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RESEARCH MEMORANDUM

A PRELIMINARY LOW-SPEED WIND-TUNNEL INVESTIGATION OF A THIN DELTA WING EQUIPPED WITH A DOUBLE AND A SINGLE SLOTTED FLAP

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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A PRELIMINARY LOW-SPEED WIND-TUNNEL INVESTIGATION OF A THIN DELTA WING EQUIPPED WITH A DOUBLE AND A SINGLE SLOTTED FLAP

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SUMMARY

A low-speed wind-tunnel investigation was made to determine the high-lift characteristics of a thin delta wing equipped with a single and a double slotted trailing edge flap. The model was a flat plate with beveled leading and trailing edges, a maximum thickness ratio of 0.045 and 60° sweepback at the leading edge (aspect ratio 2.31).

The results of the investigation indicated an increase in maximum lift coefficient of the model from 1.45 for the plain wing to 1.86 when the double slotted flap was deflected to 50°. The angle of attack of the model necessary to obtain a given lift coefficient was considerably reduced by deflection of the slotted flaps. Except for a rather large trim change, longitudinal stability characteristics of the delta wing generally were not changed by deflection of the slotted flaps.

INTRODUCTION

At the present time, there is considerable interest in the use of delta-wing plan forms for high-speed airplanes. This plan form shows desirable aerodynamic characteristics at transonic and low-supersonic speeds and has desirable structural characteristics. At low speeds the longitudinal stability problem appears to be less severe than for conventional sweptback wings. However the delta plan form wing requires an undesirably high landing attitude to obtain high lift coefficients. The problem of attaining low landing speeds is therefore not only one of increasing the maximum lift coefficient but also, and frequently this is the more important consideration, one of decreasing the angle of attack required to achieve a high lift coefficient.

Investigations are currently being made in the Langley 300 MPH 7- by 10-foot tunnel to determine the effect of various leading- and trailing-edge high-lift devices on thin delta wings in an attempt to improve the landing characteristics.

The results of a few slotted-flap configurations tested thus far, in an exploratory investigation, are given in the present paper to show the feasibility of using high-lift devices on delta wings.

COEFFICIENTS AND SYMBOLS

The results of the tests are presented as standard NACA coefficients of forces and moments about the stability axes. Pitching-moment coefficients are given about the wing 25-percent-mean-aerodynamic-chord point shown in figure 1. The positive directions of forces and moments are shown in figure 2.

The coefficients and symbols are defined as follows:

C_L lift coefficient (L/qS)

C_D drag coefficient (D/qS)

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

L lift, pounds

D drag, pounds

M pitching moment, foot-pounds

q free-stream dynamic pressure, pounds per square foot $\left(\frac{1}{2}\rho V^2\right)$

S wing area (6.93 sq ft)

$\bar{c}$ wing mean aerodynamic chord (2.31 ft) $\left(\frac{2}{S}\int_0^{b/2} c^2 dy\right)$

b wing span (4.00 ft)

V free-stream velocity, feet per second

δ_f flap deflection measured perpendicular to hinge line, degrees

δ_v vane deflection measured perpendicular to hinge line (along flat lower surface of vane), degrees

α angle of attack of wing, degrees

c local wing chord, feet

t local wing thickness, feet

y lateral distance from plane of symmetry, measured parallel to Y-axis, feet

X_f horizontal distance of flap leading edge from wing upper surface lip, inches (positive when forward of lip)

X_v horizontal distance of vane leading edge from wing upper surface lip, inches (positive when forward of lip)

y_f vertical distance of flap leading edge from wing upper surface lip, inches (positive when below lip)

y_v vertical distance of vane leading edge from wing upper surface lip, inches (positive when below lip)

MODEL AND APPARATUS

The model was tested in the Langley 300 MPH 7- by 10-foot tunnel by utilizing a sting-support system (fig. 3) and an electrical strain-gage balance.

The wing of the model had a 60° apex angle (aspect ratio 2.31) and a taper ratio of 0 (figs. 1 and table I). The model was made from a flat steel plate 5/8 inch thick, with beveled leading and trailing edges. The thickness ratio varied from 1.5 percent chord at the root to 4.5 percent at 0.67b/2.

