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RESEARCH MEMORANDUM

EFFECTS OF A FUSELAGE FLAP DIVE BRAKE ON THE AERODYNAMIC CHARACTERISTICS OF $\frac{1}{30}$-SCALE SEMISPAN MODEL OF THE BELL X-5 VARIABLE-SWEEP AIRPLANE AT A MACH NUMBER 1.24 AS DETERMINED BY THE NACA WING-FLOW METHOD

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SUMMARY

An investigation was made at a Mach number of 1.24 by the NACA wing-flow method to determine the effects of a fuselage flap dive brake on the lift, drag, and pitching-moment characteristics of a $\frac{1}{30}$-scale semispan model of the Bell X-5 variable-sweep airplane. The brake was located on the side of the fuselage forward of the wing and was deflected 60°. The wing of the model was in the 60° sweptback position and the tail was set at an incidence of -6°. The tests covered a range of angles of attack from -3° to 13°. The Reynolds number of the tests, based on the mean aerodynamic chord of the model wing, was about 1×10^6.

Comparison with previous tests without the brake installed showed that the incremental drag coefficient produced by the brake had a constant value of 0.046 through the range of lift coefficient tested. No appreciable longitudinal stability or trim changes were noted. The brake caused a slight reduction in the lift-curve slope.

INTRODUCTION

As part of a program to determine the aerodynamic characteristics of the proposed Bell X-5 research airplane incorporating a wing to which the angle of sweep can be varied in flight, an investigation is being made at low-supersonic speeds by the NACA wing-flow method on a $\frac{1}{30}$-scale semispan model.

Several phases of the investigation on longitudinal stability and control characteristics were reported in references 1 to 3. In the present paper results are presented of a test made at an effective Mach number of 1.24 to determine the effects of a fuselage flap dive brake on the aerodynamic characteristics with the wing of the model swept back 60°.

In order to expedite this information, only a limited analysis is presented.

SYMBOLS

The following symbols and coefficients are used in this paper:

V velocity, feet per second

S model wing area, semispan (includes area in fuselage between perpendiculars from wing-fuselage intersections to plane of symmetry), square feet

L lift force, pounds

D drag force, pounds

M pitching moment, inch-pounds

R Reynolds number based on mean aerodynamic chord $\bar{c}$

C_L lift coefficient (L/qS)

C_D drag coefficient (D/qS)

C_m pitching-moment coefficient referred to $0.26\bar{c}$ $(M/qS\bar{c})$

M_L local Mach number at airplane wing surface

M_W effective Mach number for wing of model

M_t effective Mach number for tail of model

$\bar{c}$ mean aerodynamic chord of wing; based on the relationship

$$\frac{\int_0^{b/2} c^2 dy}{\int_0^{b/2} c\, dy}$$ where b is wing span, c is chord, and y is spanwise coordinate, inches

$\bar{c}_t$ mean aerodynamic chord of tail, inches

i_t incidence of horizontal tail (referred to wing-chord plane), degrees

q effective dynamic pressure for wing of model, pounds per square foot $\left(\frac{1}{2}\rho V^2\right)$

α angle of attack of fuselage, degrees

ρ mass density, slugs per cubic foot

$\frac{\Delta C_m}{\Delta C_L}$ mean rate of change of pitching-moment coefficient with lift coefficient

APPARATUS AND TECHNIQUE

The investigation was made by the NACA wing-flow method in which the model is mounted in the region of high-speed flow over the wing of an F-51D airplane. The contour of the airplane wing in the test region for the present investigation gave local Mach numbers near 1.24 at a flight Mach number of about 0.71.

Model.- For the investigation reported herein, the model of the X-5 airplane was equipped with a fuselage flap dive brake mounted near the nose and had the wing in the 60° sweptback position. The stabilizer was set at an incidence of -6°.

A photograph of the model is shown as figure 1 and another view of the model with the dive brake removed is shown as figure 2. The geometric characteristics of the model, wing, and horizontal-tail surfaces are given in table I; other details of the model are shown in figure 3. The geometry and dimensions of the dive brake are shown in figure 4. A duct was included in the fuselage of the model to simulate to some extent the air intake and flow through the jet engine of the full-scale airplane. The airfoil section perpendicular to the unswept 38-percent-chord line (wing pivot point of the full-scale airplane) was an NACA $64_{(10)}$A011 at the root (through the pivot point) and tapered to NACA $64_{(08)}$A008.6 at the tip. The horizontal tail had an NACA 64A006 airfoil section parallel to the free stream and was swept back 45° along the quarter-chord line. The aspect ratio of the wing when the end plate is considered as a reflection plane was 2.18.

