0.28</td>
</tr>
<tr>
<td>Elevator full up</td>
<td>25</td>
<td>56</td>
<td>0.28</td>
</tr>
</tbody>
</table>

- **a**: Ailerons against
- **b**: Ailerons with

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

<table>
<thead>
<tr>
<th>(a) (deg)</th>
<th>(\phi) (deg)</th>
<th>(V) (fps)</th>
<th>(\Pi) (rps)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>(a)</th>
<th>(\phi)</th>
<th>(V)</th>
<th>(\Pi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90</td>
<td>254</td>
<td>0.28</td>
</tr>
<tr>
<td>1</td>
<td>45</td>
<td>254</td>
<td>0.28</td>
</tr>
</tbody>
</table>

**Note:**
- **Elevator full up**
- **No Spin**
- **App**
- **Stick Left**
- **Stick Right"
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 1/20-scale model of the XF3H-1 airplane.