A flat airfoil was used because of the simple construction and the preliminary nature of the investigation. A small fuselage was used to house the electrical strain-gage balance (figs. 1 and 3) and does not necessarily represent a typical fuselage.

The flap was constructed of steel with a wood leading edge (figs. 1 and 4 and table II). The constant-chord flap had an area equal to approximately 17.6 percent of the total wing area. The vane of the double slotted flap was constructed of steel by the addition of a $\frac{1}{8}$-inch-diameter rod faired into the leading edge of a modified Clark Y airfoil section as shown in figures 1 and 4.

TESTS

The tests were made in the Langley 300 MPH 7- by 10-foot tunnel at a dynamic pressure of approximately 22.5 pounds per square foot, corresponding to an airspeed of about 100 miles an hour. Reynolds number for this airspeed, based on the mean aerodynamic chord (2.31 ft), was approximately 2.1×10^6. The corresponding Mach number was 0.13. The tests were run through an angle of attack range of -10° to 45°.

CORRECTIONS

The approximate jet-boundary corrections applied to the data were obtained from methods outlined in reference 1. A correction has been applied to the angle of attack to account for the deflection of the support sting under load. No correction has been applied for blocking because it was considered to be negligible.

RESULTS AND DISCUSSION

The lift, drag, and pitching-moment characteristics of the plain wing and the various flap configurations are given in figure 5. The lift-curve slope of the plain wing was 0.049 and the maximum lift coefficient was 1.45. A gain of 0.28 (about 19 percent) in the maximum lift coefficient was obtained by deflecting the slotted flap to 39° and a further gain to a maximum lift coefficient of 1.86 was realized when the double slotted flap was deflected to 50°. It may be noted here that for the flap deflection resulting in the maximum lift coefficient of 1.86, the stall occurs approximately 4° earlier than the plain wing. Beyond a lift coefficient of about 0.8, the drag coefficient with flaps deflected was considerably less than that of the plain wing which resulted in higher lift-drag ratios near the stall. In general, throughout the range of angles tested, all the model configurations have stable pitching-moment curves which break stable as the angle of stall is reached. A diving moment occurred for each flap configuration tested, which would result in a loss in lift coefficient when trimming the model with a conventional tail. For example, for an airplane with the 54° double slotted flap and a tail length of $2\bar{c}$ the reduction in maximum lift coefficient to counteract the pitching-moment increment between the plain wing and the flap condition would be approximately 0.1.

Landing delta-wing airplanes at reasonable lift coefficients without flaps requires high angles of attack which result in poor visibility and necessitate long landing gears. From the curves in figure 5, it is apparent that the angle of attack of the airplane for landing could be considerably reduced while still maintaining constant lift coefficient by the addition of slotted flaps. For example, at a lift coefficient of approximately 1.0 the angle of attack for the plain wing was about 20°, whereas, with the flaps deflected to 54°, assuming a tail length of $2\bar{c}$ to correct for the increment in diving moment, the angle of attack was reduced to about 4.5°.

CONCLUSIONS

A preliminary wind-tunnel investigation at low speeds of a thin delta wing equipped with a slotted flap indicated the following:

1. The maximum lift coefficient of the model could be increased from 1.45 for the plain wing to 1.86 when the double slotted flap was deflected to 50°.

2. The angle of attack of the model necessary to obtain a given lift coefficient was considerably reduced by deflection of the slotted flaps.

3. The longitudinal stability characteristics of the delta wing generally were not changed by deflection of the slotted flaps, except for a rather large trim change.

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REFERENCE

1. Gillis, Clarence L., Polhamus, Edward C., and Gray, Joseph L., Jr.: Charts for Determining Jet-Boundary Corrections for Complete Models in 7- by 10-Foot Closed Rectangular Wind Tunnels. NACA ARR L5G31, 1945.

