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THE EFFECTS OF WING-TIP DROOP ON THE AERODYNAMIC CHARACTERISTICS OF A DELTA-WING AIRCRAFT AT SUPERSONIC SPEEDS

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THE EFFECTS OF WING-TIP DROOP ON THE AERODYNAMIC CHARACTERISTICS OF A DELTA-WING AIRCRAFT AT SUPERSONIC SPEEDS*

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SUMMARY

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Six-component force tests were conducted at Mach numbers of 3.0, 3.5, and 4.0 on a canard, delta-wing aircraft configuration to determine the effects of wing-tip droop on performance and stability. Wing-tip areas varying from 4 to 16 percent of the total wing area were drooped to angles up to 90° about streamwise hinge lines and hinge lines canted inward as much as 8°. The incremental changes in performance and stability due to the various forms of wing-tip droop are compared with estimates based on linearized theories.

In general, drooping the wing tips of the test configuration resulted in forward shifts in the aerodynamic center, increases in directional stability, and decreases in the maximum lift-drag ratio (untrimmed). Moderate, but significant, decreases in longitudinal stability and increases in directional stability were obtained in many cases with relatively small performance penalties. For example, at a Mach number of 3.0, one configuration of tip droop produced, relative to the straight-wing model, a forward shift in aerodynamic center of 4-1/2 percent of the mean aerodynamic chord and an increase in the directional stability derivative of 0.0005 per degree while the maximum lift-drag ratio was decreased less than 1 percent. Larger reductions in longitudinal stability and increases in directional stability were obtained with other configurations, but the associated performance penalties were more severe.

Estimated values of the incremental changes in performance and stability due to drooping the wing tips were in fairly good agreement with the measured values.

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INTRODUCTION

Two aerodynamic problems associated with the development of efficient supersonic aircraft are the decrease in directional stability with increasing supersonic Mach number and the large stabilizing shift in aerodynamic center during transition from subsonic to supersonic flight speeds. To compensate for these phenomena the aircraft usually must carry larger vertical stabilizing surfaces than are necessary at subsonic or low supersonic speeds, and it must have large longitudinal control surfaces to provide maneuverability and trim at supersonic speeds. Thus the requirements for directional stability and longitudinal control result in increases in drag and corresponding reductions in the trimmed lift-drag ratio at supersonic speeds.

One method of reducing the performance penalties associated with these stability problems is to droop a portion of the wing tip about essentially streamwise hinge lines at supersonic speeds. If the wing is of sweptback or delta plan form, the area drooped will be at the rear of the wing, and a forward shift in aerodynamic center will be induced. At the same time, directional stability will be improved as a result of the addition of vertical stabilizing area aft of the airplane center of gravity. The resulting decrease in effective lifting area will of course cause some loss in lift-curve slope, but the reduction in the trim drag and the drag of the vertical fin may more than compensate for this loss in lift. Thus, it may be possible to improve the trimmed maximum lift-drag ratio of an aircraft by drooping its wing tips at supersonic speeds.

Some experiments have been conducted to evaluate the effects of wing-tip droop at high supersonic speeds (refs. 1, 2, and 3) and at low supersonic speeds (ref. 4). However, these and other test results provide only limited information on the effects of varying the amount of tip drooped, the angle of droop, and the wing-tip hinge-line cant angle. The purpose of the present paper is to present experimental results showing the effects of systematic variations of these wing-tip geometry parameters on the performance and stability of a representative aircraft at supersonic speeds. These effects were evaluated from tests of a number of configurations with various spanwise hinge-line locations, hinge-line cant angles, and wing-tip droop angles. Although a rather specialized canard, delta-wing aircraft was used in these tests, the results should be roughly applicable to any delta-wing aircraft with drooped wing tips.

Estimates of the incremental effects of drooping the wing tips were made by means of linearized theories, and these estimates were compared with the measured incremental changes in aerodynamic characteristics.

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SYMBOLS

b	wing span
c_r	wing root chord
$\bar{c}$	wing mean aerodynamic chord
C_D	drag coefficient, $\frac{D}{qS}$
C_L	lift coefficient, $\frac{L}{qS}$
C_l	rolling-moment coefficient, $\frac{\text{rolling moment}}{qSb}$
C_m	pitching-moment coefficient, $\frac{\text{pitching moment}}{qS\bar{c}}$
C_n	yawing-moment coefficient, $\frac{\text{yawing moment}}{qSb}$
C_Y	side-force coefficient, $\frac{\text{side force}}{qS}$
D	drag
L	lift
M	Mach number
q	stream dynamic pressure
S	wing reference area, $\frac{bc_r}{2}$
S_t	area of deflected wing tips
α	angle of attack, measured between stream direction and wing center plane
β	angle of sideslip, measured between stream direction and vertical plane of symmetry
i_c	canard incidence angle, measured between canard center plane and wing center plane, positive when the canard angle of attack is greater than the wing angle of attack
δ_t	wing-tip droop angle, measured between wing-tip center plane and wing center plane, positive when the wing tip is deflected downward
ω	wing-tip hinge-line cant angle, measured between wing-tip hinge line and vertical plane of symmetry, positive when the forward portion of the hinge line is canted inward.

[redacted]

[redacted]

Prefix

Δ incremental change due to wing-tip droop

Subscripts

o conditions at $\alpha = 0^{\circ}$

max maximum

α rate of change with α at $\alpha = 0^{\circ}$, per radian

β rate of change with β at $\beta = 0^{\circ}$, per deg

Symbols used exclusively in the appendix are defined where used. Lift and drag coefficients are referred to wind axes; side-force coefficients and all moment coefficients are referred to body axes. All aerodynamic coefficients are based on the area, mean aerodynamic chord, and span of the complete delta wing with tips undrooped.

EXPERIMENT

Apparatus and Tests

The tests were conducted in the Ames 10- by 14-inch supersonic wind tunnel at Mach numbers of 3.0, 3.5, and 4.0. The 10- by 14-inch tunnel is described in reference 5. Normal, axial, and side forces and pitching, yawing, and rolling moments were measured with a six-component strain-gage balance. Approximately half of the balance projected into the model; the remaining half extended rearward to the tunnel sting mount. The external portions of the balance were shielded to prevent the direct action of aerodynamic forces upon the balance. In most cases the test angle-of-attack range was from about -1° to about $+8^{\circ}$; in a few cases this range was extended to include angles of attack from about -3° to about $+12^{\circ}$. The directional and lateral data were obtained through a range of sideslip angles from -4° to $+4^{\circ}$ at an angle of attack of approximately $+3\text{-}1/2^{\circ}$.

At each data point, the base pressure on the body was measured, and the body base drag, determined from the difference between the measured base pressure and the free-stream static pressure, was subtracted from the

[redacted]

measured axial force. The normal- and axial-force data were then converted to wind axes to obtain C_L and C_D. The side forces and the pitching, yawing, and rolling moments were retained in body axes.

Wind-tunnel calibration data were employed in combination with stagnation-pressure measurements to obtain the stream static and dynamic pressures. Test Reynolds numbers, based on the mean aerodynamic chord of the model wing, were:

Mach number	Reynolds number
3.0	3.2×10^6
3.5	3.9×10^6
4.0	3.2×10^6

A
2
5
6

Model

A sketch of the test model and its pertinent geometric properties is shown in figure 1. The basic configuration consisted of a delta wing mounted below the rear portion of a long fuselage. A canard control surface was mounted on the fuselage forward and somewhat above the wing. An engine installation was simulated by a wedge beneath the wing. A boundary-layer channel, located between the wing apex and the fuselage, was designed to prevent the forebody boundary layer from reaching the simulated engine installation. The rear section of the fuselage was widened to accommodate the balance.

Five wings were constructed to allow the testing of the various wing-tip hinge lines. Each wing was grooved along a different hinge line, and the wing tips were bent in successive increments downward. At each desired angle of wing-tip droop, the hinge-line grooves were filled with solder and smoothed into the wing contours before the tests.

The effect of varying the amount of wing drooped was determined with three of the wings which had streamwise hinge lines such that, respectively, 4, 9, and 16 percent of the wing area was drooped. The spanwise locations of these hinge lines were, respectively, 80, 70, and 60 percent of the wing semispan from the model vertical plane of symmetry. On the remaining two wings the hinge lines were located so that 9 percent of the wing area of each wing was drooped, but the hinge lines were canted inward by 4° and 8° (fig. 1(b)). The wing tips of the configuration with 9 percent of its wing area drooped about uncanted hinge lines were drooped downward in increments of 15° until they reached the 90°, fully deflected, position. The wing tips of the other four configurations were drooped downward in increments of 30°. All five wings were initially tested with no tip droop so that any effects of small geometric differences in the five wings could be eliminated from the incremental data.

[redacted]

The twin vertical fins shown in figure 1(a) were attached to the wing having 4 percent of its area drooped about uncanted hinge lines; the other four wings had no fins. The estimated position of the Mach line from the leading edge of the vertical fins indicates that, within the test Mach number range, no interaction between the fins and the 4-percent wing tips with the uncanted hinge lines should occur.

The canard control surface was tested at incidence angles of 0°, 3°, and 6° relative to the wing, both with the wing tips undrooped and with 16 percent of the wing area drooped 90° about an uncanted hinge line. For comparative purposes, the model was also tested without the cylindrical fuselage section containing the canard. This short-nose configuration (fig. 1(a)) was tested with the wing tips undrooped. A
2
5
6

The moment reference center for all tests was located at 25 percent of the mean aerodynamic chord and in the center plane of the wing.

Accuracy of Test Results

The accuracy of the test results was influenced by uncertainties in the measurements of forces and moments and in the determination of stream static and dynamic pressures and angles of attack and sideslip. These uncertainties resulted in estimated maximum errors in the test results as shown in the following table:

M	C_L	C_D	C_m	C_{Y_β}, per deg	C_{n_β}, per deg	C_{l_β}, per deg	α, deg
3.0	±0.003	±0.0003	±0.0005	±0.0001	±0.00003	±0.00004	±0.1
3.5	.003	.0003	.0005	.0001	.00003	.00004	.1
4.0	.003	.0004	.0007	.0002	.00004	.00006	.1

It should be noted that, for the most part, the test results presented herein are in error by less than these estimates.

RESULTS AND DISCUSSION

The complete experimental results of the tests are presented in table I. Lift, drag, and pitching-moment coefficients, angles of attack, lift-drag ratios, and the side-force, directional, and lateral stability derivatives are listed for each of the model configurations at Mach numbers of 3.0, 3.5, and 4.0.

[redacted]

In table II the incremental changes in performance and stability due to wing-tip droop, canard deflection, and the addition of vertical fins are tabulated. For reference, the aerodynamic characteristics of the basic configuration (fins off, canard incidence angle of 3°, wing tips undrooped) are also listed. These characteristics were obtained by averaging the results of the several tests of the basic model configuration.

Typical plots of the lift, drag, and pitching-moment characteristics with varying angle of attack are presented in figure 2. The data shown are for the basic configuration and the configuration with 9 percent of the wing area drooped 90° about streamwise hinge lines. The large rearward shift in aerodynamic center at angles of attack higher than 5° to 7° does not appear to be due to wind-tunnel wall interference or canard stall, and published data from tests of models with similar canard and wing placements do not show a similar shift in aerodynamic center. However, as indicated in figure 2, there was no shift in aerodynamic center when the short-nose configuration with no canard was tested which indicates that the shift probably was due to some form of canard interference.

In the following discussion, the incremental changes in aerodynamic characteristics induced by drooping the wing tips of the basic configuration are examined and compared with the incremental changes estimated with the analytical methods outlined in the appendix. The effects of adding the twin vertical fins and of changing the canard incidence angle are also discussed briefly.

Longitudinal Stability

The changes in C_{m_0} and aerodynamic-center location due to wing-tip droop are shown in figures 3 and 4. Estimated values of ΔC_{m_0} and aerodynamic center shift are presented for comparison with the experimental data. The effects of varying the spanwise location of the wing-tip hinge line are illustrated in figure 3, while the effects of canting the hinge line appear in figure 4.

In general, the experimental values of ΔC_{m_0} differed from the estimated values by a negative increment which appeared to be dependent on wing-tip droop angle. This nose-down increment in ΔC_{m_0} is believed to be primarily due to the influence of the 7° semiapex-angle wedge located beneath the wing of the test configuration. Since this increment is roughly similar, but opposite in sign, to the increment induced by canting the wing-tip hinge line slightly inward (fig. 4), it appears likely that the wedge beneath the wing causes the streamlines in the region of the wing tip to be canted outward slightly. This stream deflection would induce lifting pressures on the undersurface of the deflected tip and on the lower surface of the wing in the region of tip interference, which would lead to negative increments in ΔC_{m_0}.

[redacted]

The forward shifts in aerodynamic center induced by drooping the wing tips are in fairly good agreement with the values estimated by calculating the theoretical loss in lift at the tip. The wing with 16 percent of its area drooped 90° yielded the largest shifts in aerodynamic center (roughly 8 to 10 percent of the mean aerodynamic chord). As expected, canting the wing-tip hinge line had only a slight effect on the shift in aerodynamic center.

Directional and Lateral Stability

The directional and lateral data were plotted relative to sideslip angle, β, and the derivatives, C_{Y_β}, C_{n_β}, and C_{l_β}, were evaluated from the plots. Because the test results were essentially linear within the ±4° range of sideslip angles, only these derivatives are presented and discussed herein. In figures 5 and 6 the incremental changes in C_{Y_β}, C_{n_β}, and C_{l_β} are plotted and compared with the estimates of the changes in these derivatives. It is apparent that the estimates show the same trends as the experimental data. However, the estimates are considerably higher than the measured values, especially at the lower Mach numbers. In fact the experimental values of ΔC_{Y_β}, ΔC_{n_β}, and ΔC_{l_β} are roughly 50, 60, and 90 percent of the estimated values at $M = 3.0$, 3.5, and 4.0, respectively.

