NACA

RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

INTERIM REPORT ON FREE-SPINNING-TUNNEL INVESTIGATION OF A 1/25-SCALE MODEL OF THE McDONNELL F3H-1N AIRPLANE

TED NO. NACA AD 3100

By Henry A. Lee and L. Faye Wilkes

Langley Aeronautical Laboratory
Langley Field, Va.

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON

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SUMMARY

An investigation was conducted in the Langley 20-foot free-spinning tunnel on a 1/25-scale model of the McDonnell F3H-1N airplane. The effects of control settings and movements upon the erect and inverted spin and recovery characteristics of the model were determined for the clean condition. Spin-recovery parachute tests were also performed.

The results indicated that erect spins obtained on the airplane for the take-off or combat loadings should be satisfactorily terminated if full rudder reversal is accompanied by moving the ailerons to full with the spin (stick full right in a right spin). The spins obtained should be oscillatory in pitch, roll, and yaw. Recoveries from inverted spins should be satisfactory by full reversal of the rudder. A 16.7-foot-diameter tail parachute with a towline length of 30 feet and a drag coefficient of 0.734 should be adequate for emergency recovery from demonstration spins.

INTRODUCTION

Tests were performed in the Langley 20-foot free-spinning tunnel to determine the spin and recovery characteristics of a 1/25-scale model of the McDonnell F3H-1N airplane as requested by the Bureau of Aeronautics, Department of the Navy. The F3H-1N differs from the model of the XF3H-1 airplane previously investigated in the spin tunnel and reported in reference 1 primarily in that the F3H-1N has an all-movable horizontal tail instead of elevators and the ailerons have been moved from the outboard spanwise position to an inboard position.

The present paper is an interim report and presents only the erect and inverted spin and recovery characteristics of the F3H-1N model for the clean condition and the results of the parachute-recovery tests.

SYMBOLS

b	wing span, ft
S	wing area, sq ft
$\bar{c}$	mean aerodynamic chord, ft
$x/\bar{c}$	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 line)
m	mass of airplane, slugs
I_X, I_Y, I_Z	moments of inertia about X, Y, and Z body axes, respectively, slug-ft^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/cu ft
μ	relative density of airplane, $\frac{m}{\rho S b}$
α	angle between fuselage reference line and vertical (approximately equal to absolute value of angle of attack at plane of symmetry), deg

ϕ angle between span axis and horizontal, deg

V full-scale true rate of descent, ft/sec

Ω full-scale angular velocity about spin axis, rps

MODEL AND TEST CONDITIONS

The 1/25-scale model of the McDonnel F3H-1N airplane was furnished by the Bureau of Aeronautics, Department of the Navy, and was prepared for testing by the Langley Aeronautical Laboratory of the National Advisory Committee for Aeronautics. A three-view drawing of the model as tested is shown in figure 1. A photograph of the model is shown in figure 2. The dimensional characteristics of the airplane are presented in table I. Longitudinal control was provided by means of an all-movable tail.

The model was ballasted to obtain dynamic similarity to the airplane at an altitude of 20,000 feet (ρ = 0.001267 slug/cu ft). The mass characteristics and inertia parameters for loadings possible on the airplane and for the loading tested on the model are indicated in table II.

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

The maximum control deflections used in the tests were:

Rudder, deg . . . . 30 right, 30 left
Stabilizer incidence, deg . . 7.5 leading edge up, 17 leading edge down
Ailerons, deg . . . . 40 up, 20 down

An appendix is included which presents a general description of the model testing technique, the precision with which model test results and mass characteristics are determined, variations of model mass characteristics occurring during tests, and a general comparison between model and airplane results.

RESULTS AND DISCUSSION

The results of the spin tests of the model in the take-off loading (loading 1 in table II) are presented in charts 1 and 2 and in table III. In the charts and in table III, the horizontal tail is referred to as an elevator for convenience (elevator up, for instance, indicates that the trailing edge of the horizontal tail is up). Because of the similarity of the take-off and combat-loading (loading 2 in table II) conditions, the results presented herein are considered applicable to both. The model data are presented in terms of the full-scale values for the airplane at a test altitude of 20,000 feet. Inasmuch as the results to the right and left were generally similar, the data are arbitrarily presented in terms of right spins.

Erect Spins

The results of erect-spin tests of the model are shown in chart 1. Because of the wandering or oscillatory nature of the model motion or because of the high rate of descent, the model could be maintained in the tunnel only for short periods. Selected frames from motion-picture films of the motion of the model after being launched into the tunnel with the rudder set to maintain the spin and also of the model recoveries are shown in figures 3 to 7.

The results of the model tests indicate that, when the rudder is deflected full with the spin, generally a wandering spin oscillatory in pitch, roll, and yaw may persist on the airplane or the oscillations may become so extreme that the airplane may oscillate out of the spin without control movement. For aileron full-with settings, however, the airplane should not spin for stick positions full back and longitudinally neutral. Results of model tests indicate that, because of the oscillatory nature of the spins, recovery may not always be satisfactorily terminated by full rudder reversal (based on the results obtained for the criterion spin as explained in the appendix), but that satisfactory recoveries should be consistently obtained by full rudder reversal accompanied by aileron movement to full with the spin. It is recommended that this latter recovery technique be employed to insure satisfactory recoveries on the airplane. In order to reduce the possibility of recovering in an aileron roll when the ailerons are moved to full with the spin for recovery, model results indicate that the stick should be kept at or near full back until the spin rotation ceases, at which time it should be moved forward to regain normal flight. If the stick is moved forward prematurely and an aileron roll results or if an aileron roll should be obtained with stick full back, this motion should be quickly terminated by neutralization of the ailerons.

Inverted Spins

The results of the inverted-spin tests of the model are presented in chart 2. The order used 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 shown on the right of the chart and "stick back" is shown at the bottom. When the controls are crossed in the developed spin, the ailerons aid the rolling motion; when 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.

With the stick laterally neutral model results indicate that very steep spins should be obtained on the airplane and that, with controls crossed for the inverted spin, the airplane should not spin. Controls together should be the control settings most conducive to inverted spins, and the spins obtained for these control settings should be oscillatory in pitch, roll, and yaw. Model results indicate that mere neutralization of the rudder will not be sufficient for satisfactory recoveries from inverted spins on the airplane; to insure satisfactory recoveries it is recommended that the rudder be fully reversed.

Spin-Recovery Parachutes

The results of tests performed with spin-recovery parachutes attached on the bottom of the fuselage 2 feet (full-scale) ahead of the most rearward point are presented in table III. Model test results indicate that emergency spin recoveries from erect spins should be satisfactorily obtained on the airplane by opening a 16.7-foot-diameter (full-scale, laid-out-flat) parachute with a 30-foot towline and a drag coefficient of 0.734 (based on the laid-out-flat diameter).

Landing Condition

Current military specifications require airplanes to be spin demonstrated in the landing condition from only a 1-turn (or incipient) spin, and inasmuch as spin-tunnel test data are obtained for fully developed spins, the landing condition was not investigated on the model. Recovery characteristics in the landing condition may be of significant importance, however, because stall tests of an airplane, generally made at altitude in the landing condition early during the flight test program, may result in an inadvertent spin. An analysis of the results of tests with many models to determine the effect of landing gear and flaps (ref. 2) indicates that, although recoveries from fully developed spins may be unsatisfactory, the F3H-1N airplane should recover satisfactorily from an incipient spin in the landing condition. Therefore, if a spin is inadvertently entered in the landing condition at any time, the flaps and landing gear should be retracted and recovery should be attempted immediately.

CONCLUSIONS

Based on the results of spin tests of a 1/20-scale model of the McDonnell F3H-1N airplane, the following conclusions regarding the spin and recovery characteristics of the airplane in the combat and take-off loadings of a spin test altitude of 20,000 feet are made:

1. The erect spins obtained on the airplane will be wandering and oscillatory in pitch, roll, and yaw. The oscillations may become so violent that the airplane will oscillate out of the spin without movement of the controls. Satisfactory recoveries will be obtained by full rudder reversal accompanied by simultaneous movement of the ailerons to full with the spin (stick full right in a right spin).

2. Satisfactory recoveries from inverted spins will be obtained by full rudder reversal.

3. A 16.7-foot-diameter tail parachute with a towline 30.0 feet long and a drag coefficient of 0.734 should be satisfactory for emergency recoveries from demonstration spins.

4. If a spin is inadvertently entered in the landing condition at any time, the flaps and landing gear should be retracted and recovery should be attempted immediately.