TABLE I

PHYSICAL CHARACTERISTICS OF THE TEST MODEL

Wing:	
Span, ft	4.00
Aspect ratio	2.31
Thickness of flat plate, in. $\left[\left(\frac{t}{c}\right)_{max} = 0.045\right]$	5/8
Sweep, deg	60
Area, sq ft	6.93
Mean aerodynamic chord, ft	2.31
Leading-edge angle, deg	6.5
Vane:	
Span, ft	2.70
Chord, percent wing root chord	2.4
Flap:	
Span, ft	2.70
Chord, percent wing root chord	13.2
Area, sq ft	1.22
Area, percent wing area	17.6
Trailing-edge angle, deg	8.0

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TABLE II

ORDINATES OF THE WOOD LEADING EDGE OF

THE TRAILING-EDGE FLAP

[All dimensions in inches]

Station x	Upper y	Lower y
0	-0.15	-0.15
.1	.01	-.25
.2	.08	-.27
.4	.18	-.29
.6	.25	-.30
.8	.30	-.31
1.1	.31	-.31

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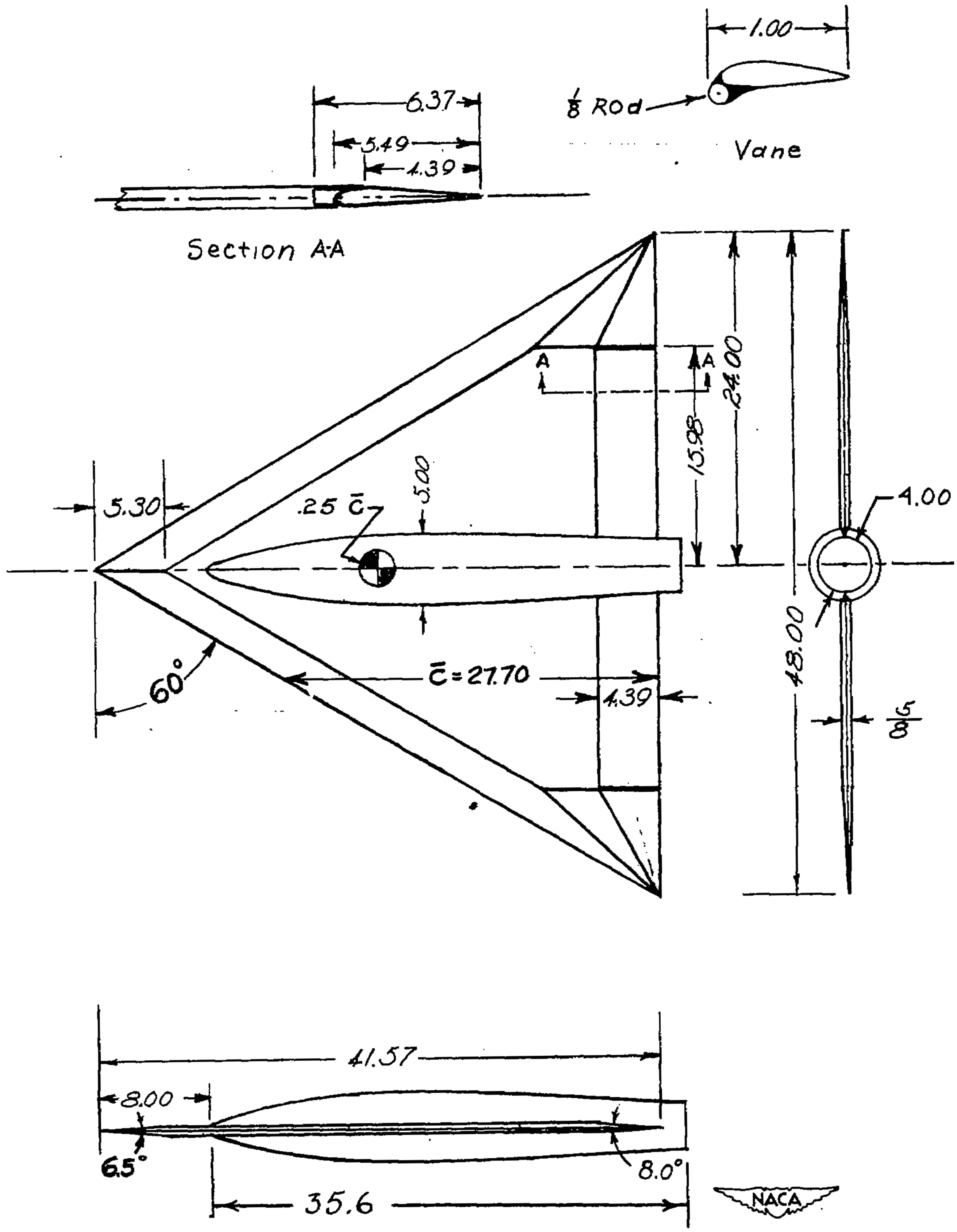

Figure 1.- General arrangement of 60° delta wing model. All dimensions are in inches.