It should be noted that the estimated incremental changes in C_{Y_β}, C_{n_β}, and C_{l_β} are for $\alpha = 0^\circ$ while the wind-tunnel results presented are for $\alpha \cong 3\text{-}1/2^\circ$. However, it is unlikely that this difference in angle of attack would result in large differences in the incremental changes in directional and lateral stability induced by wing-tip droop.

The most probable explanation of the discrepancies between the estimated and experimental values of ΔC_{Y_β}, ΔC_{n_β}, and ΔC_{l_β} is that the assumptions used in making the estimates were too simplified. It was implicitly assumed in making the estimates that the wing acted as a tip plate for the drooped wing tip, and therefore that the wing tip had the same characteristics as one half of a complete delta wing. This is consistent with the assumption that the drooped wing tip acts as a tip plate for the wing, but obviously neither of these assumptions is accurate, especially on the upper surface of the wing and the outer surface of the wing tip. In fact a more accurate prediction of the effect of the drooped wing tip might be obtained if it is assumed that the pressure distribution on the outer surface of the wing tip was not influenced by the wing, and if this pressure distribution is calculated as if the wing tip had a free edge at its hinge line. This method of estimation would reduce the estimated values of ΔC_{Y_β}, ΔC_{n_β}, and ΔC_{l_β} by roughly 20 percent in the test Mach number range.

[redacted]

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The maximum incremental change in C_{n_β} was approximately +0.0008 per degree for the configurations with considerable amounts of wing-tip droop. For similar amounts of droop, canting the wing-tip hinge lines inward 4° resulted in further increases in ΔC_{n_β} of as much as 0.0002 per degree. Drooping the wing tips also resulted in sizable increases in C_{l_β} with the maximum increase occurring at approximately 50° of droop.

Performance

The measured and the estimated incremental changes in C_{L_o}, C_{D_o}, C_{L_α}, and $(L/D)_{max}$ due to wing-tip droop are presented in figures 7, 8, 9, and 10.

As shown in figures 7 and 8, there was some loss in C_{L_α} as a result of drooping the wing tips, although, in general, this loss was less than predicted from the calculations of loss of lift in the tip region (see appendix). As expected, the additional effect of canting the wing-tip hinge lines was negligible. The variation between the estimated and experimental values of ΔC_{L_o} is again believed to be associated with the interference effect due to the wedge beneath the wing of the test configuration, as was discussed with regard to the ΔC_{m_o} induced by wing-tip droop.

The incremental changes in $(L/D)_{max}$ due to wing-tip droop are compared with the estimated values in figures 9 and 10. There is considerable scatter in the data but, in general, the experimentally determined incremental losses in $(L/D)_{max}$ were less than estimated. This may be attributed chiefly to the fact that the values of C_{L_o} were somewhat higher than those estimated, while C_{D_o} and C_{L_α} followed more closely the estimated values. As a result, for droop angles up to the order of 45°, little or no loss in $(L/D)_{max}$ occurred.

In figure 11 the variations in C_{n_β} and aerodynamic-center location are plotted as functions of the change in $(L/D)_{max}$ for all the configurations utilizing wing-tip droop. It is apparent that, in general, there is a fairly good correlation between the changes in directional and longitudinal stability and the corresponding changes in $(L/D)_{max}$ when the wing tips are drooped. Of the configurations tested, the wing with 9 percent of its area drooped about a hinge line canted inward 4° produced the largest changes in directional and longitudinal stability for a given penalty in $(L/D)_{max}$. At $M = 3$ drooping this wing tip 60° resulted in an increase in C_{n_β} of 0.0005 per degree and a forward shift in the aerodynamic center of 4-1/2 percent of the mean aerodynamic chord, while $(L/D)_{max}$ was decreased by less than 0.05.

[redacted]

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Effects of Adding Vertical Fins

The incremental changes in aerodynamic characteristics due to the addition of the twin vertical fins are tabulated in table II. Because of the close proximity of the fins to the expanded afterbody of the fuselage, some body-fin interference may have existed, but the incremental changes due to the fins do provide some basis for comparison with the incremental changes due to wing-tip droop. The fins had a total plan-form area of about 16 percent of the wing area and they produced an increase in C_{n_β} of roughly 0.0010 per degree, a decrease in C_{l_β} of about 0.0002 per degree, and a loss in $(L/D)_{max}$ of roughly 0.50.

Effects of the Canard Control Surface

The effects of varying the canard incidence angle were determined both with the wing tips undrooped and with 16 percent of the wing area drooped 90°. The second configuration was chosen to determine whether there might be any significant interactions between the drooped wing tip and the canard when the canard incidence angle was varied.

In figure 12 the aerodynamic characteristics of the configuration with no tip droop and the configuration with 16 percent of its wing area drooped 90° are plotted as functions of the canard incidence angle. The variation of each aerodynamic characteristic with varying canard incidence angle was approximately the same whether the tips were drooped or undrooped, indicating that there was little interaction between the drooped wing tip and the canard when the canard incidence angle was varied. As expected, the canard was quite effective in increasing C_{m_O}, but there was a concurrent, sizable loss in $(L/D)_{max}$.

A further test was made with the canard and a section of the fuselage removed. The reduction in fuselage length was about 17 percent. The incremental changes due to this modification are presented in table II under the designation "short nose." Removing the canard caused a decrease in drag and increased the $(L/D)_{max}$ by roughly 0.30. It was impossible to evaluate the effect on C_{n_β} of removing the canard since the associated reduction in forebody length also influenced C_{n_β}.

CONCLUDING REMARKS

In general, drooping the wing tips of the test configuration at Mach numbers of 3.0, 3.5, and 4.0 resulted in increases in directional stability and decreases in longitudinal stability with small reductions in $(L/D)_{max}$.

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Increases in C_{n_β} of up to 0.0005 per degree and forward shifts of the aerodynamic center of as much as 4 percent of the mean aerodynamic chord were obtained by configurations which suffered penalties of less than 2 percent in $(L/D)_{max}$ due to tip droop. Drooping the wing tips with the hinge line canted inward 4° induced the greatest changes in stability with the least penalties in performance. However, the superiority of this canted hinge line may be associated with the presence of the wedge beneath the wing of the test configuration.

The vertical fins used in the tests produced an increase in C_{n_β} of roughly 0.0010 per degree and a corresponding loss in $(L/D)_{max}$ of about 6 percent. In comparison, some of the tip droop configurations produced 50 percent of this change in C_{n_β} with as little as 1-percent penalty in $(L/D)_{max}$. Thus it appears that reducing the area of the vertical fins and using wing-tip droop to compensate for the associated loss in directional stability may increase $(L/D)_{max}$ at supersonic speeds. In addition the decrease in longitudinal stability due to drooping the wing tips should reduce the trim drag and further increase the trimmed lift-drag ratio of the configuration.

It should be noted that both the wing-tip droop and the reduction in area of the vertical fins lead to increases in C_{l_β} and it may be necessary to compensate for this effect in order to maintain the lateral stability of the aircraft.

For the most part, the simple linear theory methods presented in the appendix adequately predicted the incremental changes in aerodynamic characteristics induced by drooping the wing tips. However, C_{Y_β}, C_{n_β}, and C_{l_β} were somewhat overestimated by the methods of the appendix, and there were some discrepancies in C_{L_o}, C_{m_o}, and $(L/D)_{max}$ which were believed to be primarily due to the effect of the wedge beneath the wing of the test configuration.

Ames Research Center
National Aeronautics and Space Administration
Moffett Field, Calif., Dec. 18, 1959

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APPENDIX

ESTIMATES OF THE EFFECT OF WING-TIP DROOP ON PERFORMANCE AND STABILITY

In estimating the incremental changes in performance and stability due to wing-tip droop, no attempt was made to analyze the rather complex interference phenomena that are known to exist over the model configuration at supersonic speeds. Instead, only estimates of the incremental effects of drooping the wing tips of an isolated delta wing were made. This wing had a leading-edge sweep angle of $64^{\circ}50'$ which was supersonic for all conditions studied. Except where noted, the wing was assumed to be a flat plate and linearized solutions were used to estimate the various performance and stability parameters.

Performance and Longitudinal Stability Estimates

C_{L_α} and dC_m/dC_L.- The decrease in C_{L_α} and the forward shift in aerodynamic center due to drooping the wing tips were estimated on the assumption that a linearized conical flow field exists over the delta wing at angle of attack. This flow field is analyzed in reference 6, and expressions are given for the pressure along any ray from the apex of the wing when the leading edge is supersonic. To estimate C_{L_α} and C_{m_α}, it was assumed that the wing tips acted as end plates when drooped, and therefore, that the chordwise lift distribution over the undrooped portion of the wing was not affected by drooping the tips. (These comments apply only to the lifting forces due to angle of attack.) Values of C_{L_α} and C_{m_α} with the tips drooped 90° were then obtained from integrations of the lift distribution over the undrooped portion of the wing. To estimate C_{L_α} and C_{m_α} at intermediate values of tip droop it was noted that as the tip is drooped, the angle of incidence of the tip to the air stream varies as $\cos \delta_t$ if the given α is small. It was assumed that the normal force on the tip was a linear function of the angle of incidence of the tip to the air stream. (This assumption is not strictly accurate since a portion of the wing tip is influenced by the pressure distribution on the wing.) The ratio of the lifting component to the normal component of the forces on the tip also varies as $\cos \delta_t$. Therefore it was assumed that the lift carried by the tip varied as $\cos^2\delta_t$ for a given α.

Canting the hinge line of the tips caused only a slight change in the geometry of the drooped area, and for the most part, this area was in a

[redacted]

region of uniform pressure. Therefore it was presumed that canting the hinge line of the wing tips would have a negligible effect on the variation of C_{L_α} and C_{m_α}.

The location of the aerodynamic center was obtained by dividing C_{m_α} by C_{L_α} to obtain dC_m/dC_L. The variation in aerodynamic-center location was expressed in percent of the mean aerodynamic chord, $\bar{c}$, forward of the location with no tip droop which was at 50 percent of $\bar{c}$.

<u>ΔC_{L_O} and ΔC_{D_O}</u>.- If the wing is at zero angle of attack and the wing-tip hinge lines are parallel to the air stream, all surfaces of the wing remain parallel to the air stream when the tips are drooped. Therefore it was assumed that there was no change in C_{L_O} and C_{D_O} with tip droop when the hinge lines of the tips were not canted.

To estimate the changes in C_{L_O} and C_{D_O} due to drooping the wing tips with canted hinge lines, the coefficient of the normal force on each wing tip was assumed to be:

$$C_{N_t} = \frac{4}{\sqrt{M^2 - 1}} \alpha_t \frac{S_t}{2S}$$

where

C_{N_t} $\quad \dfrac{\text{normal force on the wing tip}}{qS}$

α_t $\quad$ angle of incidence of the wing tip to the air stream, radians

(Note that $\alpha_t = \omega \sin \delta_t$ if ω is small.) The lift and drag components of C_{N_t} were then calculated to obtain estimates of the change in C_{L_O} and C_{D_O} due to the aerodynamic forces acting on the drooped tips.

A further change in C_{L_O} was induced by the action of the interference pressure field of the wing tip on the lower surface of the wing. The coefficient of the pressure induced by the wing tip was taken to be:

$$C_{p_t} = \frac{2}{\sqrt{M^2 - 1}} \alpha_t$$

This pressure was assumed to act over a portion of the lower surface of the wing bounded by the Mach line from the leading edge of the wing tip at the hinge line, the trailing edge of the wing, and the wing-tip hinge line. The change in C_{L_O} due to this interference pressure from the wing

[redacted]

tip was then determined and added to the change in C_{L_o} due to the aerodynamic forces on the drooped wing tips.

$\underline{\Delta C_{m_o}}$.- The change in C_{m_o} due to tip droop was determined by adding the effects of three contributions to C_{m_o}. The first of these contributions considered was the effect of the friction drag and wave drag due to thickness of the wing tip acting through the center of area of the wing tip. Rough estimates of this effect indicated that the change in C_{m_o} due to the friction and wave drag of the tip was negligible.

The two remaining contributions to C_{m_o} occurred only when the hinge line was canted. They were respectively the effect of ΔC_{D_o} on C_{m_o} and the effect of ΔC_{L_o} on C_{m_o}. The change in C_{D_o} due to wing-tip droop, ΔC_{D_o}, was assumed to act through the center of area of the wing tip. The change in C_{L_o} due to the aerodynamic forces on the wing tip was also assumed to act through the center of area of the wing tip, and the change in C_{L_o} due to the interference field of the wing tip acting on the lower surface of the wing was assumed to act through the center of the area influenced by the wing-tip pressure field. The increment ΔC_{m_o} was determined by addition of the effects of ΔC_{D_o} and ΔC_{L_o} on C_{m_o}.

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$\underline{\Delta(L/D)_{max}}$.- To estimate $(L/D)_{max}$ it was assumed that:

$$C_L = C_{L_o} + C_{L_\alpha}\alpha$$

and

$$C_D = C_{D_o} + C_{L_o}\alpha + C_{L_\alpha}\alpha^2$$

These relationships give:

$$\left(\frac{L}{D}\right)_{max} = \frac{C_{L_\alpha}}{2\sqrt{C_{L_\alpha}C_{D_o}} - C_{L_o}}$$

For the basic configuration with no tip droop, the values of C_{L_α}, C_{L_o}, and C_{D_o} determined experimentally were used. The estimated values of ΔC_{L_α}, ΔC_{L_o}, and ΔC_{D_o} were added to these values to obtain values of C_{L_α}, C_{L_o}, and C_{D_o} with the tips drooped, and the corresponding $(L/D)_{max}$ was calculated for each of the tip-droop configurations.