Langley Aeronautical Laboratory,
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APPENDIX

TEST METHODS AND PRECISION

Model Testing Technique

The operation of the Langley 20-foot free-spinning tunnel is generally similar to that described in reference 3 for the Langley 15-foot free-spinning tunnel except that the model-launching technique is different. With the controls set in the desired position, a model is launched by hand with rotation into the vertically rising air stream. After a number of turns in the established spin, a recovery attempt is made by moving one or more controls by means of a remote-control mechanism. After recovery, the model dives into a safety net. The tests are photographed with a motion-picture camera. The spin data obtained from these tests are then converted to corresponding full-scale values by methods described in reference 3.

Spin-tunnel tests are usually performed to determine the spin and recovery characteristics of a model for the normal spinning-control configuration (elevator full up, lateral controls neutral, and rudder full with the spin) and for various other lateral control and elevator combinations including neutral and maximum settings of the surfaces. Recovery is generally attempted by rapid full reversal of the rudder, by rapid full reversal of both rudder and elevator, or by rapid full reversal of the rudder with ailerons moved simultaneously to full with the spin. The particular control manipulation required for recovery is generally dependent on the mass and dimensional characteristics of the model (refs. 4 and 5). Tests are also performed to evaluate the possible adverse effects on recovery of small deviations from the normal control configuration for spinning. For these tests, the elevator is set at either full up or two-thirds of its full-up deflection and the lateral controls are set at one-third of full deflection in the direction conducive to slower recoveries, which may be either against the spin (stick left in a right spin) or with the spin, depending primarily on the mass characteristics of the particular model. Recovery is attempted by rapidly reversing the rudder from full with the spin to only two-thirds against the spin, by simultaneous rudder reversal to two-thirds against the spin, and movement of the elevator to either neutral or two-thirds down, or by simultaneous rudder reversal to two-thirds against the spin and lateral stick movement to two-thirds of its full deflection in the favorable direction (with the spin for the present model). This control configuration and manipulation is referred to as the "criterion spin," with the particular control settings and manipulation used being dependent on the mass and dimensional characteristics of the model.

Turns for recovery are measured from the time the controls are moved to the time the spin rotation ceases. Recovery characteristics of a model are generally considered satisfactory if recovery attempted from the criterion spin in any of the manners previously described is accomplished within $2\frac{1}{4}$ turns. This value has been selected on the basis of full-scale-airplane spin-recovery data that are available for comparison with corresponding model test results.

For spins in which a model has a rate of descent in excess of that which can readily be obtained in the tunnel, the rate of descent is recorded as greater than the velocity at the time the model hit the safety net; for example, >300 feet per second, full scale. In such tests, the recoveries are attempted before the model reaches its final steeper attitude and while it is still descending in the tunnel. Such results are considered conservative; that is, recoveries are generally not as fast as when the model is in the final steeper attitude. For recovery attempts in which a model strikes the safety net while it was still in a spin, the recovery is recorded as greater than the number of turns from the time the controls were moved to the time the model struck the net, as >3. A >3-turn recovery, however, does not necessarily indicate an improvement over a >7-turn recovery. When a model recovers without control movement (rudder held with the spin), the results are recorded as "no spin."

For spin-recovery parachute tests, the minimum-size tail parachute required to effect recovery within $2\frac{1}{4}$ turns is determined. The parachute is opened for the recovery attempts by actuating the remote-control mechanism and the rudder is held with the spin so that recovery is due to the parachute action alone. The folded spin-recovery parachute is placed on the model in such a position that it does not seriously influence the established spin. A rubber band holds the packed parachute to the model and when released allows the parachute to be blown free of the model. On full-scale parachute installations it is desirable to mount the parachute pack within the airplane structure, if possible, and it is recommended that a mechanism be employed for positive ejection of the parachute.

Precision

Results determined in free-spinning tunnel tests are believed to be true values given by models within the following limits:

α, deg	±1
ϕ, deg	±1
V, percent	±5
Ω, percent	±2
Turns for recovery obtained from motion-picture records	$\pm\frac{1}{4}$
Turns for recovery obtained visually	$\pm\frac{1}{2}$

The preceding limits may be exceeded for certain spins in which it is 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.

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

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

Controls are set with an accuracy of ±1°.

Variations in Model Mass Characteristics

Because it is impracticable to ballast models exactly and because of inadvertent damage to models during tests, the measured weight and mass distribution of the F3H-1N model varied from the true scaled-down values within the following limits:

Weight, percent	0 to 1 high
Center-of-gravity location, percent $\bar{c}$	0 to 2 rearward
Moments of inertia:	
I_X, percent	4 high to 0
I_Y, percent	3 high to 6 high
I_Z, percent	3 high to 7 high

Comparison Between Model and Airplane Results

Comparison between model and full-scale results in reference 6 indicated that model tests accurately predicted full-scale recovery characteristics approximately 90 percent of the time and that for the remaining 10 percent of the time, the model results were of value in predicting some of the details of the full-scale spins, such as motions in the developed spin and proper recovery techniques. The airplanes generally spun at an angle of attack closer to 45° than did the corresponding models.

The comparison presented in reference 6 also indicated that generally the airplanes spun with the inner wing tilted more downward and with a greater altitude loss per revolution than did the corresponding models, the higher rate of descent of airplane or model, however, being generally associated with the smaller angle of attack.

REFERENCES

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2. Gale, Lawrence J.: Effect of Landing Flaps and Landing Gear on the Spin and Recovery Characteristics of Airplanes. NACA TN 1643, 1948.

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4. Neihouse, A. I.: A Mass-Distribution Criterion for Predicting the Effect of Control Manipulation on the Recovery from a Spin. NACA WR L-168, 1942. (Formerly NACA ARR, Aug. 1942).

5. Neihouse, Anshal I., Lichtenstein, Jacob H., and Pepoon, Phillip W.: Tail-Design Requirements for Satisfactory Spin Recovery. NACA TN 1045, 1946.

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TABLE I.- DIMENSIONAL CHARACTERISTICS OF THE

McDONNELL F3H-1N AIRPLANE

Overall length, ft	58.81
Wing:	
Span, ft	35.33
Area, sq ft	442.0
Root chord, in.	197.0
Tip chord, in.	103.0
Incidence, deg	2.0
Taper ratio	0.523
Aspect ratio	2.82
Sweepback at 1/4 chord, deg	45.0
Dihedral, deg	0
Mean aerodynamic chord, in.	155.0
Leading edge $\bar{c}$ aft leading-edge root chord, in.	105.50
Trailing-edge flaps:	
Total area, sq ft	29.55
Span, percent of b/2	25.43
Aileron:	
Total area, aft of hinge line, sq ft	32.81
Span, percent of b/2	34.00
Horizontal tail surface (all moveable):	
Total area, sq ft	82.49
Span, ft	15.75
Sweepback at 1/4 chord, deg	45.0
Distance from take-off loading center of gravity to intersection of the horizontal-tail hinge line and fuselage center line, ft	25.56
Vertical tail surfaces:	
Total area, sq ft	48.20
Rudder area, aft of hinge line, sq ft	11.30
Sweepback at 1/4 chord, deg	45.0
Distance from take-off loading center of gravity to intersection of rudder hinge line and the theoretical tip of the vertical tail, ft	29.51
Tail-damping power factor	0

TABLE II.- MASS CHARACTERISTICS AND INERTIA PARAMETERS FOR LOADINGS POSSIBLE ON THE McDONNELL F3H-1N AIRPLANE AND FOR THE LOADING TESTED ON THE 1/25-SCALE MODEL

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

No.	Condition	Weight, lb	Center-of-gravity location		Relative density μ		Moments of inertia, slug-ft^2			Mass parameters		
			$x/\bar{c}$	$z/\bar{c}$	Sea level	20,000 ft	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	Take-off (gear up)	29,054	0.299	0.120	24.32	45.64	18,344	81,395	93,261	-557×10^{-4}	-105×10^{-4}	662×10^{-4}
2	Combat (gear up)	25,442	0.310	0.115	21.29	39.96	16,146	78,355	88,198	-628	-99	727
3	Landing (gear down)	21,518	0.295	0.110	18.00	33.79	17,018	75,669	85,656	-700	-119	819
Model values												
1	Take-off (gear up)	29,009	0.299	0.064	24.27	45.55	19,035	83,653	95,728	-575	-107	682

TABLE III.- SPIN-RECOVERY TAIL-PARACHUTE DATA OBTAINED

WITH THE 1/25-SCALE MODEL OF THE McDONNEL F3H-1N AIRPLANE

[Take-off loading (loading point 1 in table II); ailerons set to neutral and elevator set at 17° up; recovery attempted by opening the parachute with the rudder maintained full with the spin; model values converted to corresponding full-scale values; drag coefficient of parachutes 0.734; right erect spins]

Parachute diameter, ft	Towline length, ft	Ailerons	Turns for recovery
13.5	30	Neutral	$\frac{1}{2}$, 1, 2, $>1\frac{1}{2}$, >4
14.6	30	Neutral	$\frac{3}{4}$, 1, 1, $1\frac{3}{4}$, $>2\frac{1}{2}$
15.6	30	Neutral	1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{1}{2}$, >4
16.7	30	Neutral	$\frac{1}{4}$, $\frac{3}{4}$, 1, 1, $1\frac{1}{2}$, $1\frac{1}{2}$, 2

CHART 1.- ERECT SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Loading point 1 on table II; landing gear retracted; recovery attempted by rudder reversal and aileron movement to full with the spin, except as indicated; right erect spins]

A high-velocity wandering spin oscillatory in roll, yaw, and pitch sometimes persists. Vertical velocity > 333. (See fig. 3.) Sometimes because of the roll-yaw oscillations model recovers without control movement in a roll or dive, or appears to make a few turns in an inverted spin. (See fig. 4.)