Technique.- The semispan model, which was shaped along the fuselage center line to conform to the curvature of the airplane wing in the test region, was mounted close to the F-51D modified wing surface and was connected to a balance enclosed within the wing. The model and balance were arranged to oscillate as a unit, and forces were measured normal and parallel to the fuselage reference line of the model at all angles of attack. Continuous measurements were made of angle of attack, normal force, chord force, and pitching moment as the model oscillated through an angle-of-attack range of -3° to 13°. A free-floating vane was used to determine the direction of flow at the model as described in reference 4.

A typical chordwise Mach number distribution in the test region on the F-51D airplane wing as determined from static-pressure measurements at the wing surface with the model removed is indicated in figure 5. From static measurements made with a static-pressure tube located at various distances up to 6 inches above the surface of the test section, the vertical Mach number gradient was found to be 0.009 per inch. The effective dynamic pressure for the model wing q, the effective Mach number for the model wing M_W, and the effective Mach number for the model tail M_t were determined from an integration of the velocity distribution over the area covered by the wing and tail of the model, respectively. For the chordwise velocity distribution shown in figure 5, M_W and M_t were, respectively, 1.24 and 1.23. Only a limited range of effective Mach numbers was available since a compression shock passes over the model location at an effective Mach number somewhat lower than 1.22 and an upper limit of 1.26 is determined by the maximum airplane Mach number at which the F-51D airplane may be safely operated. A more complete discussion of the method of determining the Mach number and dynamic pressure at the model can be found in reference 4.

The tests were made in high-speed dives of the F-51D airplane. The Reynolds number, based on the mean aerodynamic chord of the wing of the model, was $1 \times 10^6 \pm 5$ percent.

RESULTS AND DISCUSSION

The lift, drag, and pitching-moment characteristics of the model with the fuselage flap dive brake are presented in figure 6 and a comparison is made with similar data for the configuration without the dive brake in figure 7. Data points in figure 6 are shown for both increasing and decreasing angles as the model was oscillated through an angle-of-attack range of -3° to 13°. Pitching-moment data were obtained only from -1° to 9° because of limitations in the capacity of the pitching-moment element of the balance.

Longitudinal stability.- A comparison of pitching-moment data with and without the dive brake indicates that the static longitudinal stability was not appreciably affected by the dive brake. The value of $\Delta C_M/\Delta C_L$ taken over a range of angles of attack from 0 to 8° was about 0.40 (or an average position of the neutral point of $0.66\bar{c}$) for both configurations. The angle of attack and lift coefficient for trim are, respectively, 2.1° and 0.08 with the brake installed and 2.2° and 0.11 with the brake removed.

Lift.- The slope of the lift curve was reduced from 0.058 per degree to 0.054 per degree (at $C_L = 0$) and the angle of zero lift was decreased about 0.2° by the dive brake. The curves for both configurations remained linear up to a lift coefficient of 0.55.

Drag.- The drag coefficient of the model was increased by the dive brake by a value of 0.046 over the range of lift coefficient tested. The absolute values of drag coefficients as presented are considered qualitative because they are subject to certain unknown effects of the reflection-plane method of testing on the drag of the model fuselage and include the drag of the end plate. However, the variation of drag coefficient with lift coefficient and the differences between drag coefficients for the different configurations are believed to be unaffected by these factors.

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REFERENCES

1. Silsby, Norman S., Morris, Garland J., and Kennedy, Robert M.: Longitudinal Characteristics at a Mach Number of 1.24 of a $\frac{1}{30}$-Scale Semispan Model of Bell X-5 Variable-Sweep Airplane with Wing Swept Back 60° from Tests by NACA Wing-Flow Method. NACA RM L50E02a, 1950.

2. Morris, Garland J., Kennedy, Robert M., and Silsby, Norman S.: The Effect of Sweepback on the Longitudinal Characteristics at a Mach Number of 1.24 of a $\frac{1}{30}$-Scale Semispan Model of the Bell X-5 Airplane from Tests by the NACA Wing-Flow Method. NACA RM L50I28, 1950.

3. Sawyer, Richard H., Kennedy, Robert M., and Morris, Garland J.: Longitudinal Control Effectiveness and Downwash Characteristics at a Mach Number of 1.24 of a $\frac{1}{30}$-Scale Semispan Model of the Bell X-5 Airplane As Determined by the NACA Wing-Flow Method. NACA RM L50K15, 1950.

4. Johnson, Harold I.: Measurements of Aerodynamic Characteristics of a 35° Sweptback NACA 65-009 Airfoil Model with $\frac{1}{4}$-Chord Plain Flap by the NACA Wing-Flow Method. NACA RM L7F13, 1947.