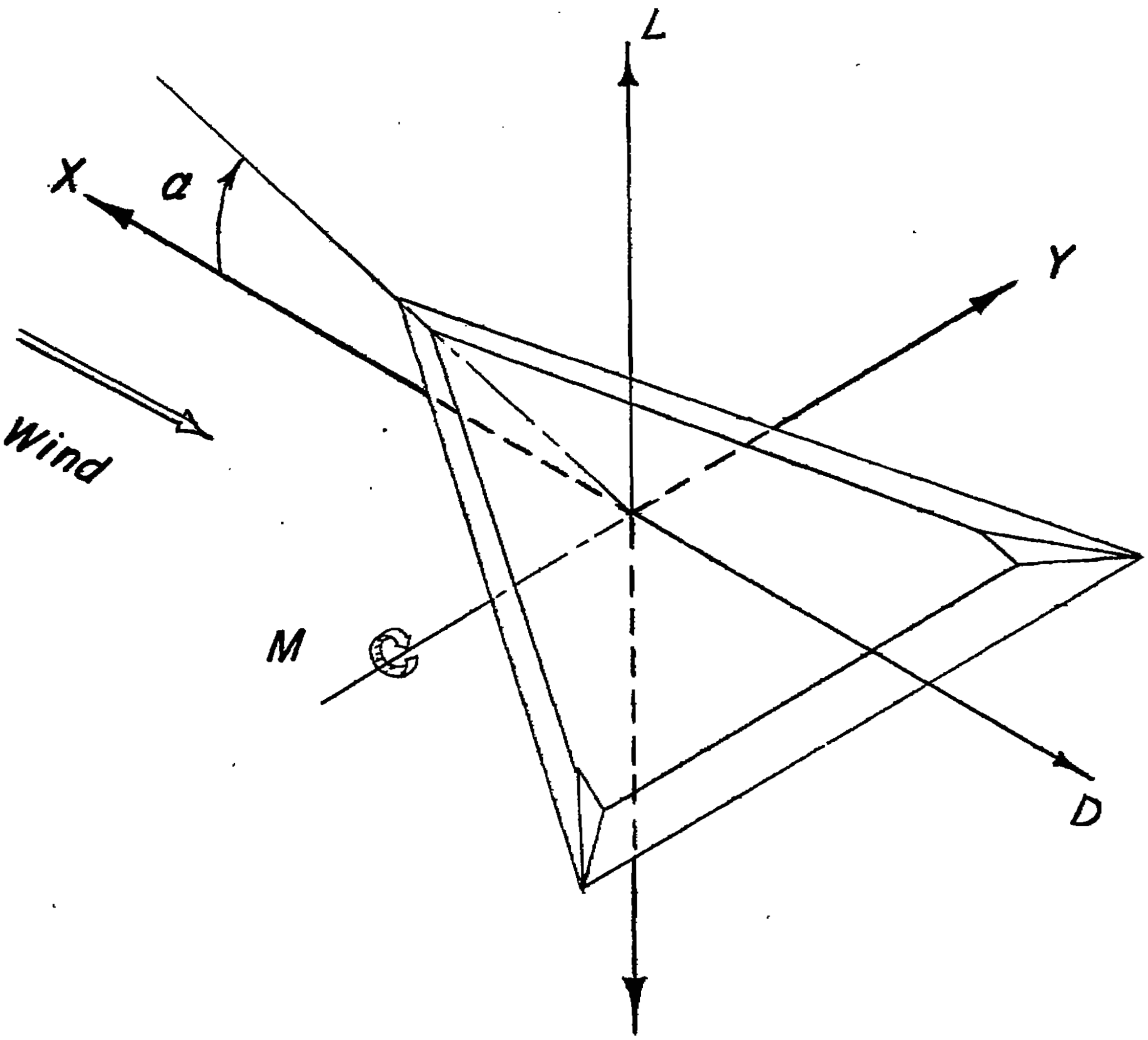

Figure 2.- System of stability axes. Positive values of forces, moments, and angles are indicated by arrows.