[redacted]

Directional and Lateral Stability Estimates

C_{Y_β} and C_{n_β}.- Estimates of C_{Y_β} and C_{n_β} were made for $\alpha = 0^\circ$. The coefficient of the normal force on each wing tip was again taken to be:

$$C_{N_t} = \frac{4}{\sqrt{M^2 - 1}} \alpha_t \frac{S_t}{2S}$$

where $\alpha_t = (\beta \pm \omega)\sin \delta_t$ if β and ω are small. The normal-force coefficient was calculated as a function of the sideslip angle, β, and the side-force component of this normal-force coefficient was then determined to give C_Y as a function of β and hence C_{Y_β}. To estimate C_{n_β} it was assumed that the side force on the tip acted at the center of area of the tip.

C_{l_β}.- The rolling moment due to sideslip angle at $\alpha = 0^\circ$ was estimated by adding the effect of the aerodynamic forces on the wing tips and the effect of the interference pressure field from the tip acting on the lower surface of the wing. The normal force on the tip, C_{N_t}, was again assumed to act at the center of area of the wing tip, and the rolling moment, C_l, due to β was evaluated to obtain C_{l_β} due to the forces on the wing tips.

The pressure coefficient induced by the wing tip was taken to be:

$$C_{p_t} = \frac{2}{\sqrt{M^2 - 1}} \alpha_t$$

and this pressure was assumed to act over the portion of the lower wing surface bounded by the Mach line from the leading edge of the wing tip at the hinge line, the trailing edge of the wing, and the wing-tip hinge line. The force due to the interference pressure was assumed to act at the center of the area affected by the interference field, and C_l due to β and C_{l_β} were calculated.

REFERENCES

1. Eggers, A. J., Jr., and Syvertson, Clarence A.: Aircraft Configurations Developing High Lift-Drag Ratios at High Supersonic Speeds. NACA RM A55L05, 1956.

2. Syvertson, Clarence A., Wong, Thomas J., and Gloria, Hermilo R.: Additional Experiments With Flat-Top Wing-Body Combinations at High Supersonic Speeds. NACA RM A56I11, 1957.

3. Syvertson, Clarence A., Gloria, Hermilo R., and Sarabia, Michael F.: Aerodynamic Performance and Static Stability and Control of Flat-Top Hypersonic Gliders at Mach Numbers From 0.6 to 18. NACA RM A58G17, 1958.

4. Peterson, Victor L.: The Effects of Streamwise-Deflected Wing Tips on the Aerodynamic Characteristics of an Aspect-Ratio-2 Triangular Wing, Body, and Tail Combination. NASA MEMO 5-18-59A, 1959.

5. Eggers, A. J., Jr., and Nothwang, George J.: The Ames 10- by 14-Inch Supersonic Wind Tunnel. NACA TN 3095, 1954.

6. Cohen, Doris: The Theoretical Lift of Flat Swept-Back Wings at Supersonic Speeds. NACA TN 1555, 1948.

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TABLE I.- EXPERIMENTAL RESULTS

Fins on, $i_c = 3^o$, $S_t/S = 0.04$, $\omega = 0^o$, $\delta_t = 0^o$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-2.2	-0.038	0.0136	-2.82	0.0075			
	-1.0	-.010	.0116	-.85	.0072			
	.2	.019	.0115	1.65	.0043			
	1.4	.048	.0129	3.71	.0014			
	2.5	.074	.0152	4.89	-.0004			
	3.7	.103	.0187	5.48	-.0034	-0.0055	0.00023	-0.00073
	4.9	.129	.0232	5.54	-.0055			
	6.0	.158	.0291	5.41	-.0124			
	7.2	.187	.0364	5.14	-.0214			
	8.3	.217	.0442	4.90	-.0328			
3.5	-2.2	-.036	.0121	-3.00	.0071			
	-1.0	-.010	.0102	-.98	.0062			
	.1	.016	.0102	1.53	.0035			
	1.3	.040	.0112	3.59	.0014			
	2.5	.065	.0134	4.84	-.0005			
	3.6	.089	.0166	5.36	-.0019	-.0050	-.00002	-.00056
	4.8	.112	.0206	5.46	-.0036			
	6.0	.136	.0256	5.31	-.0067			
	7.1	.161	.0317	5.09	-.0135			
	8.2	.187	.0395	4.74	-.0235			
	9.3	.218	.0501	4.36	-.0394			
4.0	-3.2	-.051	.0131	-3.90	.0090			
	-2.1	-.032	.0114	-2.84	.0081			
	-1.0	-.008	.0098	-.81	.0055			
	.1	.012	.0097	1.18	.0034			
	1.2	.032	.0106	3.03	.0012			
	2.3	.053	.0122	4.32	-.0007			
	3.4	.074	.0147	4.99	-.0023	-.0045	-.00004	-.00033
	4.5	.094	.0181	5.21	-.0038			
	5.6	.114	.0222	5.14	-.0048			
	6.7	.134	.0272	4.94	-.0059			
	7.8	.155	.0332	4.67	-.0076			
	8.9	.176	.0399	4.40	-.0077			
	10.0	.197	.0478	4.12	-.0132			
	11.0	.221	.0571	3.88	-.0227			
	12.1	.245	.0667	3.67	-.0308			

Fins on, $i_c = 3^o$, $S_t/S = 0.04$, $\omega = 0^o$, $\delta_t = 60^o$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-0.013	0.0118	-1.09	0.0060			
	.1	.015	.0115	1.33	.0035			
	1.3	.043	.0127	3.38	.0014			
	2.5	.071	.0149	4.74	-.0008			
	3.7	.097	.0181	5.36	-.0018	-0.0056	0.00039	-0.00055
	4.9	.124	.0225	5.51	-.0037			
	6.0	.150	.0278	5.39	-.0054			
	7.2	.177	.0344	5.13	-.0083			
	8.3	.205	.0425	4.83	-.0162			
3.5	-1.0	-.013	.0104	-1.21	.0055			
	.1	.011	.0102	1.10	.0033			
	1.3	.036	.0111	3.26	.0012			
	2.4	.061	.0131	4.62	-.0008			
	3.6	.084	.0161	5.25	-.0013	-.0054	.00023	-.00036
	4.8	.108	.0200	5.40	-.0027			
	6.0	.131	.0247	5.28	-.0034			
	7.1	.154	.0306	5.02	-.0040			
	8.3	.179	.0379	4.72	-.0104			
4.0	-1.0	-.012	.0099	-1.17	.0051			
	.1	.008	.0097	.81	.0034			
	1.2	.028	.0104	2.69	.0014			
	2.2	.048	.0119	4.06	-.0004			
	3.3	.069	.0142	4.84	-.0020	-.0051	.00032	-.00010
	4.4	.091	.0176	5.16	-.0040			
	5.5	.110	.0215	5.12	-.0050			
	6.6	.129	.0262	4.93	-.0047			
	7.8	.149	.0319	4.69	-.0057			

Fins on, $i_c = 3^o$, $S_t/S = 0.04$, $\omega = 0^o$, $\delta_t = 30^o$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-.010	.0118	-.83	.0063			
	.2	.020	.0117	1.70	.0033			
	1.3	.048	.0131	3.68	.0006			
	2.5	.076	.0154	4.92	-.0016			
	3.7	.103	.0189	5.46	-.0044	-.0057	.00029	-.00061
	4.9	.132	.0226	5.58	-.0080			
	6.0	.159	.0295	5.38	-.0138			
	7.2	.187	.0366	5.11	-.0196			
	8.3	.218	.0451	4.84	-.0325			
3.5	-1.0	-.010	.0105	-.92	.0055			
	.2	.016	.0105	1.51	.0032			
	1.3	.040	.0115	2.50	.0010			
	2.5	.066	.0138	4.76	-.0012			
	3.6	.090	.0178	5.33	-.0034	-.0053	.00006	-.00040
	4.8	.114	.0210	5.43	-.0051			
	6.0	.140	.0264	5.29	-.0106			
	7.1	.164	.0325	5.04	-.0148			
	8.2	.190	.0398	4.78	-.0233			
4.0	-1.0	-.010	.0100	-.96	.0062			
	.1	.011	.0099	1.10	.0030			
	1.2	.031	.0107	2.94	.0007			
	2.3	.052	.0123	4.22	-.0011			
	3.4	.073	.0148	4.92	-.0028	-.0047	.00010	-.00014
	4.5	.093	.0181	5.15	-.0043			
	5.6	.114	.0224	5.12	-.0058			
	6.7	.135	.0275	4.93	-.0082			
	7.8	.156	.0334	4.66	-.0095			

Fins on, $i_c = 3^o$, $S_t/S = 0.04$, $\omega = 0^o$, $\delta_t = 90^o$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-2.2	-.032	.0130	-2.49	.0055			
	-1.0	-.008	.0116	-.72	.0052			
	.2	.018	.0117	1.56	.0038			
	1.3	.045	.0129	3.50	.0022			
	2.5	.070	.0150	4.69	.0010			
	3.7	.097	.0181	5.33	-.0012	-.0058	.00046	-.00060
	4.9	.122	.0225	5.45	-.0032			
	6.0	.149	.0279	5.32	-.0050			
	7.2	.174	.0344	5.05	-.0068			
	8.3	.202	.0425	4.76	-.0148			
3.5	-2.2	-.031	.0115	-2.71	.0053			
	-1.0	-.009	.0102	-.88	.0050			
	.1	.014	.0102	1.41	.0033			
	1.3	.038	.0112	3.42	.0017			
	2.5	.062	.0133	4.64	.0005			
	3.6	.085	.0163	5.19	-.0010	-.0054	.00026	-.00047
	4.8	.108	.0202	5.34	-.0025			
	5.9	.130	.0250	5.21	-.0034			
	7.1	.152	.0308	4.96	-.0041			
	8.3	.176	.0378	4.67	-.0086			
	9.4	.204	.0474	4.29	-.0151			
4.0	-3.2	-.046	.0123	-3.73	.0068			
	-2.1	-.027	.0107	-2.56	.0056			
	-1.0	-.009	.0097	-.91	.0053			
	.1	.010	.0097	1.06	.0031			
	1.2	.030	.0104	2.88	.0014			
	2.3	.050	.0120	4.14	0			
	3.4	.070	.0144	4.82	-.0014	-.0054	.00044	-.00024
	4.4	.089	.0176	5.03	-.0021			
	5.5	.108	.0216	5.01	-.0028			
	6.6	.128	.0265	4.84	-.0045			
	7.7	.148	.0322	4.60	-.0056			
	8.9	.169	.0392	4.30	-.0045			
	10.0	.188	.0467	4.02	-.0050			
	11.1	.209	.0554	3.78	-.0060			
	12.2	.228	.0644	3.54	-.0061			

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TABLE I.- EXPERIMENTAL RESULTS - Continued