TABLE I

GEOMETRIC CHARACTERISTICS OF $\frac{1}{30}$-SCALE SEMISPAN MODEL OF THE BELL X-5 VARIABLE-SWEEP AIRPLANE WITH WING IN 60° SWEEP POSITION

Wing dimensions:	
Section (perpendicular to unswept 38-percent-chord line)	
Root	NACA $64_{(10)}$A011
Tip	NACA $64_{(08)}$A008.6
Semispan, in.	3.88
Mean aerodynamic chord, in.	3.64
Chord at tip, in.	1.84
Chord at fuselage intersection, in.	4.25
Area (semispan), sq in.	13.79
Aspect ratio	2.18
Sweepback (0.25 chord line), deg	60
Dihedral (chord plane), deg	0
Incidence (chord plane), deg	0
Horizontal tail:	
Section	NACA 64A006
Semispan, in.	1.91
Mean aerodynamic chord, in.	1.43
Chord at tip, in.	0.72
Chord at plane of symmetry, in.	1.95
Area (semispan), sq in.	2.55
Aspect ratio	2.86
Length ($0.26\bar{c}$ wing to $0.25\bar{c}$ tail), in.	6.83
Height (above wing chord), in.	0.56

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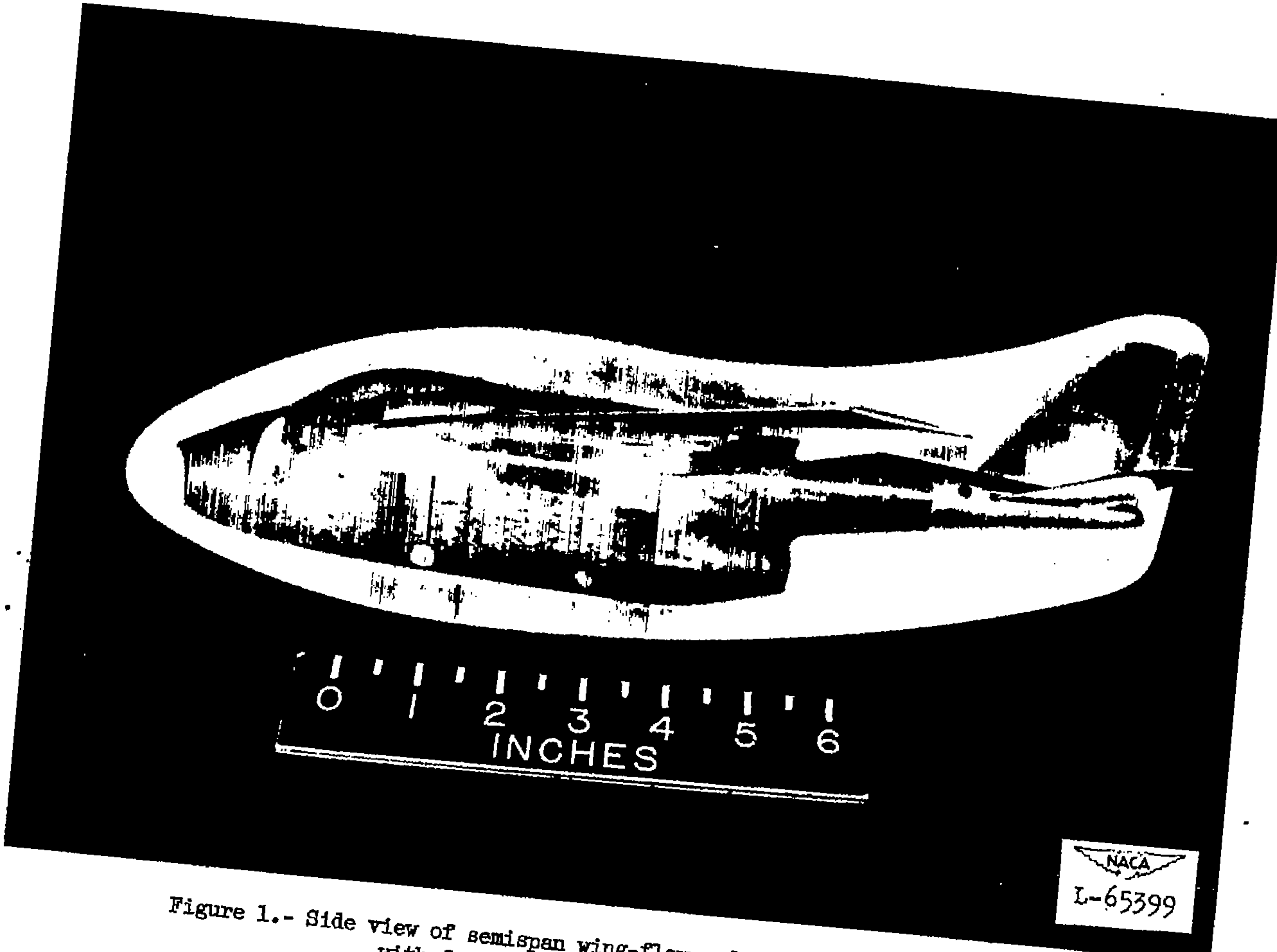

Figure 1.- Side view of semispan wing-flow model of the Bell X-5 airplane with fuselage flap dive brake attached.