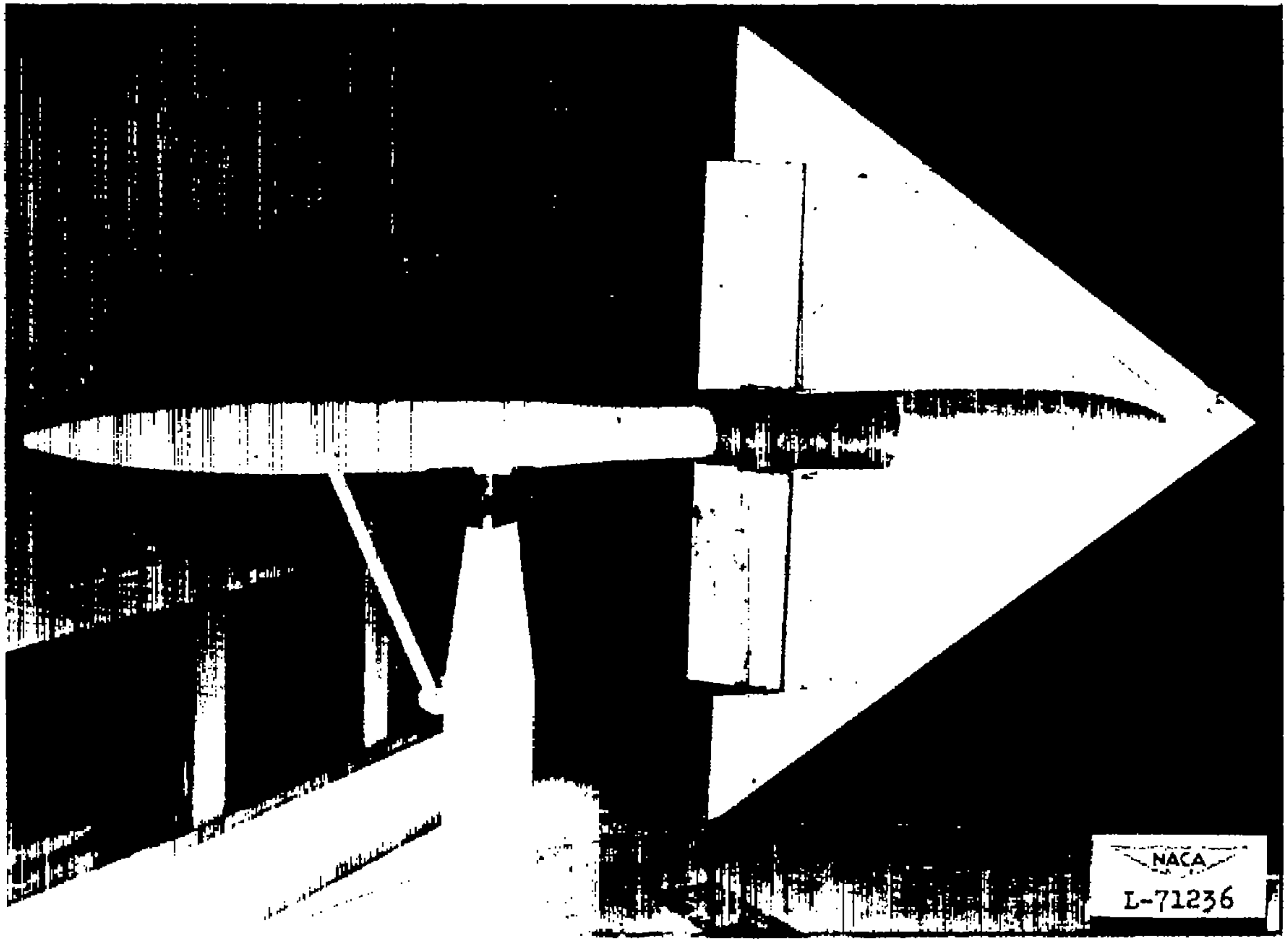

Figure 3.- The 60° delta wing model mounted in the Langley 300 MPH 7- by 10-foot tunnel.