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 0^\circ$, $\delta_t = 0^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-0.008	0.0103	-0.80	0.0060			
	.2	.020	.0104	1.96	.0032			
	1.3	.049	.0117	4.17	.0004			
	2.5	.075	.0141	5.33	-.0015			
	3.7	.102	.0174	5.88	-.0044	-0.0025	-0.00089	-0.00043
	4.9	.129	.0221	5.85	-.0070			
	6.0	.158	.0279	5.64	-.0132			
	7.2	.186	.0349	5.34	-.0208			
	8.3	.217	.0433	5.00	-.0337			
3.5	-2.2	-.032	.0103	-3.08	.0050			
	-1.0	-.009	.0090	-.96	.0049			
	.1	.017	.0091	1.87	.0025			
	1.3	.042	.0102	4.10	.0003			
	2.5	.067	.0124	5.36	-.0018			
	3.7	.091	.0157	5.79	-.0037	-.0025	-.00094	-.00029
	4.8	.114	.0198	5.75	-.0050			
	6.0	.138	.0249	5.56	-.0091			
	7.1	.165	.0316	5.21	-.0169			
	8.2	.194	.0391	4.97	-.0305			
	9.3	.221	.0504	4.38	-.0419			
4.0	-1.0	-.007	.0084	-.89	.0042			
	.1	.013	.0084	1.54	.0021			
	1.2	.033	.0093	3.54	0			
	2.3	.054	.0111	4.86	-.0017			
	3.4	.074	.0137	5.43	-.0032	-.0025	-.00086	-.00010
	4.5	.095	.0172	5.55	-.0049			
	5.6	.116	.0215	5.42	-.0055			
	6.7	.136	.0265	5.14	-.0062			
	7.8	.157	.0327	4.81	-.0072			
	8.9	.177	.0395	4.48	-.0099			
	9.9	.202	.0480	4.20	-.0188			
	11.0	.225	.0574	3.92	-.0282			
	12.1	.249	.0676	3.68	-.0367			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 0^\circ$, $\delta_t = 30^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-0.001	0.0102	-0.10	0.0032			
	.2	.027	.0105	2.56	.0008			
	1.4	.055	.0120	4.57	-.0015			
	2.5	.082	.0145	5.65	-.0036			
	3.7	.108	.0183	5.93	-.0058	-0.0030	-0.00078	-0.00020
	4.9	.136	.0231	5.90	-.0101			
	6.0	.163	.0289	5.65	-.0141			
	7.2	.192	.0361	5.32	-.0218			
	8.3	.223	.0448	4.98	-.0346			
3.5	-1.0	-.003	.0088	-.36	.0032			
	.2	.021	.0090	2.34	.0010			
	1.3	.046	.0103	4.46	-.0010			
	2.5	.071	.0128	5.56	-.0032			
	3.7	.095	.0162	5.89	-.0053	-.0029	-.00084	-.00005
	4.8	.120	.0206	5.80	-.0072			
	6.0	.143	.0260	5.52	-.0111			
	7.1	.168	.0322	5.23	-.0150			
	8.2	.195	.0380	5.13	-.0254			
4.0	-3.2	-.046	.0106	-4.32	.0068			
	-2.1	-.027	.0092	-2.99	.0054			
	-1.0	-.003	.0082	-.39	.0031			
	.1	.016	.0083	1.92	.0012			
	1.2	.036	.0093	3.88	-.0007			
	2.3	.057	.0111	5.10	-.0026			
	3.4	.076	.0139	5.52	-.0038	-.0030	-.00068	.00020
	4.5	.097	.0173	5.60	-.0055			
	5.6	.117	.0216	5.42	-.0067			
	6.7	.138	.0268	5.14	-.0075			
	7.8	.158	.0328	4.82	-.0089			
	8.9	.178	.0397	4.48	-.0099			
	10.0	.198	.0474	4.17	-.0107			
	11.1	.219	.0563	3.88	-.0121			
	12.2	.239	.0659	3.62	-.0131			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 0^\circ$, $\delta_t = 15^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-.002	.0105	-.19	.0046			
	.2	.025	.0107	2.37	.0018			
	1.4	.054	.0121	4.42	-.0010			
	2.6	.081	.0147	5.51	-.0033			
	3.7	.108	.0184	5.86	-.0048	-.0029	-.00082	-.00034
	4.9	.136	.0231	5.86	-.0089			
	6.0	.162	.0289	5.62	-.0136			
	7.2	.190	.0359	5.31	-.0197			
	8.3	.220	.0446	4.94	-.0318			
3.5	-1.0	-.004	.0090	-.40	.0039			
	.2	.020	.0092	2.17	.0019			
	1.3	.045	.0104	4.31	-.0003			
	2.5	.070	.0129	5.43	-.0024			
	3.7	.094	.0163	5.76	-.0036	-.0027	-.00088	-.00019
	4.8	.118	.0205	5.72	-.0056			
	6.0	.143	.0259	5.52	-.0112			
	7.1	.167	.0322	5.19	-.0134			
	8.2	.193	.0377	5.12	-.0232			
4.0	-1.0	-.004	.0081	-.48	.0039			
	.1	.015	.0082	1.82	.0019			
	1.2	.035	.0092	3.82	-.0002			
	2.3	.056	.0110	5.07	-.0020			
	3.4	.076	.0136	5.58	-.0037	-.0026	-.00082	.00005
	4.5	.097	.0172	5.65	-.0055			
	5.6	.118	.0216	5.45	-.0069			
	6.7	.137	.0267	5.15	-.0071			
	7.8	.158	.0328	4.81	-.0086			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 0^\circ$ $\delta_t = 45^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	0	.0102	-.04	.0025			
	.2	.026	.0104	2.50	.0007			
	1.4	.052	.0118	4.41	-.0011			
	2.5	.079	.0142	5.55	-.0031			
	3.7	.106	.0179	5.92	-.0054	-.0030	-.00068	-.00010
	4.9	.132	.0225	5.89	-.0075			
	6.0	.158	.0282	5.60	-.0090			
	7.2	.184	.0349	5.26	-.0113			
	8.4	.213	.0434	4.89	-.0189			
3.5	-1.0	-.003	.0089	-.38	.0028			
	.2	.020	.0090	2.18	.0011			
	1.3	.044	.0103	4.29	-.0008			
	2.5	.069	.0126	5.46	-.0026			
	3.7	.092	.0159	5.82	-.0044	-.0032	-.00066	0
	4.8	.115	.0200	5.75	-.0051			
	6.0	.139	.0252	5.51	-.0068			
	7.2	.162	.0313	5.18	-.0079			
	8.3	.187	.0386	4.83	-.0134			
4.0	-1.0	-.004	.0083	-.52	.0030			
	.1	.015	.0084	1.76	.0015			
	1.2	.035	.0093	3.70	-.0004			
	2.3	.055	.0111	4.92	-.0020			
	3.4	.075	.0137	5.50	-.0036	-.0033	-.00044	.00027
	4.5	.097	.0173	5.60	-.0052			
	5.6	.117	.0216	5.41	-.0065			
	6.7	.137	.0267	5.12	-.0077			
	7.8	.157	.0327	4.80	-.0088			

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TABLE I.- EXPERIMENTAL RESULTS - Continued

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 0^\circ$, $\delta_t = 60^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-2.2	-0.028	0.0115	-2.44	0.0034			
	-1.0	-.001	.0103	-.08	.0022			
	.2	.025	.0105	2.41	.0008			
	1.4	.052	.0120	4.34	-.0009			
	2.5	.077	.0144	5.35	-.0020			
	3.7	.102	.0177	5.79	-.0029	-0.0033	-0.00057	-0.00011
	4.9	.128	.0222	5.75	-.0044			
	6.0	.154	.0278	5.51	-.0060			
	7.2	.180	.0347	5.19	-.0076			
	8.4	.208	.0428	4.86	-.0143			
3.5	-2.2	-.028	.0101	-2.80	.0035			
	-1.0	-.004	.0089	-.40	.0024			
	.2	.020	.0091	2.17	.0009			
	1.3	.044	.0104	4.21	-.0006			
	2.5	.067	.0126	5.31	-.0016			
	3.6	.090	.0157	5.69	-.0023	-.0034	-.00058	-.00001
	4.8	.112	.0198	5.68	-.0034			
	6.0	.135	.0248	5.46	-.0043			
	7.1	.158	.0309	5.12	-.0054			
	8.3	.181	.0378	4.79	-.0086			
4.0	-3.2	-.042	.0104	-4.05	.0046			
	-2.0	-.025	.0091	-2.70	.0037			
	-1.0	-.004	.0084	-.45	.0027			
	.1	.015	.0085	1.74	.0011			
	1.2	.034	.0094	3.66	-.0004			
	2.3	.054	.0111	4.86	-.0020			
	3.4	.074	.0137	5.39	-.0033	-.0038	-.00032	.00029
	4.5	.094	.0172	5.48	-.0045			
	5.6	.114	.0214	5.33	-.0053			
	6.7	.134	.0264	5.06	-.0056			
	7.8	.156	.0324	4.80	-.0087			
	8.9	.176	.0393	4.47	-.0096			
	10.0	.195	.0470	4.16	-.0109			
	11.1	.216	.0557	3.87	-.0116			
	12.2	.236	.0650	3.63	-.0130			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 0^\circ$, $\delta_t = 90^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-2.2	-0.025	0.0111	-2.22	0.0022			
	-1.0	.002	.0103	.17	.0016			
	.2	.026	.0107	2.43	.0015			
	1.4	.050	.0121	4.14	.0014			
	2.5	.073	.0143	5.12	.0015			
	3.7	.099	.0177	5.56	-.0008	-0.0038	-0.00042	-0.00019
	4.9	.123	.0221	5.58	-.0018			
	6.0	.149	.0276	5.40	-.0051			
	7.1	.177	.0340	5.20	-.0135			
	8.2	.211	.0427	4.94	-.0299			
3.5	-2.2	-.024	.0098	-2.46	.0020			
	-1.0	-.001	.0090	-.10	.0013			
	.2	.021	.0093	2.24	.0012			
	1.3	.043	.0105	4.05	.0009			
	2.5	.064	.0127	5.04	.0012			
	3.6	.088	.0161	5.45	-.0008	-.0037	-.00045	-.00017
	4.8	.109	.0200	5.46	-.0014			
	6.0	.131	.0248	5.28	-.0022			
	7.1	.156	.0307	5.06	-.0088			
	8.2	.181	.0377	4.81	-.0188			
4.0	-3.2	-.040	.0103	-3.84	.0034			
	-2.1	-.021	.0090	-2.36	.0021			
	-1.0	-.003	.0084	-.39	.0017			
	.1	.016	.0085	1.94	.0009			
	1.2	.035	.0095	3.63	0			
	2.3	.053	.0113	4.71	-.0006			
	3.4	.072	.0138	5.22	-.0015	-.0042	-.00022	.00008
	4.5	.091	.0171	5.29	-.0022			
	5.6	.109	.0212	5.16	-.0024			
	6.7	.128	.0261	4.92	-.0031			
	7.8	.147	.0318	4.63	-.0036			
	8.9	.166	.0385	4.33	-.0042			
	10.0	.185	.0459	4.04	-.0050			
	11.1	.206	.0543	3.79	-.0069			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 0^\circ$, $\delta_t = 75^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	0	.0105	-.03	.0020			
	.2	.025	.0106	2.34	.0012			
	1.4	.050	.0120	4.14	.0002			
	2.5	.075	.0144	5.22	-.0008			
	3.7	.101	.0178	5.68	-.0025	-.0035	-.00046	-.00015
	4.9	.126	.0223	5.66	-.0042			
	6.0	.152	.0280	5.44	-.0058			
	7.2	.179	.0348	5.15	-.0105			
	8.3	.208	.0424	4.89	-.0188			
3.5	-1.0	-.003	.0091	-.33	.0020			
	.2	.020	.0092	2.14	.0011			
	1.3	.043	.0105	4.10	-.0002			
	2.5	.065	.0126	5.19	-.0007			
	3.6	.088	.0157	5.58	-.0016	-.0036	-.00046	-.00009
	4.8	.110	.0197	5.59	-.0026			
	6.0	.133	.0247	5.38	-.0038			
	7.1	.155	.0306	5.08	-.0048			
	8.3	.180	.0376	4.78	-.0116			
4.0	-1.0	-.004	.0084	-.52	.0024			
	.1	.015	.0085	1.74	.0013			
	1.2	.034	.0094	3.58	-.0001			
	2.3	.053	.0111	4.78	-.0012			
	3.4	.073	.0137	5.32	-.0024	-.0041	-.00023	.00021
	4.5	.092	.0171	5.42	-.0032			
	5.6	.112	.0213	5.27	-.0038			
	6.7	.132	.0263	5.02	-.0048			
	7.8	.152	.0322	4.72	-.0060			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.16$, $\omega = 0^\circ$, $\delta_t = 0^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-.006	.0099	-.63	.0053			
	.2	.023	.0101	2.31	.0021			
	1.4	.051	.0116	4.45	-.0004			
	2.5	.079	.0140	5.64	-.0029			
	3.7	.106	.0177	6.00	-.0048	-.0028	-.00090	-.00046
	4.9	.134	.0224	5.96	-.0079			
	6.0	.160	.0283	5.66	-.0119			
	7.2	.187	.0348	5.38	-.0172			
	8.3	.218	.0414	5.26	-.0293			
3.5	-1.0	-.006	.0086	-.71	.0043			
	.2	.018	.0087	2.12	.0022			
	1.3	.044	.0099	4.39	-.0001			
	2.5	.069	.0123	5.58	-.0021			
	3.7	.092	.0156	5.92	-.0030	-.0027	-.00092	-.00035
	4.8	.116	.0197	5.87	-.0044			
	6.0	.141	.0251	5.60	-.0096			
	7.1	.164	.0311	5.28	-.0129			
	8.2	.190	.0367	5.18	-.0210			
4.0	-1.0	-.006	.0080	-.69	.0039			
	.1	.015	.0081	1.80	.0019			
	1.2	.035	.0090	3.84	-.0002			
	2.3	.055	.0108	5.12	-.0021			
	3.4	.076	.0134	5.65	-.0035	-.0024	-.00086	-.00012
	4.5	.097	.0169	5.70	-.0049			
	5.6	.117	.0213	5.50	-.0062			
	6.7	.136	.0263	5.19	-.0062			
	7.8	.157	.0323	4.85	-.0071			

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TABLE I.- EXPERIMENTAL RESULTS - Continued