$\frac{1}{2}$ Recovers in a dive (See fig. 5.)

$\frac{1}{2}$ Recovers in a dive

Rudder reversal { $\frac{1}{2}$, >2; 2 Recovery attempted before model reached final spin attitude

A high-velocity wandering spin oscillatory in roll yaw, and pitch sometimes persists. Vertical velocity > 333.
Sometimes because of the roll-yaw oscillations model rolls inverted in the direction of the aileron setting without control movement.

Rudder reversed to 2/3 against the spin and ailerons reversed 1/3 with the spin { $\frac{3}{4}$ Recovers in a dive; $1\frac{1}{4}$ Recovery attempted before model reached final spin attitude. Recovers in a dive.

Rudder reversed to $\frac{2}{3}$ against the spin. { 1, $2\frac{1}{4}$, >3; $3\frac{1}{4}$ Recovery attempted before model reached final spin attitude.

A high-velocity wandering spin oscillatory in roll, yaw, and pitch sometimes persists. *Vertical velocity > 333. (See fig. 6.)* Sometimes because of the roll-yaw oscillations model dives out of spin without control movement.

No recovery attempted.

After launching rotation ceases, the model recovers in a glide or spiral. (See fig. 7.)

After launching, model motion becomes increasingly oscillatory in roll and yaw until model rolls out of the spin inverted in the direction of the aileron setting.

A high-velocity wandering spin oscillatory in roll, yaw, and pitch sometimes persists. Vertical velocity approximately 333. Sometimes because of the roll-yaw oscillations model dives out of spin without control movement.

$\frac{3}{4}$ Recovers in a dive.

1 Recovery attempted before model reached final spin attitude. Recovers in a vertical aileron roll.

$1\frac{1}{2}$ Recovers in vertical aileron roll.

Rudder reversal $\frac{1}{2}$, 2, $3\frac{1}{4}$

After launching rotation ceases, model whips, then recovers in a dive.

After launching, model motion becomes increasingly oscillatory in roll and yaw until model rolls out of the spin inverted in the direction of the aileron setting.

A high-velocity wandering spin oscillatory in roll, yaw, and pitch sometimes persists. Vertical velocity approximately 333. Sometimes because of the roll-yaw oscillations model dives out of spin without control movement.

$\frac{1}{2}$ Recovers in vertical aileron roll.

1 Recovery attempted before model reached final spin attitude. Recovers in vertical aileron roll.

A steep wandering and oscillatory spin sometimes persists. At times a very steep spin or steep aileron roll is obtained. Vertical velocity > 333.

Rudder reversal { $\frac{1}{2}$ Recovers in an aileron roll. $\frac{3}{4}$ Recovers in an aileron roll.

Key to control settings

Ail. against Elev. up	Ail. $\frac{1}{3}$ against Elev. $\frac{2}{3}$ up	Ail. neutral Elev. up	Ail. with Elev. up
Ail. against Elev. neutral		Ail. neutral Elev. neutral	Ail. with Elev. neutral
Ail. against Elev. down		Ail. neutral Elev. down	Ail. with Elev. down

Legend

Description of model motion with rudder set to maintain spin.
Turns for recovery. Recovery attempted by simultaneous movement of ailerons to full with the spin and rudder reversal to full against the spin unless otherwise noted.

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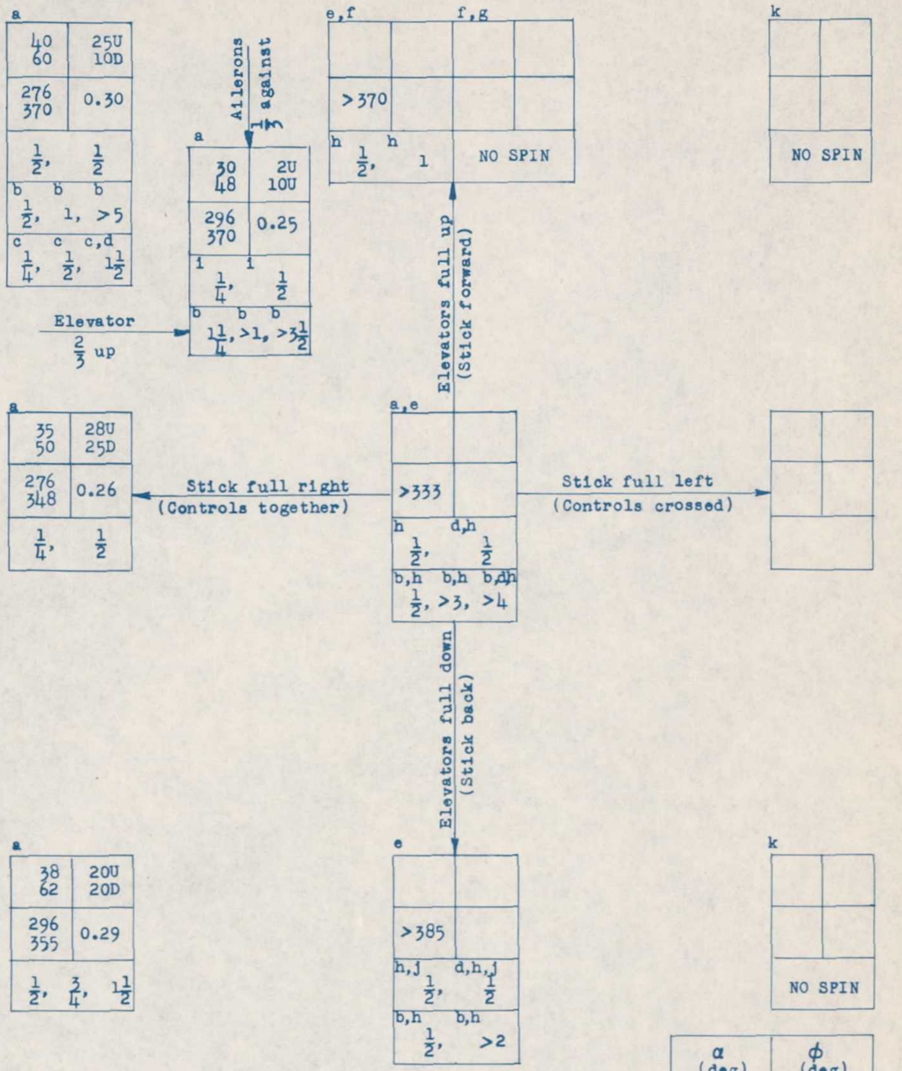
CHART 2.- INVERTED SPIN AND RECOVERY CHARACTERISTICS OF THE MODEL

[Take-off loading (point 1 on table II); recovery attempted by rapid full rudder reversal except as indicated (recovery attempted from, and steady-spin data presented for, rudder-full-with spins); model rotation to the pilot's right]



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

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

[a]Oscillatory spin, range or average values given.

[b]Recovery attempted by moving rudder from full with to neutral.

[c]Recovery attempted by reversing rudder from full with to 10° against.

[d]Visual estimate.

[e]Steep spin.

[f]Two conditions possible.

[g]Model goes into a steep dive.

[h]Recovery attempted before model in final steep attitude.

[i]Recovery attempted by reversing rudder from full with to $\frac{2}{3}$ against the spin.

[j]Model goes into erect spin in opposite direction upon recovery.

[k]Model goes into a roll.