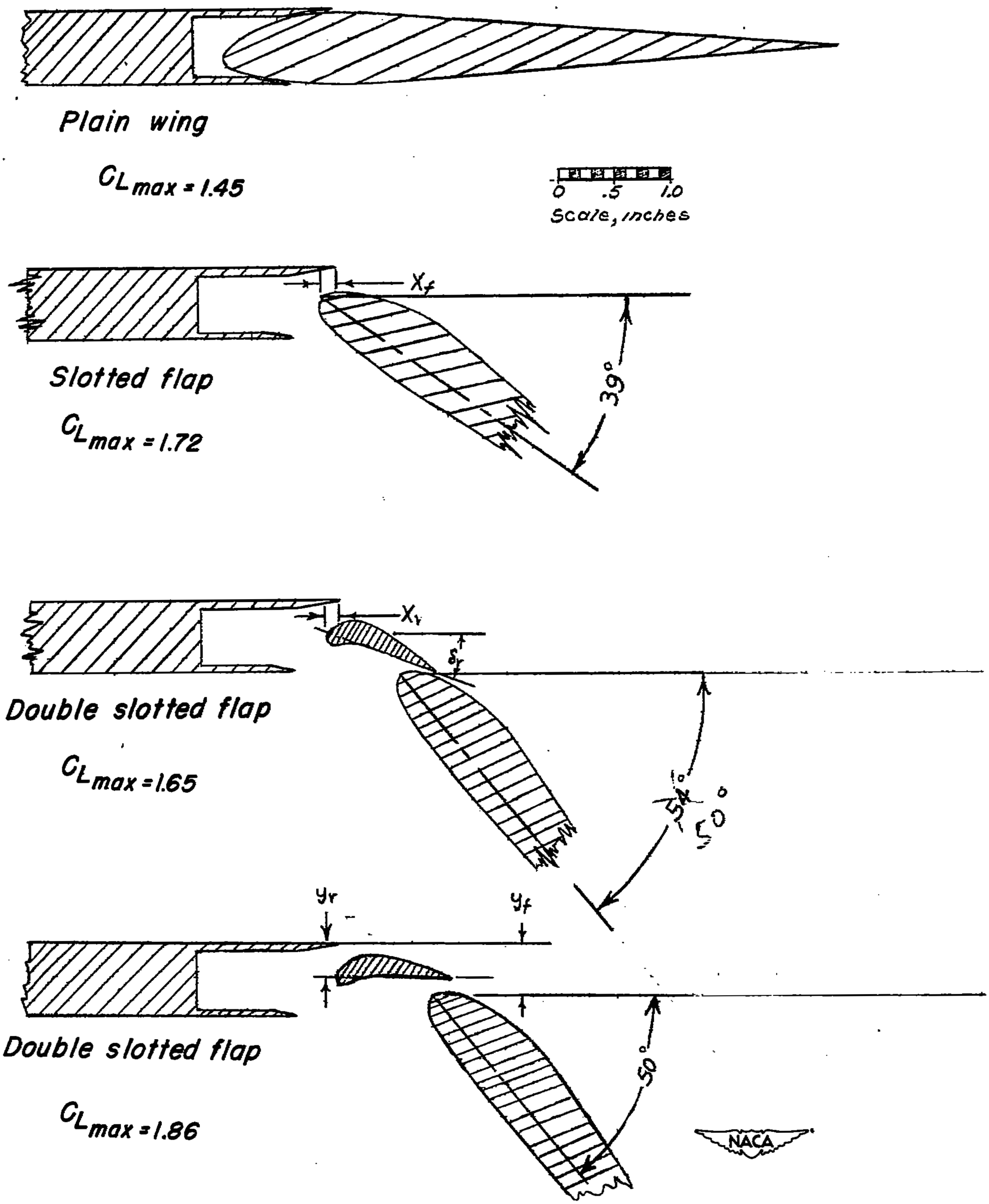

Figure 4.- The trailing-edge flaps used on the 60° delta wing model.