Fins off, $i_c = 3^\circ$, $S_t/S = 0.16$, $\omega = 0^\circ$, $\delta_t = 30^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-0.001	0.0100	-0.10	0.0025			
	.2	.026	.0102	2.59	.0003			
	1.4	.053	.0117	4.52	-.0016			
	2.5	.080	.0142	5.60	-.0037			
	3.7	.106	.0178	5.96	-.0052	-0.0029	-0.00074	0.00006
	4.9	.133	.0225	5.91	-.0088			
	6.0	.161	.0283	5.67	-.0133			
	7.2	.188	.0353	5.34	-.0188			
	8.3	.220	.0444	4.96	-.0323			
3.5	-1.0	-.004	.0088	-.43	.0024			
	.2	.021	.0090	2.29	.0003			
	1.3	.045	.0102	4.40	-.0013			
	2.5	.070	.0126	5.51	-.0033			
	3.7	.094	.0159	5.89	-.0046	-.0029	-.00083	.00010
	4.8	.118	.0202	5.83	-.0064			
	6.0	.142	.0255	5.56	-.0105			
	7.1	.166	.0317	5.23	-.0138			
	8.2	.194	.0392	4.95	-.0248			
4.0	-1.0	-.004	.0081	-.52	.0029			
	.1	.014	.0082	1.77	.0014			
	1.2	.034	.0091	3.77	-.0006			
	2.3	.055	.0109	5.03	-.0022			
	3.4	.077	.0136	5.65	-.0042	-.0030	-.00063	.00040
	4.5	.097	.0171	5.68	-.0059			
	5.6	.118	.0216	5.48	-.0071			
	6.7	.138	.0267	5.18	-.0080			
	7.8	.158	.0327	4.84	-.0089			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.16$, $\omega = 0^\circ$, $\delta_t = 90^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-3.3	-0.043	0.0124	-3.49	-0.0003			
	-2.2	-.023	.0109	-2.07	-.0001			
	-1.0	0	.0102	-.04	.0004			
	.2	.021	.0103	2.07	.0011			
	1.3	.043	.0116	3.69	.0017			
	2.5	.065	.0136	4.81	.0018			
	3.6	.088	.0164	5.34	.0020	-0.0050	-0.00004	0.00004
	4.8	.111	.0203	5.45	.0018			
	6.0	.134	.0252	5.30	.0015			
	7.1	.158	.0312	5.04	.0011			
	8.3	.182	.0383	4.75	-.0013			
3.5	-3.3	-.042	.0112	-3.75	-.0001			
	-2.2	-.023	.0097	-2.37	0			
	-1.0	-.002	.0090	-.18	0			
	.1	.018	.0092	1.94	.0004			
	1.3	.038	.0102	3.69	.0008			
	2.4	.058	.0121	4.80	.0011			
	3.6	.078	.0148	5.25	.0019	-.0047	-.00012	.00003
	4.8	.099	.0184	5.36	.0015			
	5.9	.119	.0228	5.24	.0018			
	7.1	.140	.0282	4.97	.0016			
	8.2	.161	.0345	4.67	.0011			
4.0	-4.3	-.051	.0117	-4.32	.0008			
	-3.2	-.036	.0100	-3.62	.0007			
	-2.1	-.020	.0088	-2.32	.0008			
	-1.0	-.003	.0081	-.36	.0008			
	.1	.013	.0083	1.62	.0007			
	1.2	.031	.0092	3.37	.0002			
	2.2	.048	.0107	4.47	0			
	3.3	.066	.0130	5.04	-.0001	-.0052	.00013	.00008
	4.4	.084	.0161	5.20	-.0004			
	5.5	.102	.0198	5.13	-.0005			
	6.6	.120	.0244	4.91	-.0002			
	7.7	.139	.0302	4.59	-.0005			
	8.8	.157	.0365	4.30	-.0007			
	9.9	.175	.0435	4.02	-.0006			
	11.0	.193	.0511	3.78	-.0006			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.16$, $\omega = 0^\circ$, $\delta_t = 60^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-.001	.0100	-.07	.0003			
	.2	.023	.0100	2.31	-.0005			
	1.3	.047	.0113	4.20	-.0011			
	2.5	.071	.0134	5.33	-.0018			
	3.7	.095	.0166	5.74	-.0015	-.0041	-.00029	.00024
	4.8	.121	.0208	5.80	-.0027			
	6.0	.145	.0260	5.57	-.0036			
	7.2	.170	.0324	5.25	-.0045			
	8.3	.197	.0401	4.92	-.0091			
3.5	-1.0	-.004	.0087	-.45	.0004			
	.1	.018	.0088	2.07	-.0003			
	1.3	.041	.0099	4.09	-.0012			
	2.5	.063	.0119	5.25	-.0017			
	3.6	.084	.0148	5.67	-.0012	-.0042	-.00035	.00025
	4.8	.106	.0186	5.69	-.0018			
	6.0	.128	.0234	5.49	-.0023			
	7.1	.151	.0291	5.18	-.0032			
	8.3	.174	.0358	4.85	-.0051			
4.0	-1.0	-.005	.0082	-.65	.0016			
	.1	.013	.0082	1.53	.0005			
	1.2	.031	.0090	3.48	-.0005			
	2.3	.050	.0106	4.78	.0017			
	3.3	.070	.0130	5.34	.0026	-.0046	-.00001	.00051
	4.4	.090	.0164	5.50	.0036			
	5.5	.109	.0203	5.36	.0045			
	6.6	.128	.0251	5.10	.0042			
	7.7	.147	.0308	4.79	.0047			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 4^\circ$, $\delta_t = 0^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-.006	.0104	-.53	.0049			
	.2	.024	.0105	2.29	.0015			
	1.4	.054	.0120	4.51	-.0018			
	2.5	.083	.0145	5.69	-.0049			
	3.7	.109	.0180	6.05	-.0069	-.0025	-.00089	-.00046
	4.9	.138	.0230	6.00	-.0125			
	6.0	.168	.0296	5.67	-.0211			
	7.1	.198	.0371	5.33	-.0307			
	8.2	.229	.0454	5.04	-.0445			
3.5	-1.0	-.006	.0091	-.67	.0037			
	.2	.019	.0092	2.07	.0012			
	1.3	.045	.0103	4.35	-.0011			
	2.5	.071	.0128	5.55	-.0040			
	3.7	.096	.0161	5.93	-.0059	-.0025	-.00095	-.00036
	4.8	.120	.0203	5.89	-.0083			
	5.9	.146	.0260	5.61	-.0154			
	7.1	.172	.0327	5.26	-.0230			
	8.2	.199	.0402	4.95	-.0342			
4.0	-1.0	-.007	.0087	-.76	.0034			
	.1	.015	.0087	1.68	.0011			
	1.2	.035	.0096	3.63	-.0013			
	2.3	.056	.0113	4.97	-.0033			
	3.4	.078	.0140	5.59	-.0056	-.0024	-.00080	-.00011
	4.5	.099	.0175	5.67	-.0072			
	5.6	.120	.0219	5.49	-.0089			
	6.7	.141	.0270	5.21	-.0105			
	7.8	.161	.0331	4.87	-.0119			

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TABLE I.- EXPERIMENTAL RESULTS - Continued

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 4^\circ$, $\delta_t = 30^\circ$								
M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-0.005	0.0106	-0.46	0.0049			
	.2	.023	.0105	2.18	.0023			
	1.4	.051	.0118	4.33	-.0003			
	2.5	.079	.0141	5.63	-.0029			
	3.7	.107	.0174	6.11	-.0055	-0.0029	-0.00073	-0.00010
	4.8	.135	.0220	6.10	-.0101			
	6.0	.164	.0284	5.78	-.0189			
	7.1	.195	.0356	5.47	-.0281			
	8.2	.226	.0440	5.14	-.0421			
3.5	-1.0	-.008	.0093	-.83	.0045			
	.1	.017	.0093	1.86	.0023			
	1.3	.043	.0102	4.19	0			
	2.5	.068	.0125	5.49	-.0025			
	3.6	.093	.0155	5.98	-.0045	-.0030	-.00074	.00005
	4.8	.117	.0196	5.99	-.0068			
	5.9	.143	.0250	5.70	-.0135			
	7.1	.169	.0315	5.38	-.0210			
	8.2	.197	.0389	5.07	-.0328			
4.0	-1.0	-.007	.0087	-.82	.0043			
	.1	.013	.0087	1.52	.0020			
	1.2	.033	.0094	3.54	-.0002			
	2.3	.055	.0110	4.96	-.0021			
	3.4	.075	.0134	5.61	-.0038	-.0030	-.00062	.00026
	4.5	.097	.0168	5.76	-.0059			
	5.6	.118	.0210	5.61	-.0078			
	6.7	.139	.0261	5.33	-.0095			
	7.8	.159	.0320	4.98	-.0109			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 4^\circ$, $\delta_t = 90^\circ$								
M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-2.2	-0.026	0.0117	-2.27	0.0027			
	-1.0	-.001	.0105	-.13	.0027			
	.2	.023	.0105	2.21	.0022			
	1.3	.047	.0116	4.03	.0021			
	2.5	.072	.0137	5.24	.0009			
	3.7	.097	.0168	5.78	-.0003	-0.0043	-0.00018	-0.00020
	4.8	.124	.0213	5.81	-.0049			
	6.0	.151	.0269	5.60	-.0124			
	7.1	.180	.0343	5.26	-.0218			
	8.2	.210	.0433	4.87	-.0354			
3.5	-2.2	-.026	.0104	-3.04	.0026			
	-1.0	-.004	.0094	-.38	.0021			
	.2	.019	.0093	2.05	.0014			
	1.3	.042	.0103	4.06	.0010			
	2.5	.064	.0123	5.22	0			
	3.6	.086	.0151	5.71	-.0005	-.0042	-.00026	-.00019
	4.8	.108	.0188	5.76	-.0018			
	5.9	.132	.0238	5.54	-.0081			
	7.0	.158	.0302	5.21	-.0160			
	8.1	.184	.0370	4.97	-.0260			
	9.2	.211	.0457	4.61	-.0381			
4.0	-3.2	-.040	.0112	-3.57	.0037			
	-2.1	-.023	.0098	-2.34	.0031			
	-1.0	-.002	.0088	-.25	.0020			
	.1	.016	.0088	1.77	.0009			
	1.2	.034	.0095	3.59	-.0002			
	2.3	.053	.0110	4.82	-.0011			
	3.4	.072	.0133	5.41	-.0014	-.0044	0	.00003
	4.5	.091	.0164	5.58	-.0024			
	5.6	.110	.0202	5.46	-.0029			
	6.6	.130	.0249	5.20	-.0037			
	7.7	.148	.0304	4.89	-.0043			
	8.8	.170	.0376	4.53	-.0081			
	9.9	.193	.0455	4.24	-.0161			
	11.0	.216	.0544	3.98	-.0250			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 4^\circ$, $\delta_t = 60^\circ$								
M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-.003	.0105	-.23	.0042			
	.2	.024	.0104	2.26	.0024			
	1.4	.050	.0117	4.32	.0008			
	2.5	.077	.0139	5.58	-.0015			
	3.7	.103	.0171	6.04	-.0033	-.0036	-.00037	-.00003
	4.8	.131	.0218	6.00	-.0089			
	6.0	.161	.0281	5.71	-.0178			
	7.1	.191	.0348	5.48	-.0292			
	8.2	.221	.0442	5.02	-.0409			
3.5	-1.0	-.005	.0095	-.54	.0038			
	.2	.018	.0094	1.95	.0022			
	1.3	.043	.0104	4.19	.0005			
	2.5	.067	.0124	5.42	-.0015			
	3.6	.091	.0154	5.90	-.0027	-.0038	-.00040	.00004
	4.8	.115	.0194	5.92	-.0057			
	5.9	.141	.0250	5.64	-.0129			
	7.0	.167	.0311	5.38	-.0219			
	8.2	.195	.0390	4.99	-.0324			
4.0	-1.0	-.005	.0089	-.56	.0038			
	.1	.014	.0089	1.57	.0022			
	1.2	.034	.0096	3.51	.0005			
	2.3	.054	.0111	4.83	-.0011			
	3.4	.074	.0135	5.50	-.0023	-.0041	-.00006	.00031
	4.5	.095	.0168	5.67	-.0044			
	5.6	.116	.0209	5.55	-.0058			
	6.7	.136	.0258	5.29	-.0023			
	7.8	.156	.0316	4.96	-.0084			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 8^\circ$, $\delta_t = 0^\circ$								
M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-.006	.0103	-.58	.0046			
	.2	.023	.0103	2.27	.0013			
	1.4	.054	.0119	4.55	-.0022			
	2.5	.082	.0144	5.72	-.0055			
	3.7	.110	.0179	6.12	-.0083	-.0025	-.00087	-.00044
	4.9	.138	.0228	6.04	-.0130			
	6.0	.167	.0293	5.70	-.0216			
	7.1	.197	.0368	5.35	-.0306			
	8.2	.229	.0455	5.03	-.0449			
3.5	-1.0	-.007	.0091	-.74	.0036			
	.1	.018	.0092	2.00	.0010			
	1.3	.045	.0103	4.31	-.0016			
	2.5	.070	.0128	5.50	-.0046			
	3.6	.094	.0160	5.90	-.0067	-.0025	-.00091	-.00034
	4.8	.118	.0201	5.87	-.0089			
	5.9	.144	.0258	5.57	-.0158			
	7.0	.171	.0325	5.24	-.0251			
	8.2	.196	.0399	4.91	-.0331			
4.0	-1.0	-.007	.0087	-.80	.0033			
	.1	.014	.0088	1.54	.0009			
	1.2	.036	.0095	3.80	-.0017			
	2.3	.057	.0113	5.09	-.0036			
	3.4	.079	.0139	5.66	-.0059	-.0024	-.00080	-.00011
	4.5	.100	.0175	5.74	-.0086			
	5.6	.121	.0218	5.56	-.0102			
	6.7	.142	.0278	5.26	-.0119			
	7.8	.163	.0331	4.91	-.0136			

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[redacted]