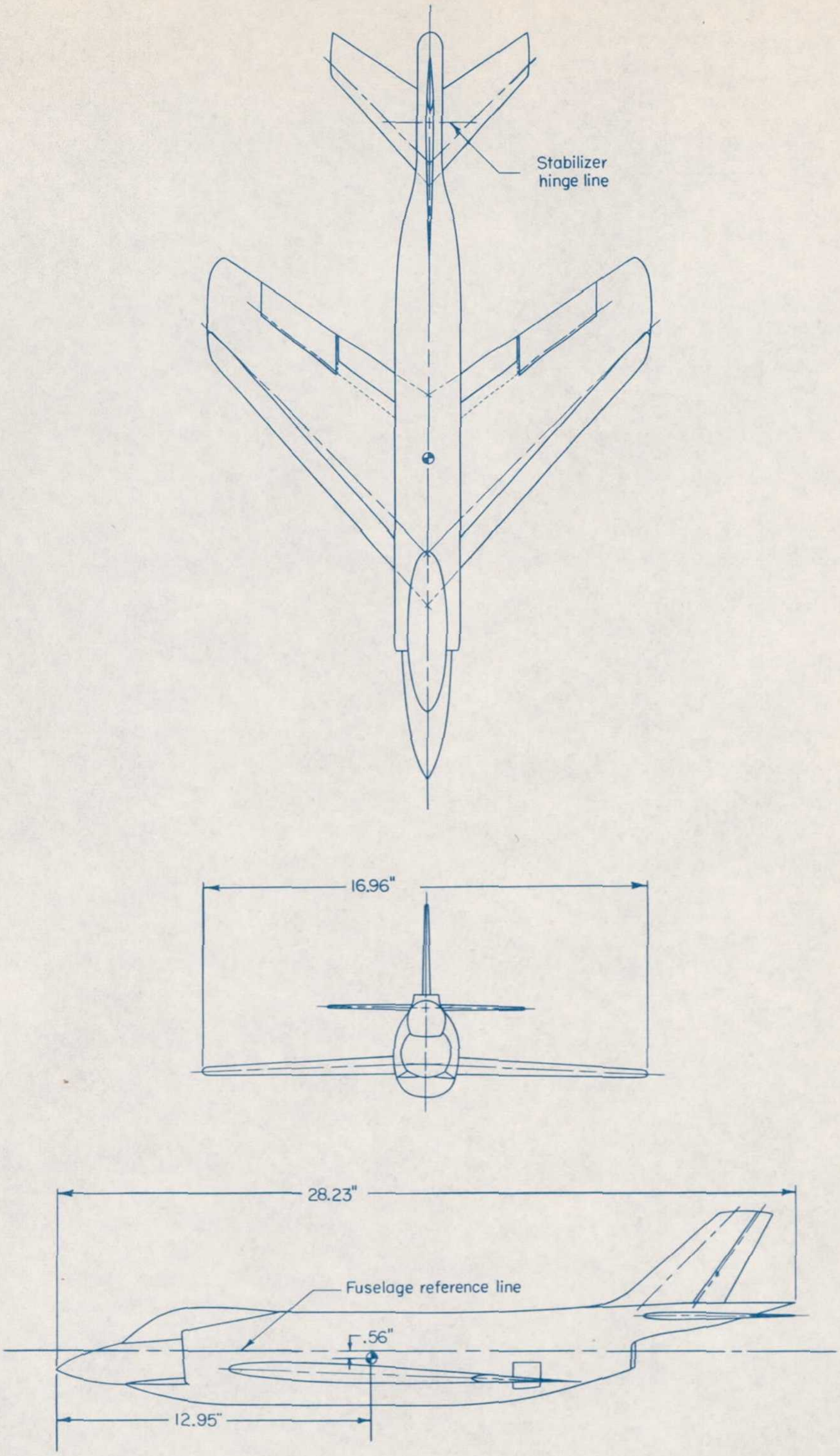


Figure 1.- Three-view drawing of the 1/25-scale model of the McDonnell F3H-1N airplane as tested in the Langley 20-foot free-spinning tunnel. Dimensions are model values. Center-of-gravity position shown for the take-off loading.

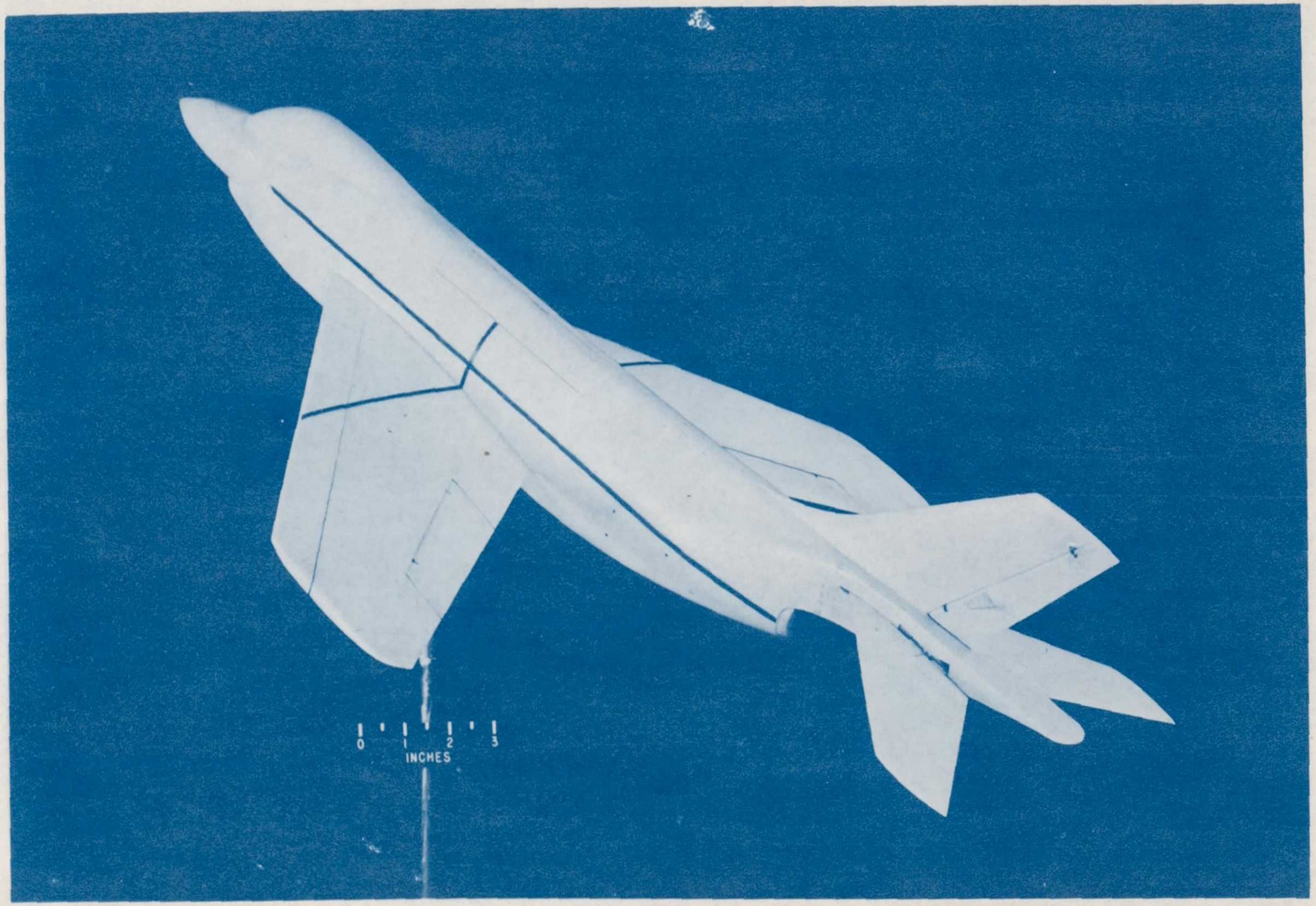


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Figure 2.- The 1/25-scale model of the McDonnell F3H-1N airplane in the clean condition.

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Figure 3.- Spinning motion of model with ailerons full against the spin, elevator full up, and rudder maintained full with the spin. 64 frames per second.