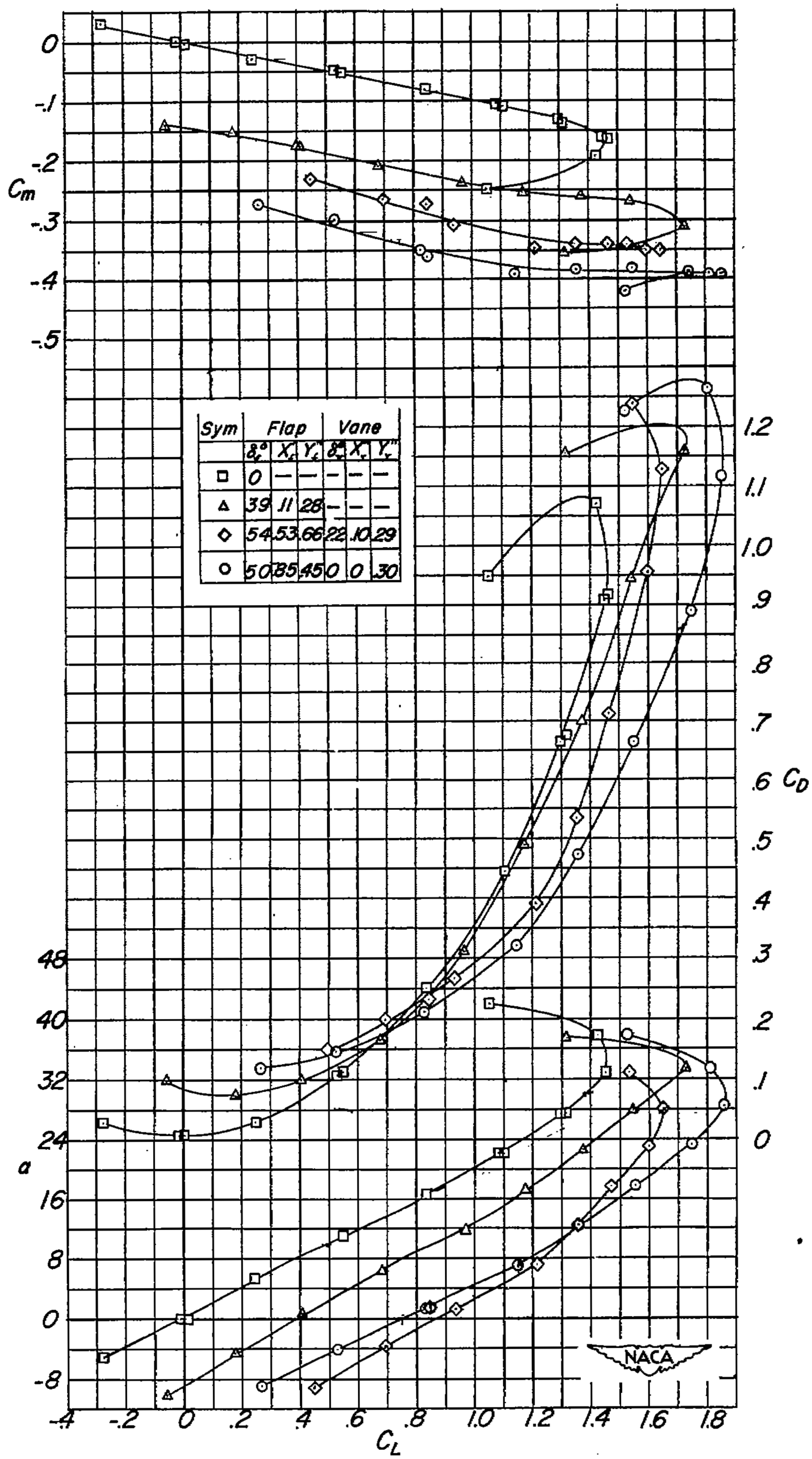

Figure 5.- The aerodynamic characteristics of the 60° delta wing model.

SECURITY INFORMATION

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