TABLE I.- EXPERIMENTAL RESULTS - Continued

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 8^\circ$, $\delta_t = 30^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-0.011	0.0110	-0.96	0.0073			
	.2	.018	.0106	1.65	.0047			
	1.3	.046	.0115	4.00	.0022			
	2.5	.075	.0136	5.48	-.0011			
	3.7	.102	.0168	6.07	-.0036	-0.0030	-0.00069	-0.00005
	4.8	.131	.0217	6.06	-.0111			
	6.0	.161	.0277	5.83	-.0198			
	7.0	.191	.0350	5.47	-.0285			
	8.2	.223	.0434	5.14	-.0426			
3.5	-1.0	-.011	.0098	-1.16	.0063			
	.1	.013	.0096	1.38	.0041			
	1.3	.038	.0103	3.69	.0021			
	2.5	.065	.0123	5.25	-.0007			
	3.6	.089	.0151	5.86	-.0025	-.0031	-.00067	.00011
	4.8	.114	.0192	5.93	-.0067			
	5.9	.140	.0246	5.69	-.0139			
	7.0	.166	.0310	5.37	-.0216			
	8.2	.194	.0386	5.04	-.0325			
4.0	-1.0	-.011	.0093	-1.14	.0059			
	.1	.010	.0090	1.05	.0038			
	1.2	.030	.0096	3.11	.0017			
	2.3	.050	.0110	4.56	-.0001			
	3.4	.072	.0133	5.39	-.0021	-.0031	-.00052	.00026
	4.5	.093	.0165	5.66	-.0043			
	5.6	.115	.0206	5.57	-.0063			
	6.7	.135	.0254	5.33	-.0079			
	7.8	.156	.0312	5.01	-.0099			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 8^\circ$, $\delta_t = 90^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-0.005	0.0118	-0.40	0.0044			
	.2	.020	.0116	1.74	.0038			
	1.3	.044	.0125	3.54	.0032			
	2.5	.069	.0144	4.81	.0021			
	3.7	.094	.0173	5.46	.0008	-0.0044	-0.00008	-0.00018
	4.8	.120	.0213	5.63	-.0024			
	5.9	.148	.0267	5.53	-.0105			
	7.1	.176	.0334	5.28	-.0190			
	8.2	.206	.0407	5.07	-.0322			
3.5	-1.0	-.006	.0106	-.56	.0037			
	.1	.017	.0104	1.60	.0027			
	1.3	.039	.0112	3.46	.0021			
	2.5	.061	.0130	4.74	.0015			
	3.6	.083	.0155	5.34	.0010	-.0043	-.00012	-.00016
	4.8	.105	.0190	5.51	-.0001			
	5.9	.129	.0239	5.39	-.0060			
	7.0	.154	.0295	5.23	-.0134			
	8.1	.179	.0365	4.92	-.0229			
4.0	-2.1	-.024	.0112	-2.18	.0039			
	-1.0	-.005	.0100	-.54	.0033			
	.1	.013	.0099	1.30	.0023			
	1.2	.032	.0106	3.01	.0012			
	2.3	.050	.0119	4.25	.0002			
	3.4	.069	.0139	4.97	-.0002	-.0046	.00014	.00002
	4.4	.088	.0168	5.23	-.0007			
	5.5	.106	.0203	5.24	-.0012			
	6.6	.125	.0248	5.06	-.0017			
	7.7	.144	.0300	4.80	-.0022			
	8.8	.163	.0363	4.50	-.0044			
	9.9	.185	.0440	4.20	-.0102			
	11.0	.207	.0521	3.96	-.0168			

Fins off, $i_c = 3^\circ$, $S_t/S = 0.09$, $\omega = 8^\circ$, $\delta_t = 60^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-.008	.0115	-.68	.0063			
	.2	.018	.0111	1.62	.0048			
	1.3	.044	.0119	3.70	.0035			
	2.5	.071	.0139	5.13	.0005			
	3.7	.097	.0168	5.77	-.0013	-.0039	-.00027	.00002
	4.8	.124	.0212	5.88	-.0067			
	5.9	.153	.0269	5.69	-.0151			
	7.1	.183	.0340	5.38	-.0242			
	8.2	.214	.0424	5.05	-.0382			
3.5	-1.0	-.010	.0104	-.93	.0056			
	.1	.014	.0100	1.36	.0042			
	1.3	.038	.0107	3.51	.0028			
	2.5	.062	.0124	4.99	.0003			
	3.6	.085	.0150	5.68	-.0010	-.0041	-.00024	.00009
	4.8	.108	.0186	5.83	-.0034			
	5.9	.134	.0239	5.62	-.0111			
	7.0	.162	.0302	5.35	-.0220			
	8.1	.187	.0367	5.10	-.0305			
4.0	-1.0	-.009	.0097	-.89	.0054			
	.1	.010	.0095	1.03	.0040			
	1.2	.029	.0100	2.90	.0023			
	2.3	.049	.0114	4.32	.0009			
	3.4	.068	.0135	5.09	.0001	-.0043	.00004	.00029
	4.4	.089	.0163	5.46	-.0024			
	5.5	.110	.0201	5.45	-.0041			
	6.6	.130	.0246	5.26	-.0051			
	7.7	.150	.0301	4.97	-.0067			

Fins off, $i_c = 0^\circ$, $S_t/S = 0.09$, $\omega = 0^\circ$, $\delta_t = 0^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.1	-.011	.0107	-1.02	.0019			
	.1	.017	.0105	1.67	-.0008			
	1.3	.046	.0114	4.03	-.0035			
	2.5	.074	.0136	5.41	-.0058			
	3.6	.100	.0169	5.92	-.0074	-.0025	-.00082	-.00042
	4.8	.127	.0214	5.93	-.0093			
	6.0	.154	.0270	5.71	-.0134			
	7.1	.184	.0339	5.42	-.0214			
	8.3	.214	.0420	5.08	-.0315			
3.5	-1.1	-.011	.0095	-1.11	.0013			
	.1	.014	.0089	1.59	-.0007			
	1.3	.039	.0098	3.99	-.0030			
	2.4	.064	.0118	5.36	-.0049			
	3.6	.088	.0150	5.88	-.0066	-.0024	-.00090	-.00025
	4.8	.111	.0189	5.86	-.0074			
	5.9	.134	.0238	5.62	-.0089			
	7.1	.159	.0299	5.32	-.0152			
	8.2	.184	.0370	4.98	-.0220			
4.0	-1.0	-.008	.0083	-1.00	.0016			
	.1	.011	.0082	1.35	-.0004			
	1.1	.031	.0090	3.49	-.0026			
	2.2	.052	.0106	4.87	-.0044			
	3.3	.072	.0130	5.55	-.0062	-.0024	-.00082	-.00008
	4.4	.093	.0164	5.66	-.0075			
	5.5	.112	.0204	5.49	-.0087			
	6.6	.132	.0254	5.20	-.0096			
	7.7	.152	.0311	4.87	-.0104			

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TABLE I.- EXPERIMENTAL RESULTS - Concluded

Fins off, $i_c = 6^\circ$, $S_t/S = 0.09$, $\omega = 0^\circ$, $\delta_t = 0^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-0.9	-0.002	0.0112	-0.16	0.0099			
	.2	.026	.0115	2.23	.0073			
	1.4	.055	.0130	4.20	.0042			
	2.6	.082	.0157	5.23	.0018			
	3.8	.109	.0193	5.66	-.0003	-0.0026	-0.00096	-0.00047
	4.9	.138	.0242	5.69	-.0076			
	6.0	.166	.0302	5.49	-.0159			
	7.2	.196	.0377	5.21	-.0255			
	8.3	.226	.0461	4.90	-.0383			
3.5	-.9	-.003	.0097	-.30	.0086			
	.2	.021	.0100	2.09	.0065			
	1.4	.046	.0113	4.05	.0045			
	2.5	.071	.0138	5.10	.0027			
	3.7	.094	.0172	5.46	.0013	-.0026	-.00098	-.00036
	4.9	.118	.0216	5.49	-.0022			
	6.0	.144	.0269	5.34	-.0085			
	7.1	.170	.0335	5.08	-.0164			
	8.2	.197	.0407	4.84	-.0282			
4.0	-1.0	-.003	.0089	-.35	.0071			
	.1	.016	.0091	1.77	.0051			
	1.2	.037	.0102	3.59	.0032			
	2.3	.057	.0120	4.72	.0017			
	3.4	.078	.0148	5.25	.0001	-.0026	-.00086	-.00015
	4.5	.098	.0185	5.33	-.0012			
	5.6	.119	.0228	5.20	-.0019			
	6.7	.139	.0281	4.95	-.0028			
	7.8	.158	.0340	4.66	-.0037			

Fins off, $i_c = 6^\circ$, $S_t/S = 0.16$, $\omega = 0^\circ$, $\delta_t = 90^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-0.9	0.004	0.0110	0.39	0.0048			
	.2	.026	.0114	2.28	.0060			
	1.4	.048	.0128	3.77	.0065			
	2.6	.069	.0151	4.59	.0075			
	3.7	.091	.0181	5.02	.0080	-0.0054	0.00015	0.00001
	4.9	.115	.0222	5.16	.0082			
	6.0	.137	.0273	5.03	.0080			
	7.2	.161	.0334	4.82	.0071			
	8.3	.189	.0410	4.62	-.0011			
3.5	-1.0	.002	.0097	.21	.0030			
	.2	.022	.0101	2.18	.0042			
	1.4	.042	.0113	3.71	.0047			
	2.5	.062	.0134	4.60	.0055			
	3.7	.080	.0163	4.93	.0072	-.0052	-.00003	-.00002
	4.8	.101	.0201	5.04	.0076			
	6.0	.121	.0246	4.94	.0084			
	7.1	.142	.0301	4.73	.0083			
	8.3	.166	.0367	4.51	.0033			
4.0	-1.0	-.001	.0088	-.07	.0036			
	.1	.017	.0091	1.85	.0032			
	1.2	.034	.0102	3.32	.0032			
	2.3	.052	.0119	4.33	.0031			
	3.4	.069	.0143	4.83	.0033	-.0054	.00016	.00013
	4.5	.087	.0175	4.96	.0037			
	5.6	.105	.0215	4.89	.0039			
	6.7	.122	.0260	4.70	.0058			
	7.8	.140	.0314	4.46	.0062			

Fins off, $i_c = 0^\circ$, $S_t/S = 0.16$, $\omega = 0^\circ$, $\delta_t = 90^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.1	-.002	.0100	-.22	-.0040			
	.1	.020	.0098	2.07	-.0032			
	1.3	.043	.0110	3.94	-.0029			
	2.4	.065	.0129	5.04	-.0025			
	3.6	.087	.0157	5.55	-.0018	-.0050	.00010	.00007
	4.8	.111	.0196	5.65	-.0027			
	5.9	.135	.0247	5.46	-.0029			
	7.1	.159	.0308	5.16	-.0031			
	8.3	.184	.0380	4.85	-.0056			
3.5	-1.1	-.004	.0088	-.42	-.0038			
	.1	.017	.0089	1.86	-.0030			
	1.3	.037	.0098	3.73	-.0028			
	2.4	.057	.0116	4.88	-.0021			
	3.6	.077	.0143	5.39	-.0018	-.0048	-.00010	.00003
	4.7	.098	.0177	5.51	-.0019			
	5.9	.118	.0221	5.35	-.0019			
	7.0	.139	.0274	5.09	-.0019			
	8.2	.160	.0337	4.75	-.0024			
4.0	-1.0	-.004	.0082	-.49	-.0019			
	.1	.013	.0082	1.55	-.0020			
	1.1	.030	.0091	3.27	-.0024			
	2.2	.047	.0105	4.50	-.0030			
	3.3	.065	.0127	5.11	-.0033	-.0053	.00015	.00022
	4.4	.082	.0157	5.24	-.0033			
	5.5	.101	.0195	5.19	-.0037			
	6.6	.119	.0240	4.95	-.0035			
	7.7	.136	.0292	4.67	-.0040			

Fins off, short nose, $S_t/S = 0.09$, $\omega = 4^\circ$, $\delta_t = 0^\circ$

M	α, deg	C_L	C_D	L/D	C_m	C_{Y_β}	C_{n_β}	C_{l_β}
3.0	-1.0	-.008	.0093	-.86	.0019			
	.1	.020	.0091	2.20	-.0042			
	1.3	.047	.0102	4.64	-.0097			
	2.4	.074	.0124	5.97	-.0152			
	3.5	.099	.0154	6.43	-.0199	-.0025	-.00070	-.00025
	4.7	.124	.0195	6.35	-.0253			
	5.8	.148	.0245	6.04	-.0300			
	6.9	.172	.0306	5.64	-.0349			
	8.1	.196	.0378	5.20	-.0401			
3.5	-1.1	-.008	.0083	-.98	.0014			
	.1	.015	.0081	1.88	-.0032			
	1.2	.038	.0089	4.32	-.0077			
	2.3	.062	.0109	5.71	-.0124			
	3.5	.084	.0137	6.18	-.0162	-.0025	-.00071	-.00014
	4.6	.106	.0173	6.14	-.0205			
	5.7	.128	.0217	5.88	-.0244			
	6.8	.148	.0269	5.50	-.0282			
	8.0	.168	.0331	5.09	-.0318			
	9.1	.186	.0395	4.71	-.0348			
	10.2	.205	.0472	4.36	-.0383			
4.0	-2.1	-.028	.0090	-3.06	.0051			
	-1.0	-.007	.0078	-.93	.0012			
	0	.012	.0077	1.52	-.0028			
	1.1	.032	.0084	3.76	-.0068			
	2.2	.051	.0099	5.17	-.0106			
	3.3	.071	.0122	5.81	-.0144	-.0025	-.00059	.00002
	4.4	.090	.0153	5.90	-.0182			
	5.4	.106	.0190	5.57	-.0211			
	6.5	.124	.0234	5.30	-.0244			
	7.6	.142	.0286	4.97	-.0278			
	8.6	.159	.0343	4.64	-.0306			
	9.7	.177	.0408	4.32	-.0338			
	10.8	.194	.0481	4.03	-.0369			

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TABLE II.- SUMMARY OF RESULTS

(a) M = 3.0

Aerodynamic characteristics of basic configuration									
Configuration	C_{L_o}	C_{D_o}	C_{L_α}	$\left(\frac{L}{D}\right)_{max}$	C_{m_o}	$\frac{dC_m}{dC_L}$	C_{Y_β}	C_{n_β}	C_{l_β}
Fins off, $i_c = 3^o$, $\delta_t = 0^o$	0.018	0.0102	1.40	6.04	0.0026	-0.102	-0.0026	-0.00089	-0.00045