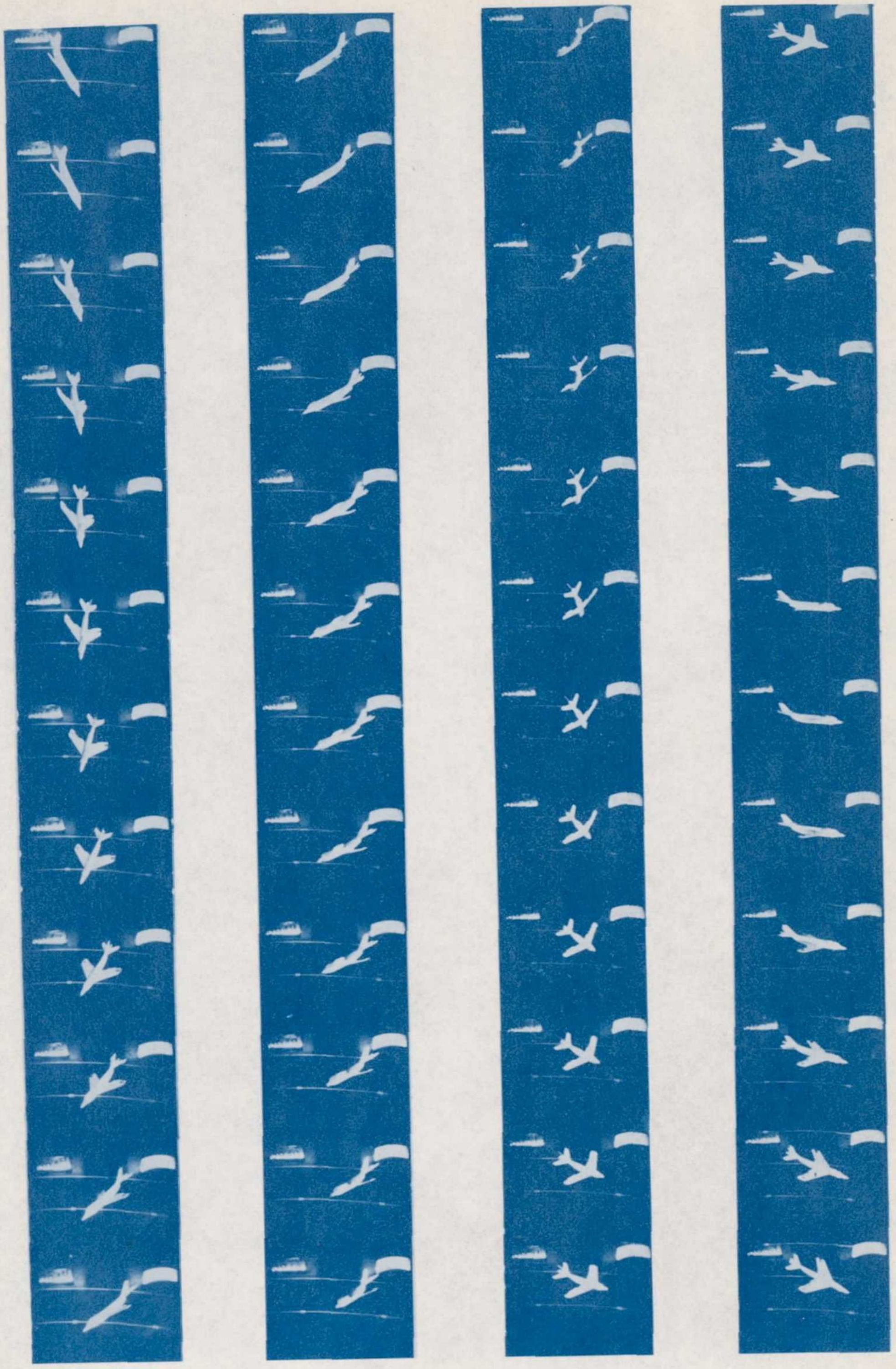

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Figure 3.- Continued.

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Figure 3.- Continued.

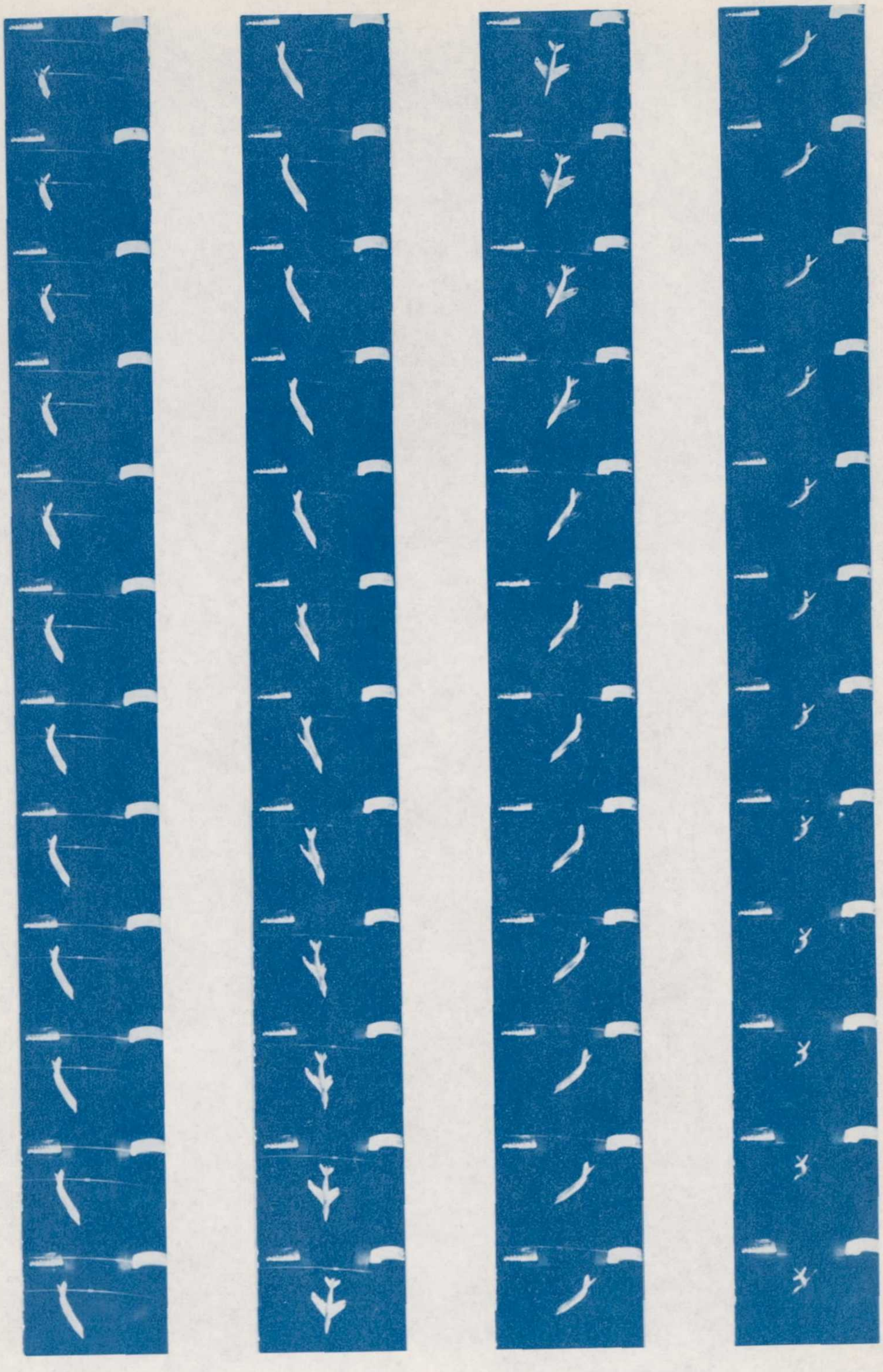

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Figure 3.- Continued.

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Figure 3.- Concluded.