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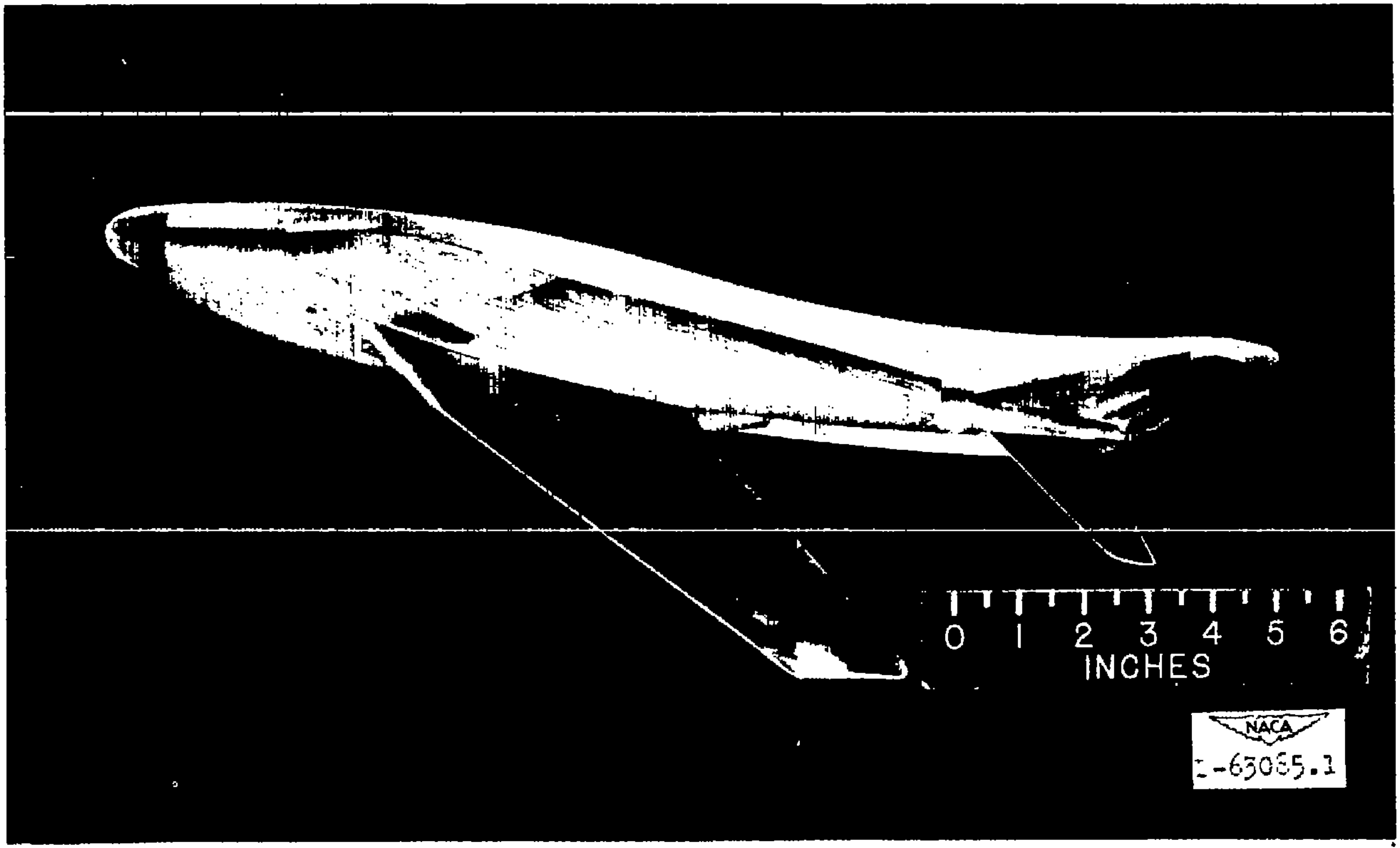

Figure 2.- Semispan wing-flow model of the Bell X-5 variable-sweep airplane with wing in 60° sweptback position without dive brake.