Incremental changes in aerodynamic characteristics due to changes in configuration													
Vertical fins	i_c, deg	$\frac{S_t}{S}$	ω, deg	δ_t, deg	ΔC_{L_o}	ΔC_{D_o}	ΔC_{L_α}	$\Delta\left(\frac{L}{D}\right)_{max}$	ΔC_{m_o}	$\Delta\frac{dC_m}{dC_L}$	ΔC_{Y_β}	ΔC_{n_β}	ΔC_{l_β}
Off	3	0.04	0	30	0	0.0002	0	0.04	-0.0006	-0.013	-0.0002	0.00006	0.00012
↓	↓	↓	↓	60	-.003	.0001	-.05	-.04	-.0010	.018	-.0001	.00016	.00018
				90	0	.0002	-.09	-.09	-.0006	.022	-.0003	.00023	.00013
Off	3	.09	0	15	.006	.0002	-.03	0	-.0014	-.006	-.0004	.00007	.00009
↓	↓	↓	↓	30	.007	0	-.02	.06	-.0025	.010	-.0005	.00011	.00023
				45	.007	-.0001	-.07	.05	-.0028	.017	-.0005	.00021	.00033
				60	.006	0	-.10	-.08	-.0028	.040	-.0008	.00032	.00032
				75	.006	.0001	-.12	-.20	-.0022	.038	-.0010	.00043	.00028
				90	.006	.0002	-.16	-.29	-.0027	.066	-.0013	.00047	.00024
Off	3	.16	0	30	.003	.0001	-.03	-.05	-.0019	.007	-.0001	.00016	.00052
↓	↓	↓	↓	60	.001	-.0001	-.16	-.21	-.0029	.065	-.0013	.00061	.00070
				90	.001	.0002	-.27	-.57	-.0020	.083	-.0022	.00086	.00050
Off	3	.09	4	30	0	0	-.05	.07	.0005	.020	-.0004	.00016	.00036
↓	↓	↓	↓	60	0	-.0001	-.10	-.02	.0004	.045	-.0011	.00052	.00043
				90	.001	0	-.23	-.25	0	.089	-.0018	.00071	.00026
Off	3	.09	8	30	-.005	.0003	-.03	-.03	.0032	.019	-.0005	.00018	.00039
↓	↓	↓	↓	60	-.004	.0009	-.13	-.25	.0033	.033	-.0014	.00060	.00046
				90	-.002	.0013	-.20	-.51	.0021	.075	-.0019	.00079	.00026
On	3	0	0	0	-.003	.0012	-.03	-.49	.0021	.014	-.0029	.00112	-.00028
Off	Short nose	0	0	0	-.002	-.0013	-.14	.37	-.0059	-.091	0	.00019	.00021
Off	0	0	0	0	0	.0001	-.02	.07	-.0042	.001	0	.00007	.00001
Off	6	0	0	0	.006	.0010	.01	-.18	.0041	-.004	-.0001	-.00007	-.00004
Off	0	(1)	(1)	(1)	-.001	-.0004	.04	.21	-.0038	-.003	0	.00014	.00003
Off	6	(1)	(1)	(1)	.002	.0011	.02	-.29	.0054	.011	-.0004	.00019	-.00003

[1]Incremental changes due to canard deflection with tips in deflected position. Reference configuration $i_c = 3^o$, $S_t/S = 0.16$, $\omega = 0^o$, $\delta_t = 90^o$.

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TABLE II.- SUMMARY OF RESULTS - Continued

(b) M = 3.5

Aerodynamic characteristics of basic configuration									
Configuration	C_{L_o}	C_{D_o}	C_{L_α}	$\left(\frac{L}{D}\right)_{max}$	C_{m_o}	$\frac{dC_m}{dC_L}$	C_{Y_β}	C_{n_β}	C_{l_β}
Fins off, $i_c = 3^\circ$, $\delta_t = 0^\circ$	0.015	0.0090	1.24	5.91	0.0020	-0.094	-0.0026	-0.00093	-0.00034

Incremental changes in aerodynamic characteristics due to changes in configuration													
Vertical fins	i_c, deg	$\frac{S_t}{S}$	ω, deg	δ_t, deg	ΔC_{L_o}	ΔC_{D_o}	ΔC_{L_α}	$\Delta\left(\frac{L}{D}\right)_{max}$	ΔC_{m_o}	$\Delta\frac{dC_m}{dC_L}$	ΔC_{Y_β}	ΔC_{n_β}	ΔC_{l_β}
Off	3	0.04	0	30	0	0.0003	0	-0.02	-0.0001	-0.015	-0.0003	0.00008	0.00016
↓	↓	↓	↓	60	-.003	.0001	-.05	-.07	-.0004	.015	-.0004	.00025	.00020
				90	-.001	0	-.07	-.12	-.0003	.018	-.0004	.00028	.00009
Off	3	.09	0	15	.003	.0001	-.01	-.03	-.0006	-.001	-.0002	.00006	.00010
↓	↓	↓	↓	30	.003	-.0001	-.01	.10	-.0013	-.001	-.0004	.00010	.00024
				45	.003	-.0001	-.05	.02	-.0014	.018	-.0007	.00028	.00029
				60	.003	0	-.07	-.08	-.0015	.037	-.0009	.00036	.00028
				75	.003	.0001	-.10	-.18	-.0015	.042	-.0011	.00048	.00020
				90	.004	.0002	-.13	-.30	-.0014	.054	-.0012	.00049	.00012
Off	3	.16	0	30	.002	.0003	0	-.04	-.0020	.008	-.0002	.00009	.00045
↓	↓	↓	↓	60	.001	.0002	-.12	-.22	-.0028	.075	-.0015	.00057	.00060
				90	.001	.0006	-.20	-.58	-.0021	.107	-.0020	.00080	.00038
Off	3	.09	4	30	-.002	.0002	-.01	.09	.0009	.005	-.0005	.00021	.00041
↓	↓	↓	↓	60	-.001	.0002	-.06	.01	.0008	.025	-.0013	.00055	.00040
				90	0	.0002	-.16	-.16	-.0001	.061	-.0017	.00069	.00017
Off	3	.09	8	30	-.005	.0005	-.03	.01	.0033	.011	-.0006	.00024	.00045
↓	↓	↓	↓	60	-.004	.0009	-.08	-.10	.0032	.024	-.0016	.00067	.00043
				90	-.001	.0013	-.17	-.43	.0016	.068	-.0018	.00079	.00018
On	3	0	0	0	-.003	.0011	-.01	-.44	.0017	.018	-.0024	.00091	-.00022
Off	Short nose	0	0	0	-.002	-.0011	-.12	.25	-.0044	-.101	0	.00024	.00022
Off	0	0	0	0	-.002	-.0001	-.02	.11	-.0033	.008	.0001	.00004	.00004
Off	6	0	0	0	.002	.0009	.01	-.30	.0042	-.002	-.0001	-.00004	-.00007
Off	0	(1)	(1)	(1)	-.001	-.0003	.01	.15	-.0036	.001	-.0001	.00002	0
Off	6	(1)	(1)	(1)	.002	.0008	-.01	-.31	.0035	.026	-.0005	.00009	-.00005

[1]Incremental changes due to canard deflection with tips in deflected position. Reference configuration $i_c = 3^\circ$, $S_t/S = 0.16$, $\omega = 0^\circ$, $\delta_t = 90^\circ$.

[redacted]

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TABLE II.- SUMMARY OF RESULTS - Concluded

(c) $M = 4.0$

Aerodynamic characteristics of basic configuration													
Configuration					C_{L_o}	C_{D_o}	C_{L_α}	$\left(\frac{L}{D}\right)_{max}$	C_{m_o}	$\frac{dC_m}{dC_L}$	C_{Y_β}	C_{n_β}	C_{l_β}
Fins off, $i_c = 3^\circ$, $\delta_t = 0^\circ$					0.012	0.0085	1.08	5.68	0.0017	-0.091	-0.0024	-0.00083	-0.00011
Incremental changes in aerodynamic characteristics due to changes in configuration													
Vertical fins	i_c, deg	$\frac{S_t}{S}$	ω, deg	δ_t, deg	ΔC_{L_o}	ΔC_{D_o}	ΔC_{L_α}	$\Delta\left(\frac{L}{D}\right)_{max}$	ΔC_{m_o}	$\Delta\frac{dC_m}{dC_L}$	ΔC_{Y_β}	ΔC_{n_β}	ΔC_{l_β}
Off	3	0.04	0	30	-0.001	0.0002	0.01	-0.04	-0.0008	-0.003	-0.0002	0.00014	0.00019
↓	↓	↓	↓	60	-.004	0	.01	-.04	-.0004	.002	-.0006	.00036	.00023
				90	-.001	0	-.04	-.16	-.0004	.019	-.0009	.00048	.00009
Off	3	.09	0	15	.002	-.0002	0	.11	-.0001	-.006	-.0001	.00004	.00015
↓	↓	↓	↓	30	.003	-.0001	-.01	.05	-.0008	.004	-.0005	.00018	.00030
				45	.002	0	-.02	.05	-.0006	-.003	-.0008	.00042	.00037
				60	.002	.0001	-.03	-.08	-.0010	.007	-.0013	.00054	.00039
				75	.002	.0001	-.05	-.13	-.0008	.019	-.0016	.00063	.00031
				90	.003	.0001	-.09	-.25	-.0012	.037	-.0017	.00064	.00018
Off	3	.16	0	30	0	0	0	-.02	-.0007	0	-.0006	.00023	.00052
↓	↓	↓	↓	60	-.001	.0001	-.05	-.22	-.0015	.026	-.0022	.00085	.00063
				90	-.002	.0001	-.11	-.52	-.0016	.073	-.0028	.00099	.00004
Off	3	.09	4	30	-.001	0	-.01	.06	.0009	.015	-.0006	.00018	.00037
↓	↓	↓	↓	60	0	.0002	-.04	-.03	.0010	.031	-.0017	.00074	.00042
				90	.002	.0001	-.12	-.12	-.0003	.065	-.0020	.00080	.00014
Off	3	.09	8	30	-.004	.0002	-.02	-.10	.0029	.010	-.0007	.00028	.00037
↓	↓	↓	↓	60	-.004	.0007	-.06	-.26	.0028	.029	-.0019	.00084	.00040
				90	0	.0011	-.13	-.49	.0012	.064	-.0022	.00094	.00013
On	3	0	0	0	-.002	.0012	-.01	-.47	.0019	.010	-.0021	.00079	-.00022
Off	Short nose	0	0	0	0	-.0010	-.08	.23	-.0040	-.092	-.0001	.00021	.00013
Off	0	0	0	0	0	-.0002	-.02	.11	-.0025	-.006	.0001	.00004	.00002
Off	6	0	0	0	.003	.0006	0	-.23	.0031	.004	-.0001	0	-.00005
Off	0	(1)	(1)	(1)	.001	0	-.03	.05	-.0025	-.011	-.0001	.00002	.00030
Off	6	(1)	(1)	(1)	.004	.0008	-.03	-.24	.0031	.013	-.0002	.00003	.00021

[1]Incremental changes due to canard deflection with tips in deflected position. Reference configuration $i_c = 3^\circ$, $S_t/S = 0.16$, $\omega = 0^\circ$, $\delta_t = 90^\circ$.

A 2 5 6

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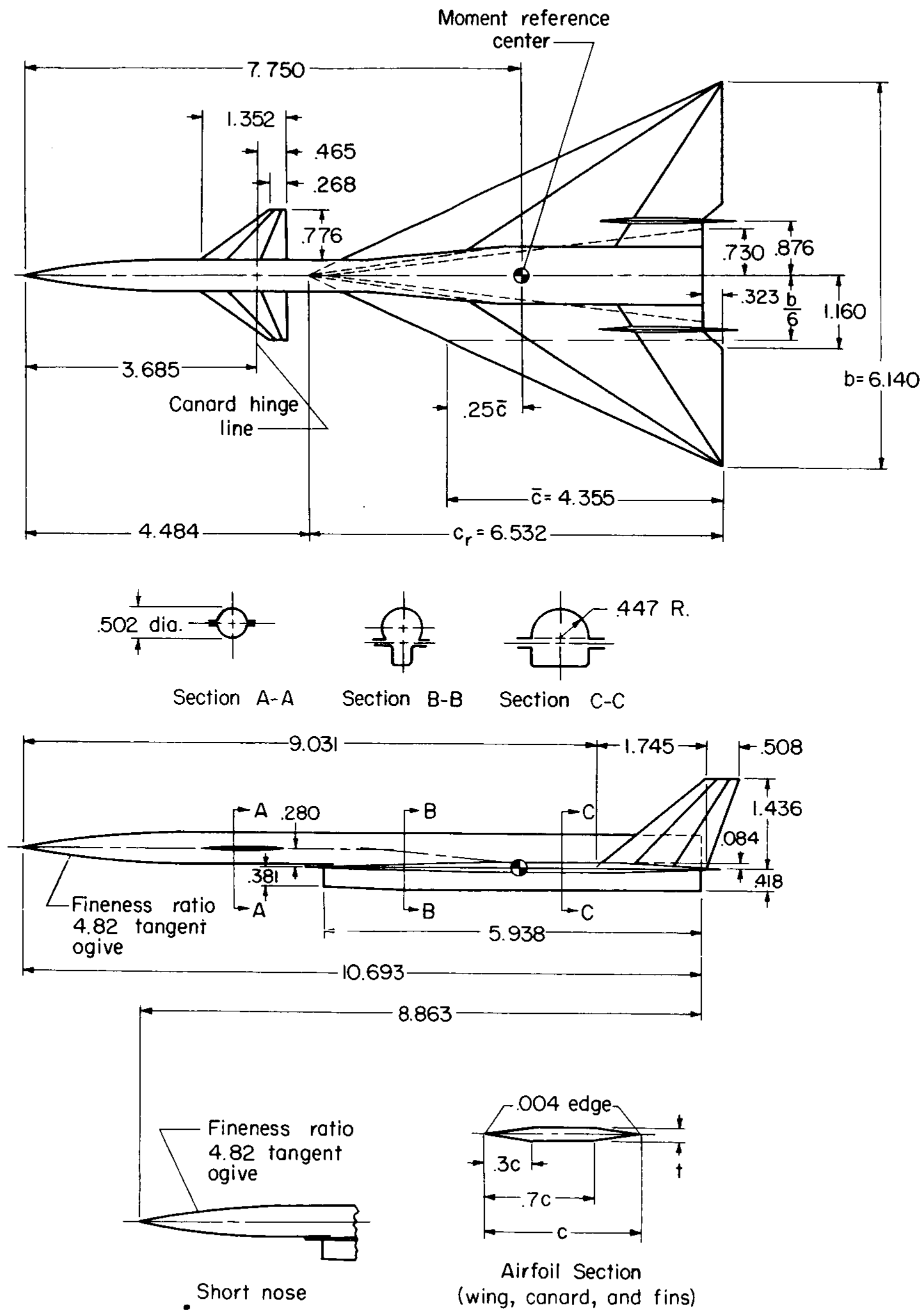
	t/c	Leading-edge sweep	Trailing-edge sweep
Wing	.025	64° 50'	0°
Canard	.030	54° 24'	0°
Vertical Fin	.030	50° 33'	19° 29'

Note: All dimensions in inches.