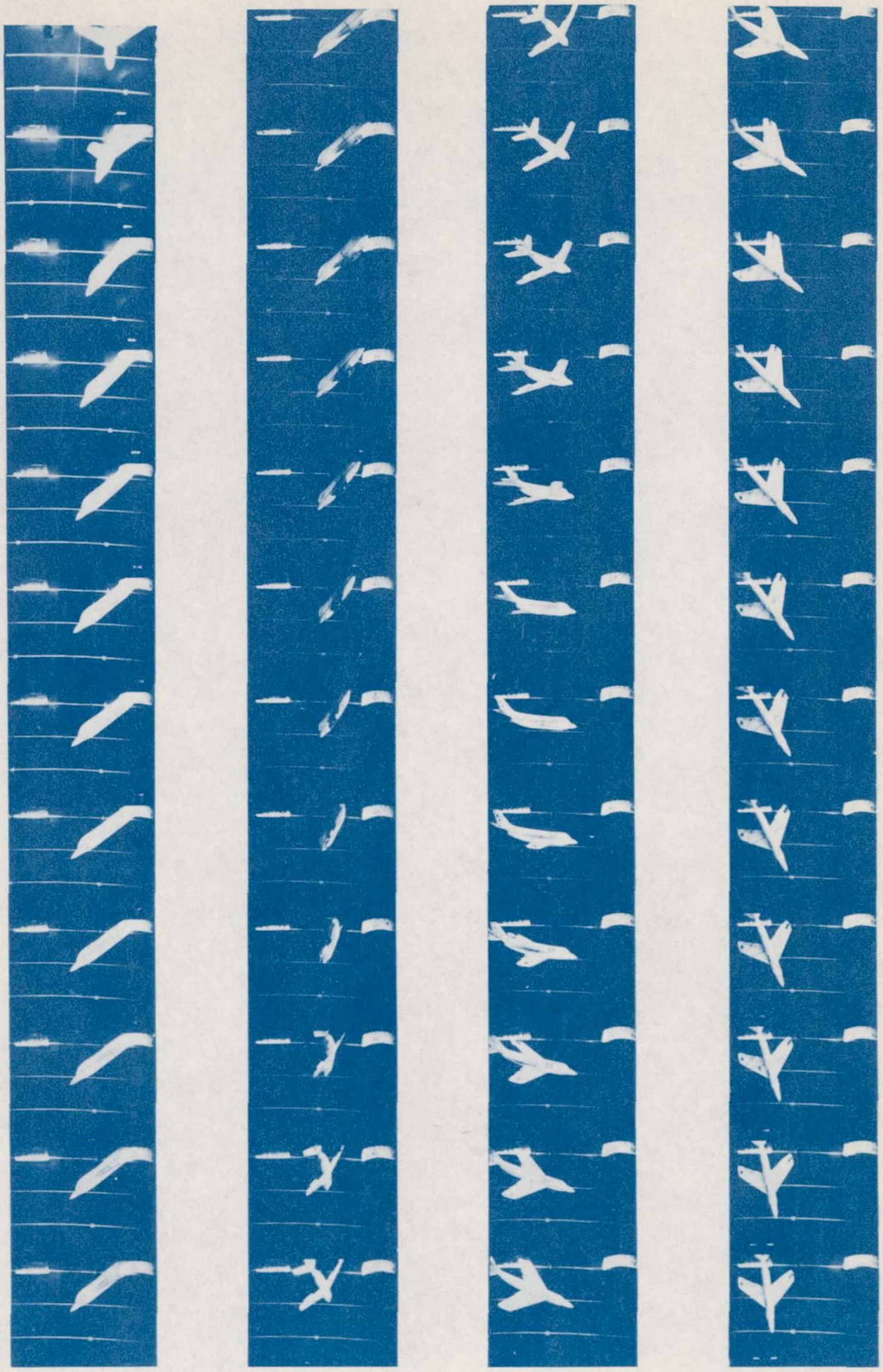

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Figure 4.- A "no-spin" condition of model (showing cessation of initial spin motion without control movement) with ailerons full against the spin, elevator full up, and rudder maintained full with the spin. 64 frames per second.

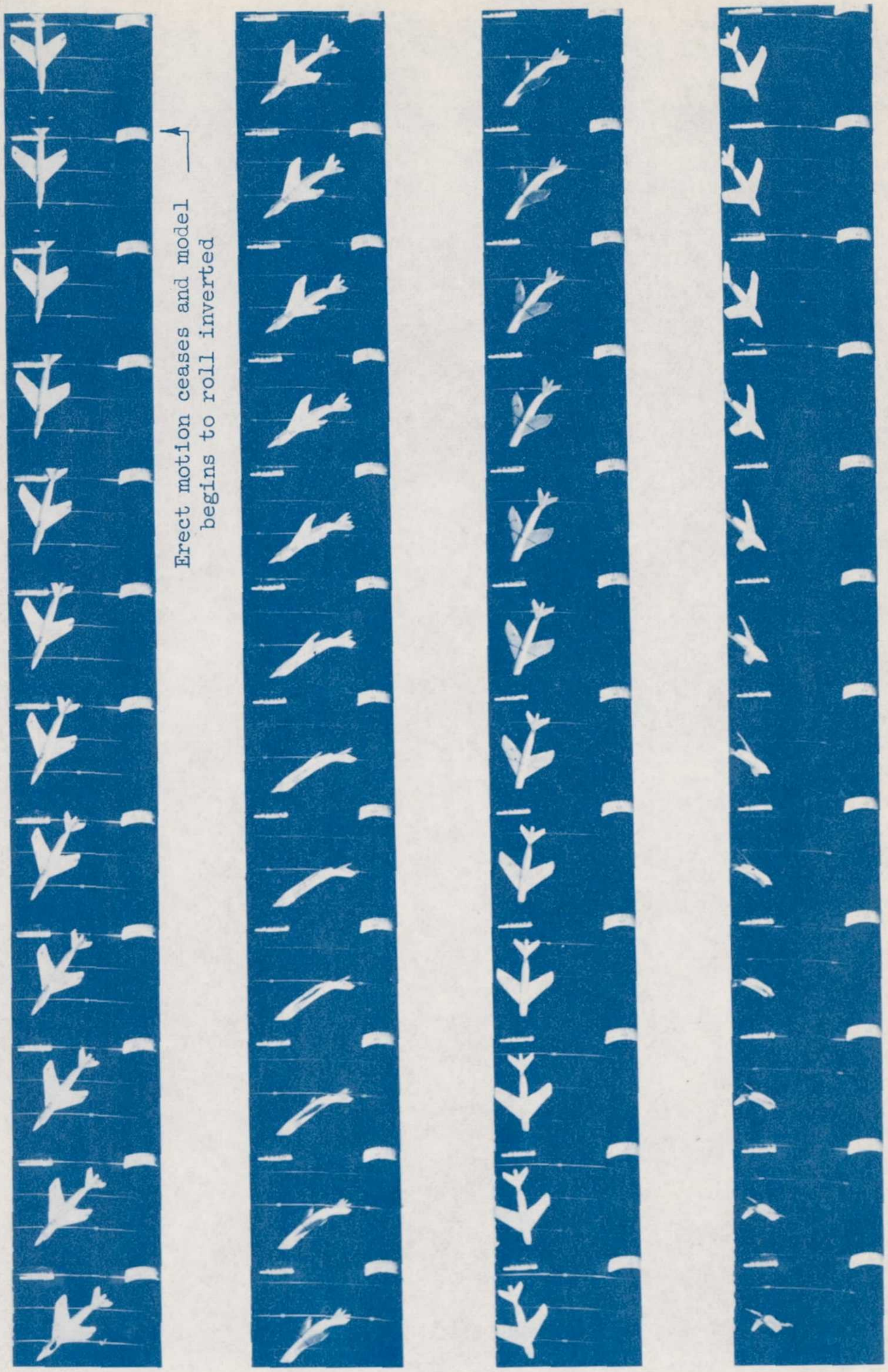

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Figure 4.- Continued.