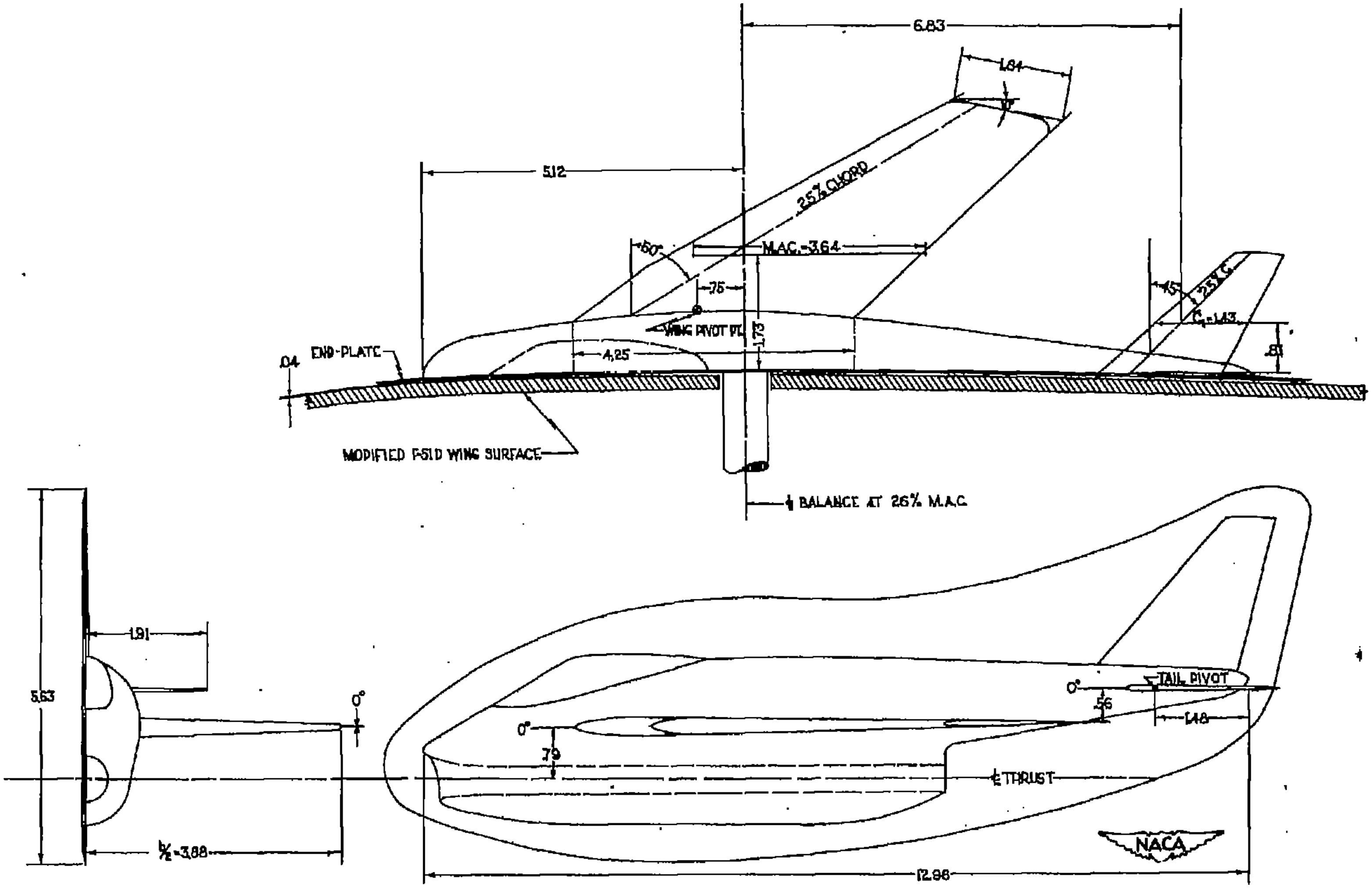

Figure 3.- Details of the semispan model of the Bell X-5 variable-sweep airplane with wing in 60° sweptback position. (All dimensions are in inches.)

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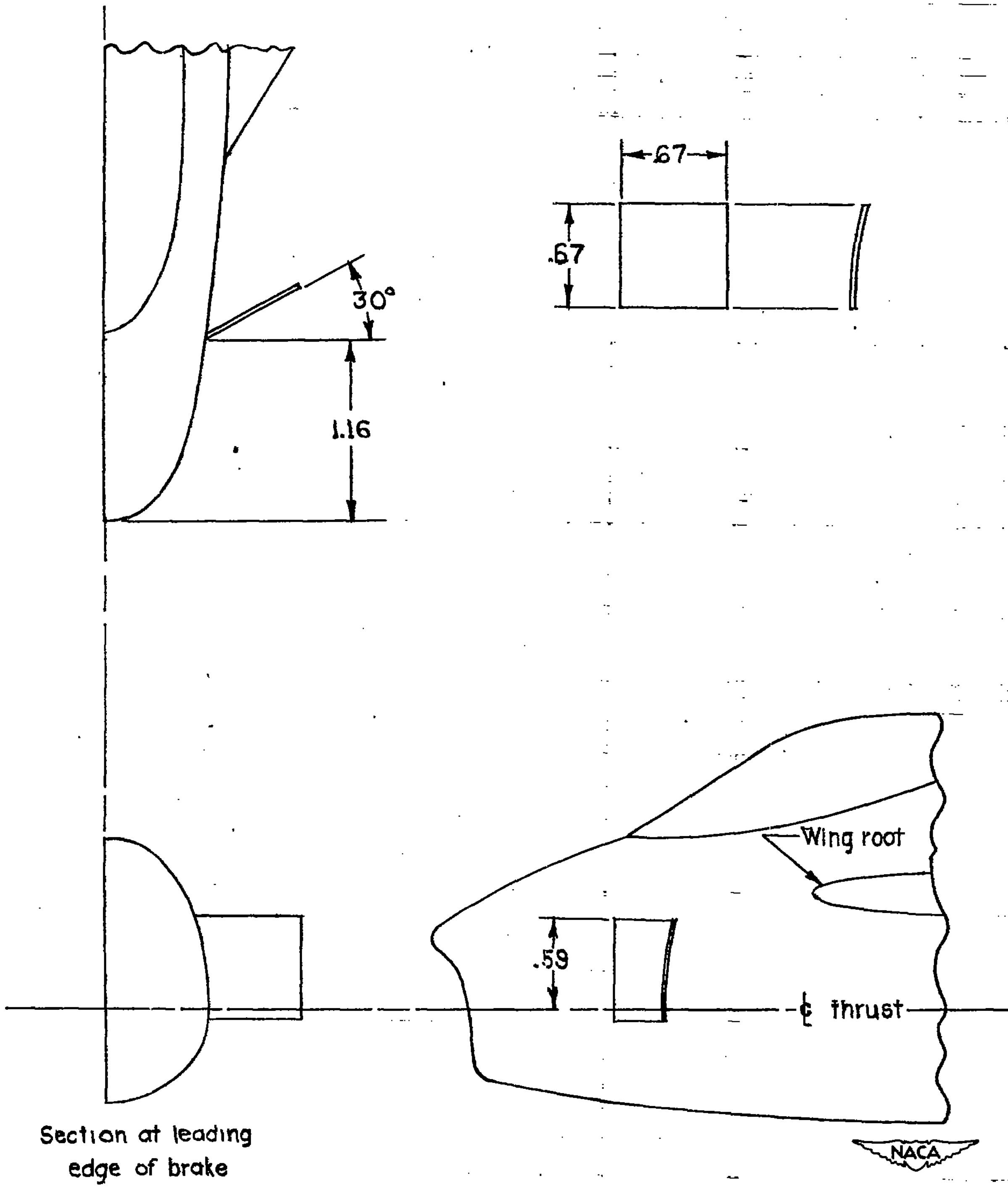

Figure 4.- Fuselage flap dive brake on $\frac{1}{30}$ - scale X-5 model. All dimensions are in inches.