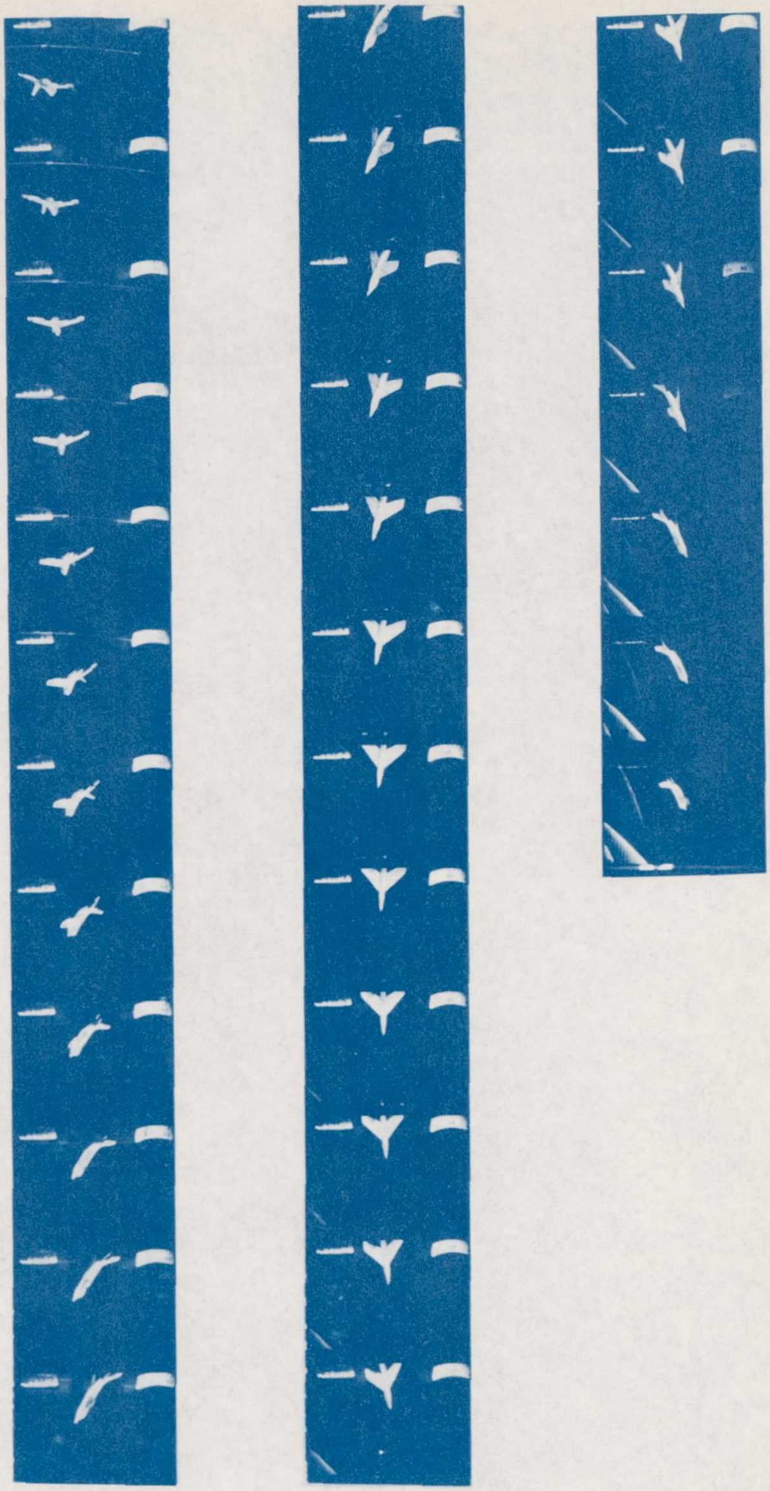
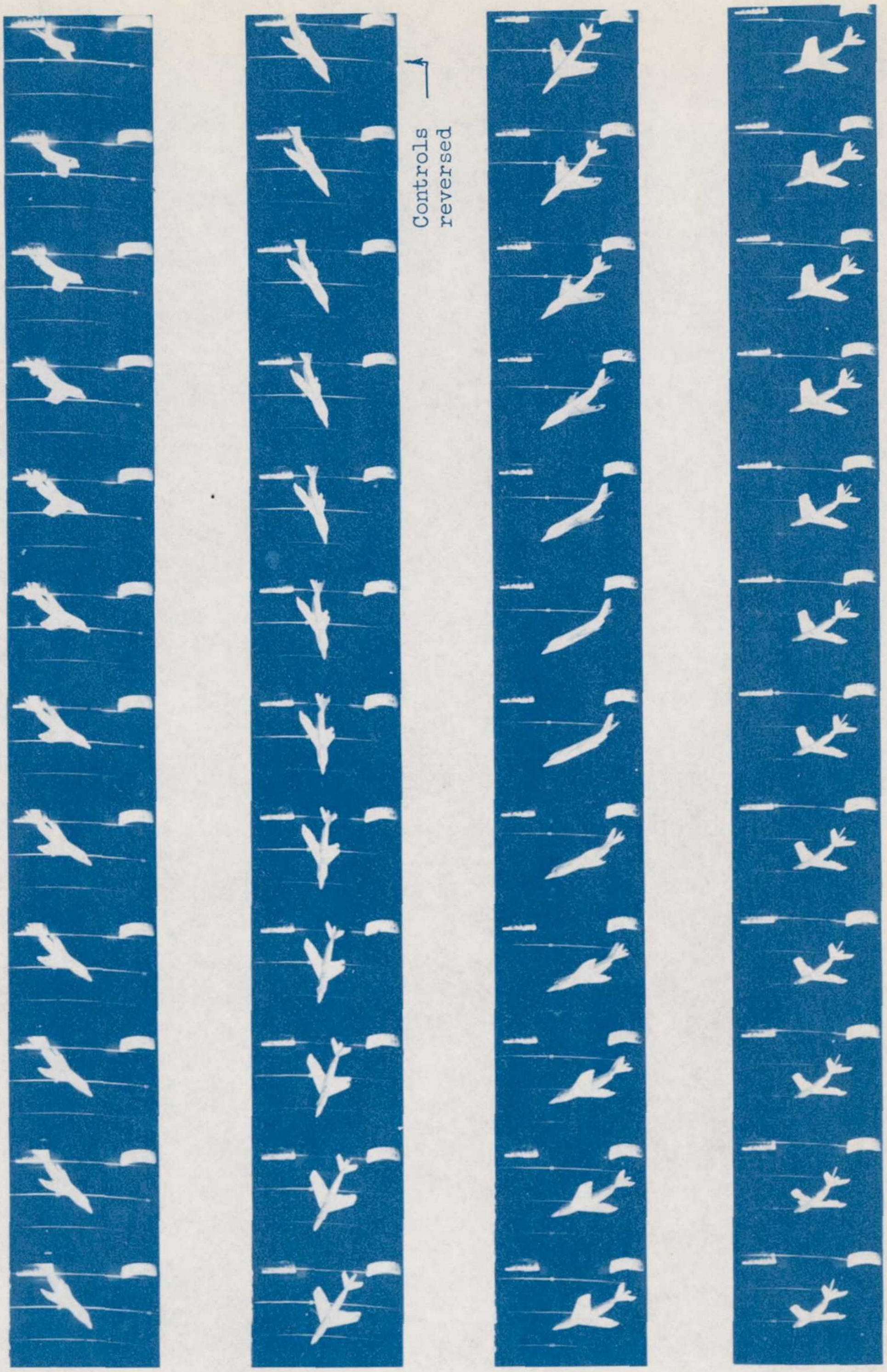


Figure 4.- Concluded.

L-87543

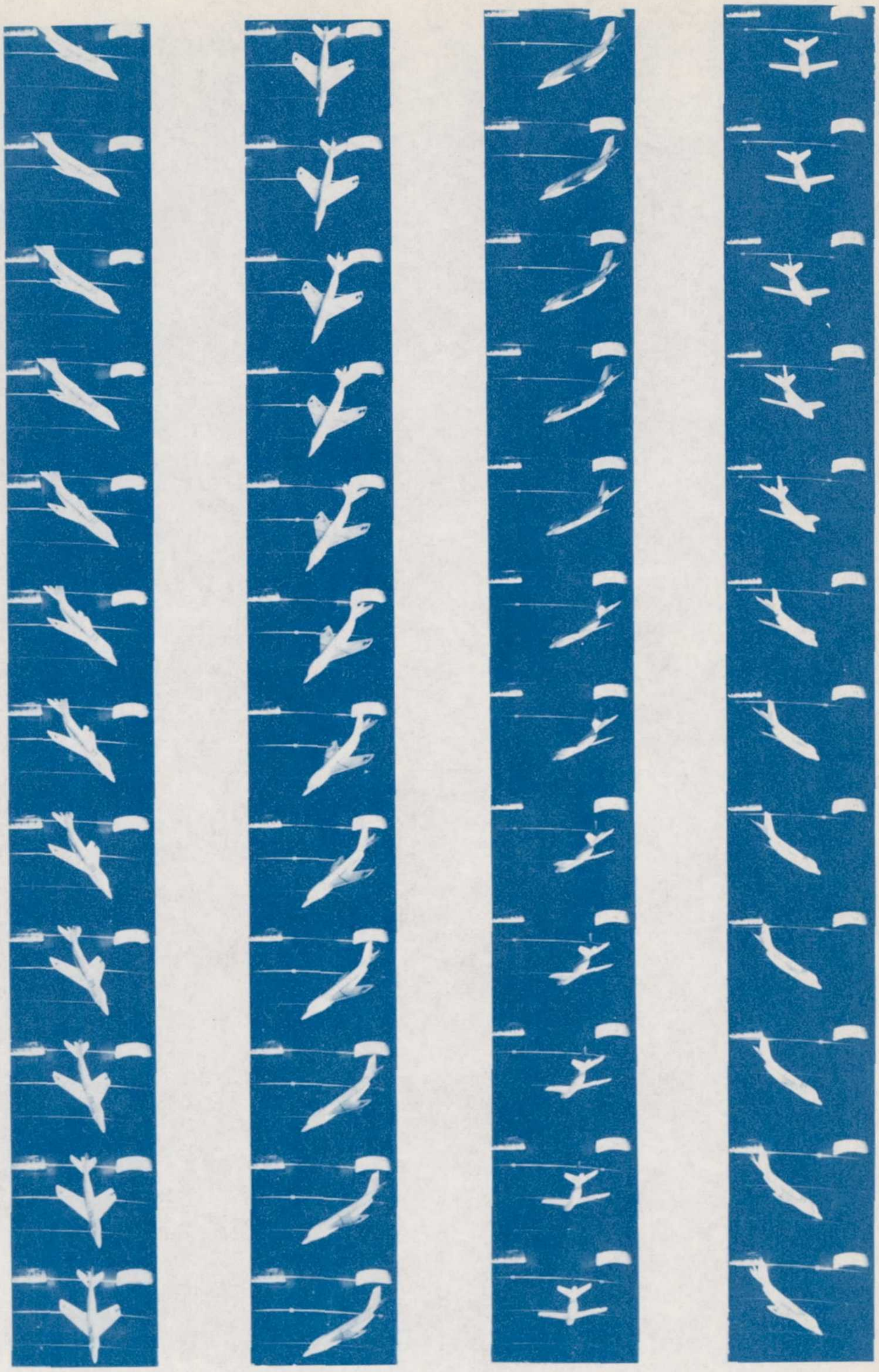


L-87544

Figure 5.- Recovery attempt by simultaneous full rudder reversal and movement of ailerons to full with the spin from the ailerons-full-against, elevator-full-up control setting. 64 frames per second.

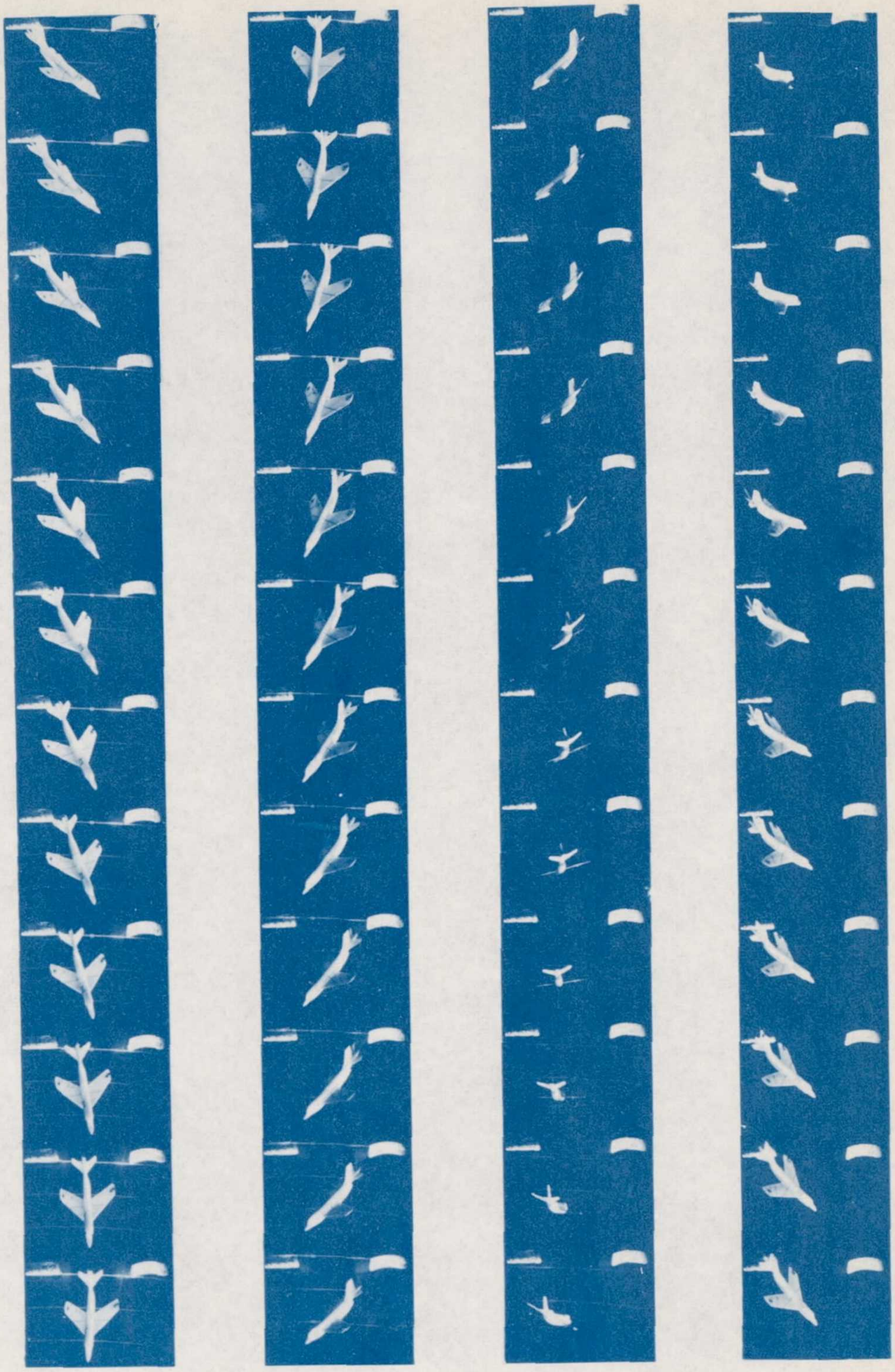
L-87545

Figure 5.- Concluded.



L-87546

Figure 6.- Spinning motion of model with ailerons neutral, elevator full up, and rudder maintained full with the spin. 64 frames per second.



L-87547

Figure 6.- Continued.

Figure 6.- Continued.

L-87548

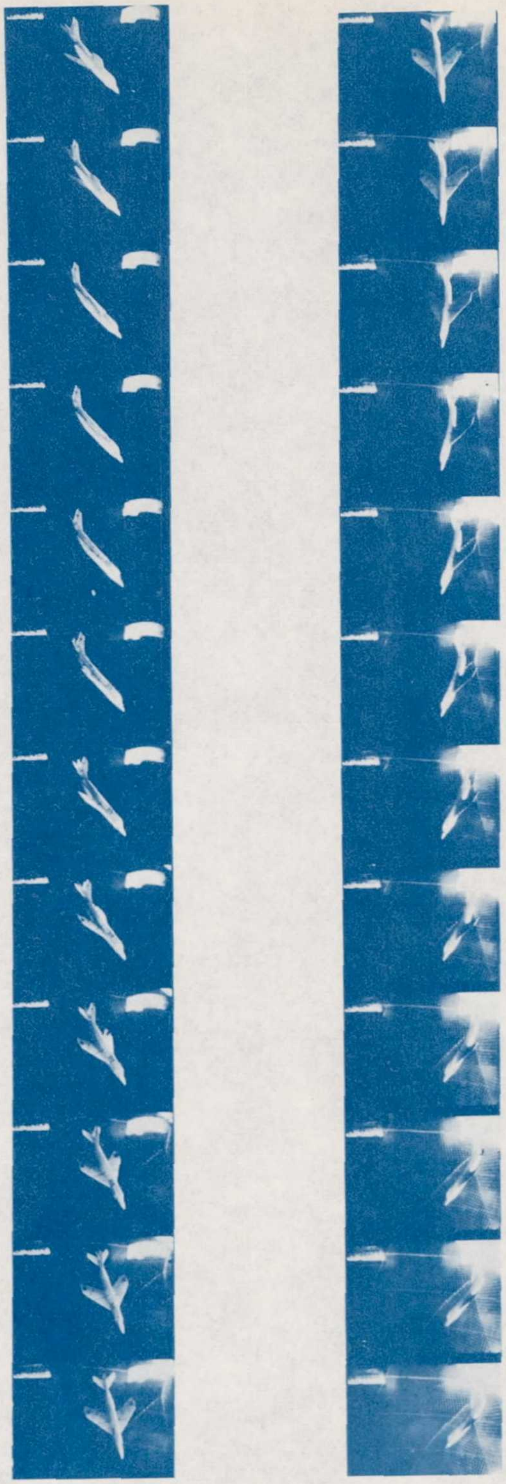


Figure 6.- Concluded.

L-87549

L-87550

Figure 7.- A "no-spin" condition of model (showing cessation of initial spin motion without control movement) with ailerons full with the spin, elevator full up, and rudder maintained full with the spin. 64 frames per second.

L-87551

Figure 7.- Concluded.