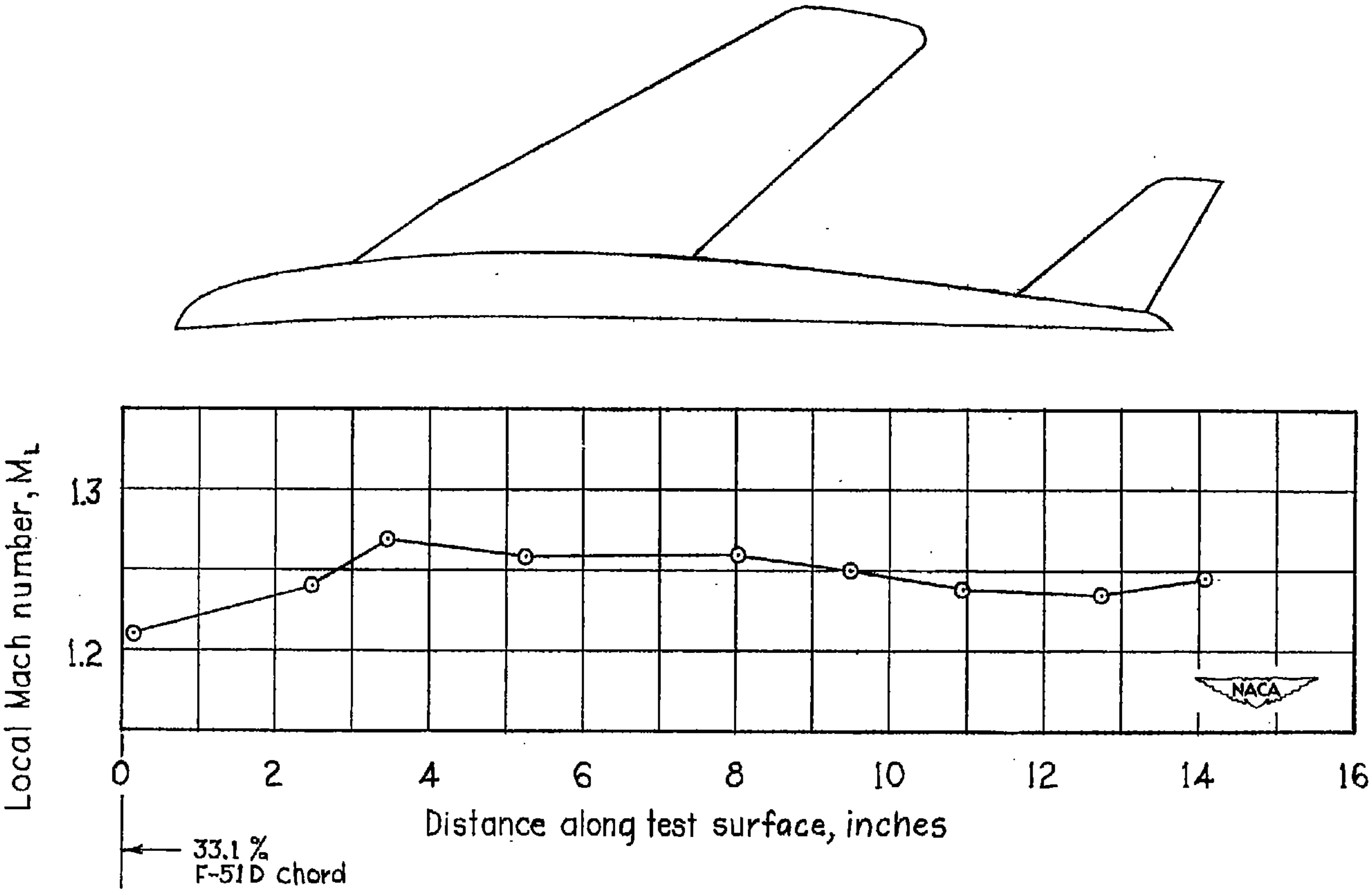

Figure 5.- Typical chordwise local Mach number variation measured at surface of test section. Chordwise location of model also shown.

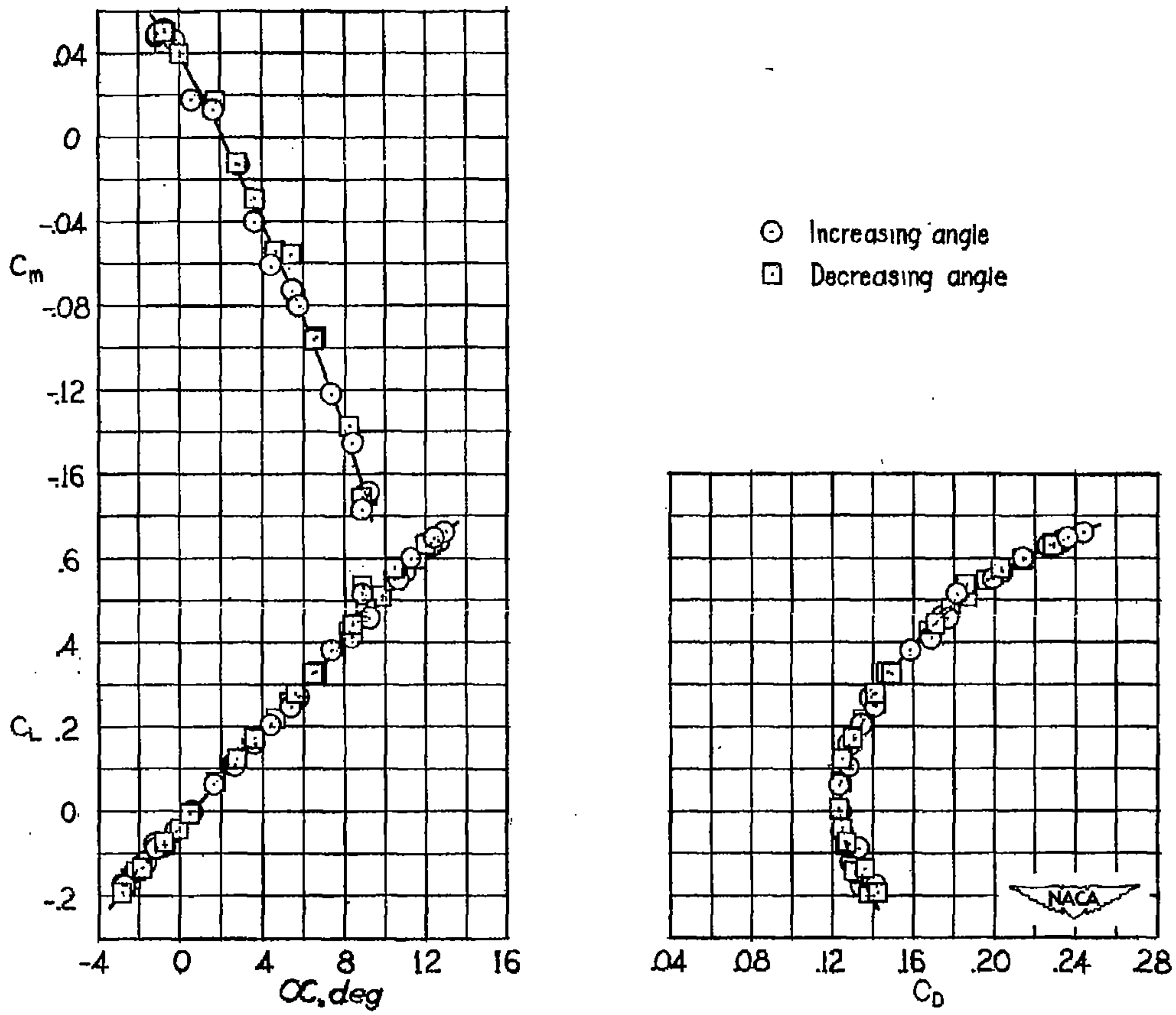

Figure 6.- Aerodynamic characteristics of semispan model of the Bell X-5 with fuselage flap dive brake installed; $\Lambda = 60^\circ$, $i_t = -6^\circ$, $M_w = 1.24$.

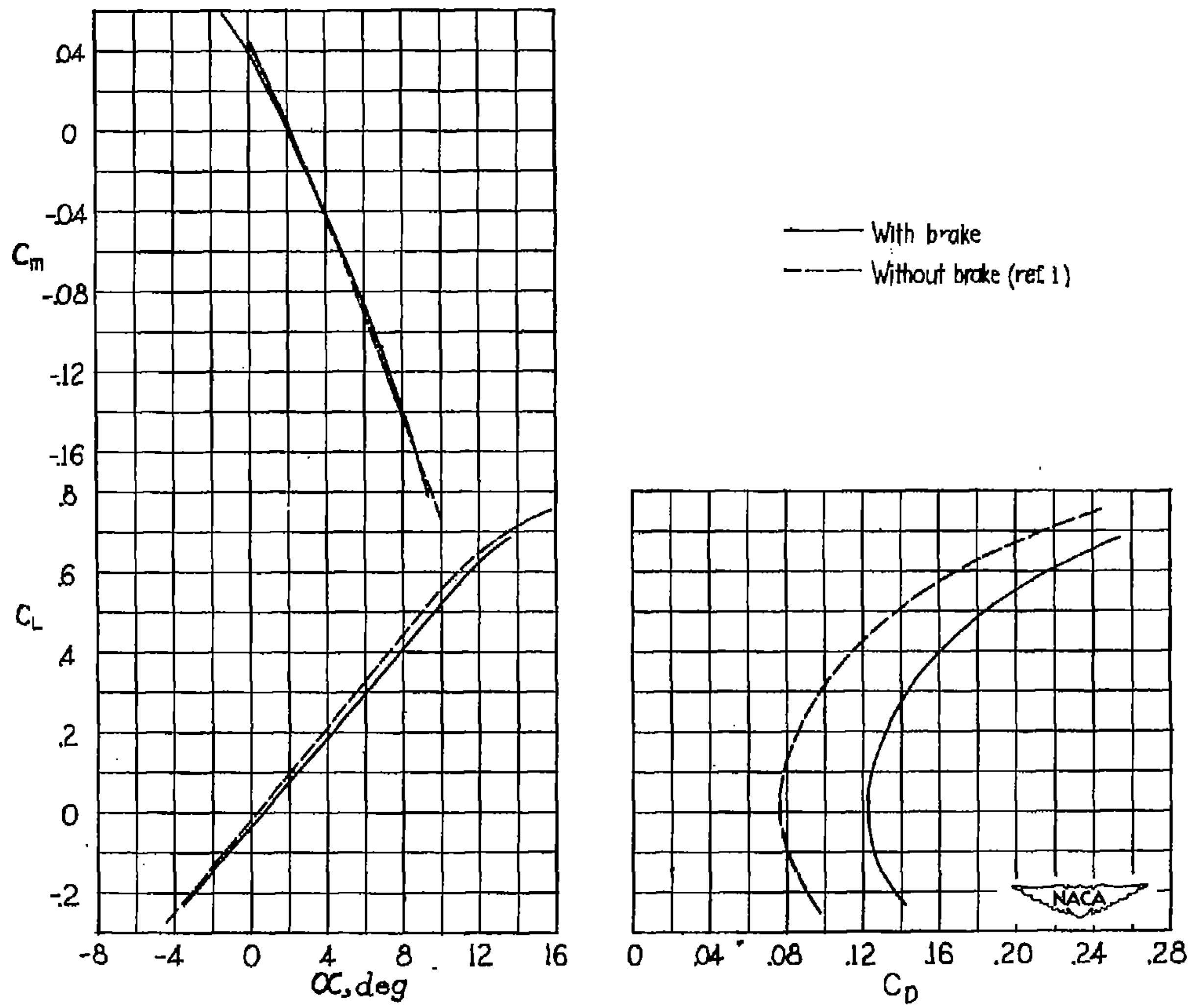

Figure 7.- Comparison of aerodynamic characteristics of semispan model of the Bell X-5 airplane with and without fuselage flap dive brake; $\Lambda = 60^\circ$, $i_t = -6^\circ$, $M_W = 1.24$.