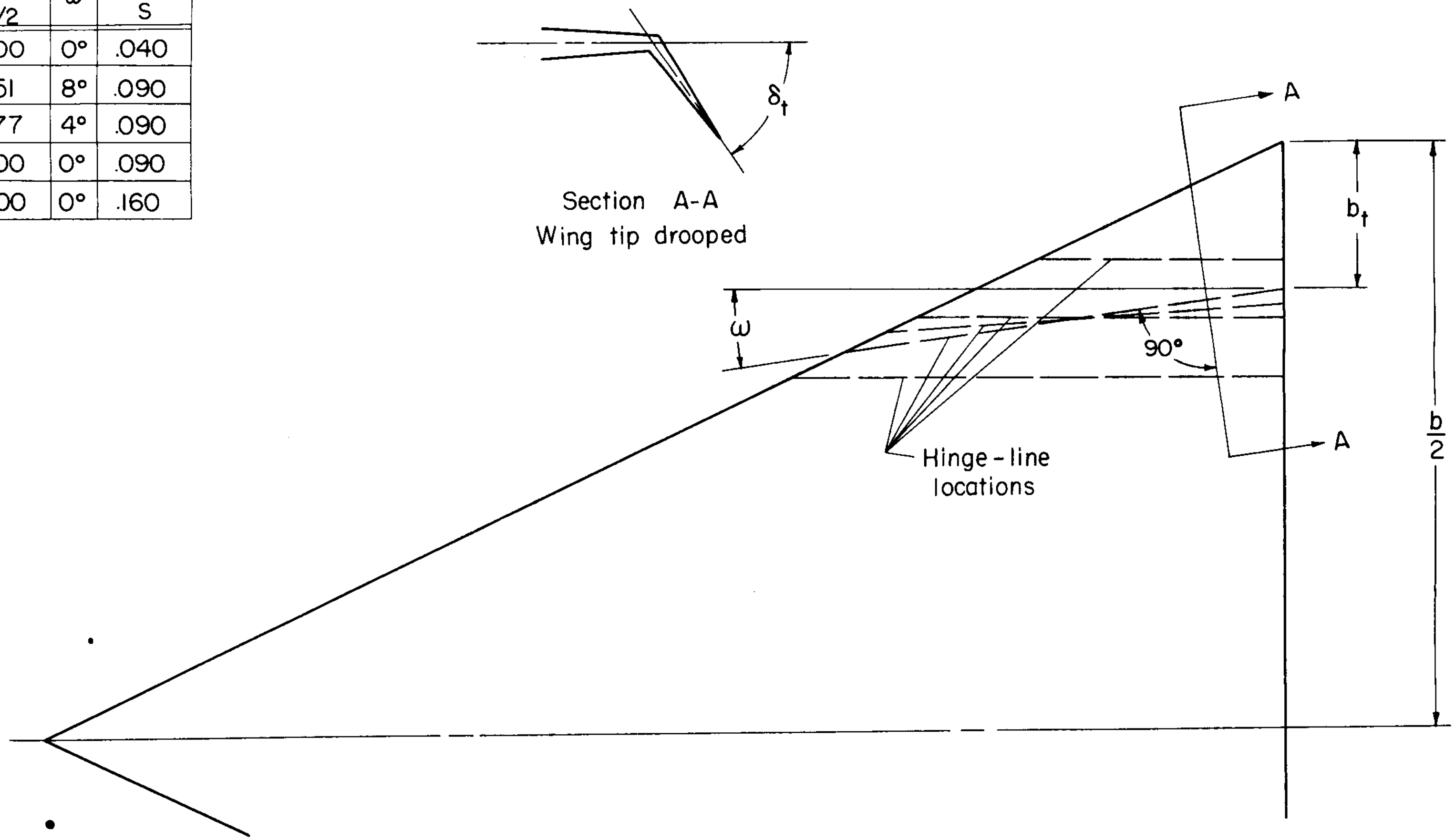
(a) Model configuration.

Figure 1.- Test model.

[redacted]

[redacted]

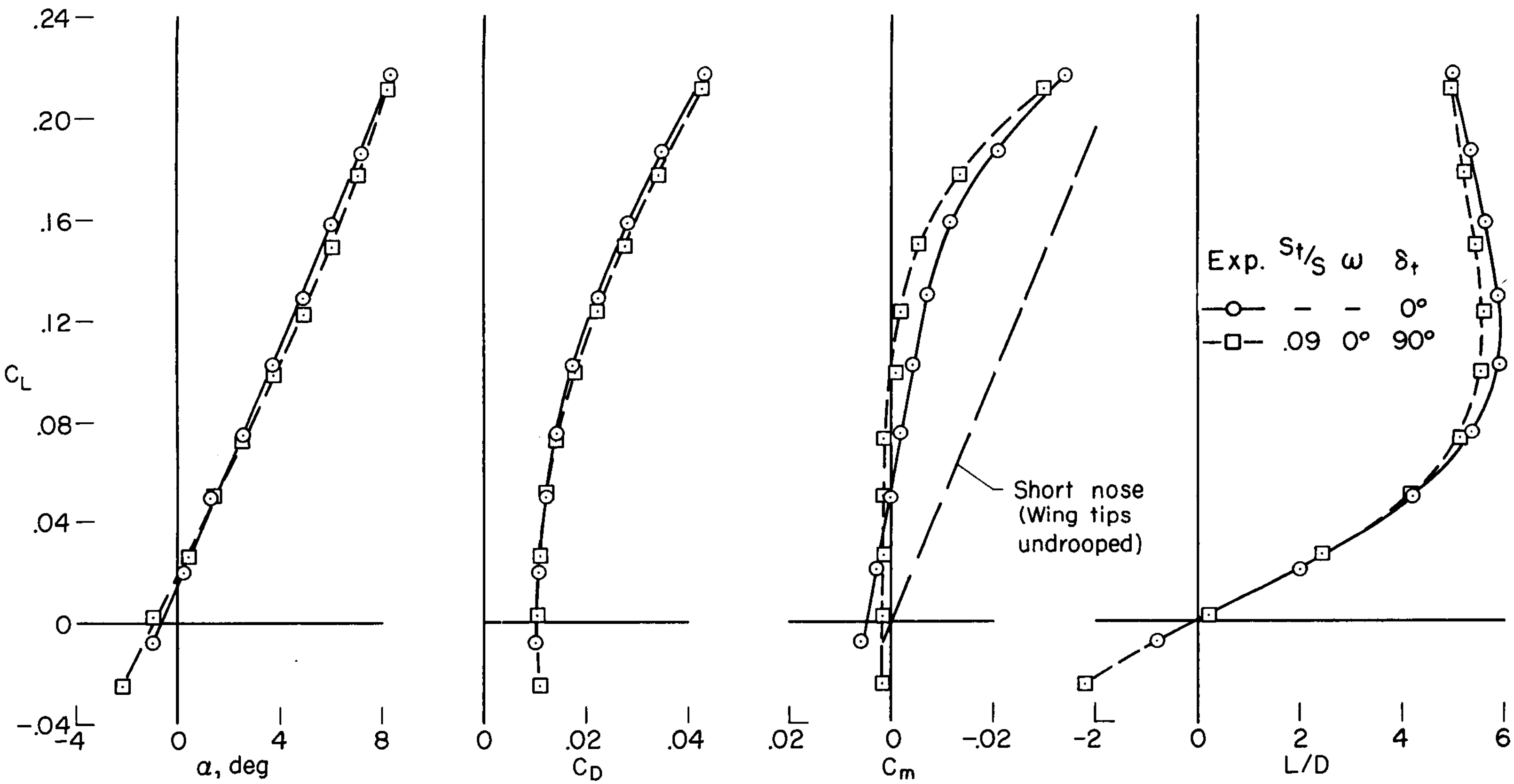
Hinge line geometry		
$\frac{b_t}{b/2}$	ω	$\frac{S_t}{S}$
.200	0°	.040
.251	8°	.090
.277	4°	.090
.300	0°	.090
.400	0°	.160



(b) Wing-tip hinge-line geometry.

Figure 1.- Concluded.

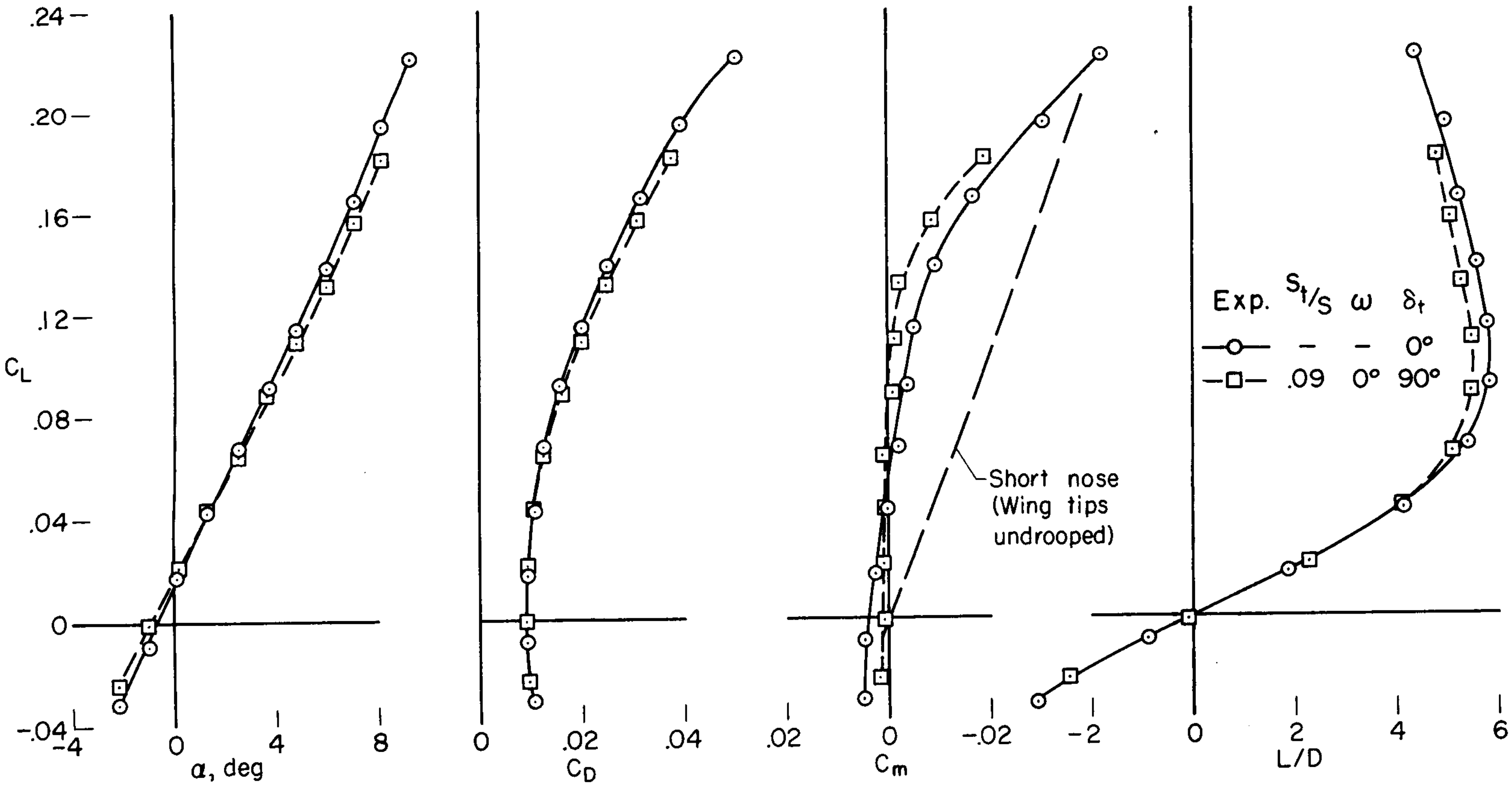
[redacted]



(a) M = 3.0

Figure 2.- Comparison of the measured longitudinal characteristics of the test model with tips undrooped and with $S_t/S = 0.09$, $\omega = 0^\circ$, $\delta_t = 90^\circ$.

[redacted]



(b) M = 3.5

Figure 2.- Continued.

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A
2
5
6

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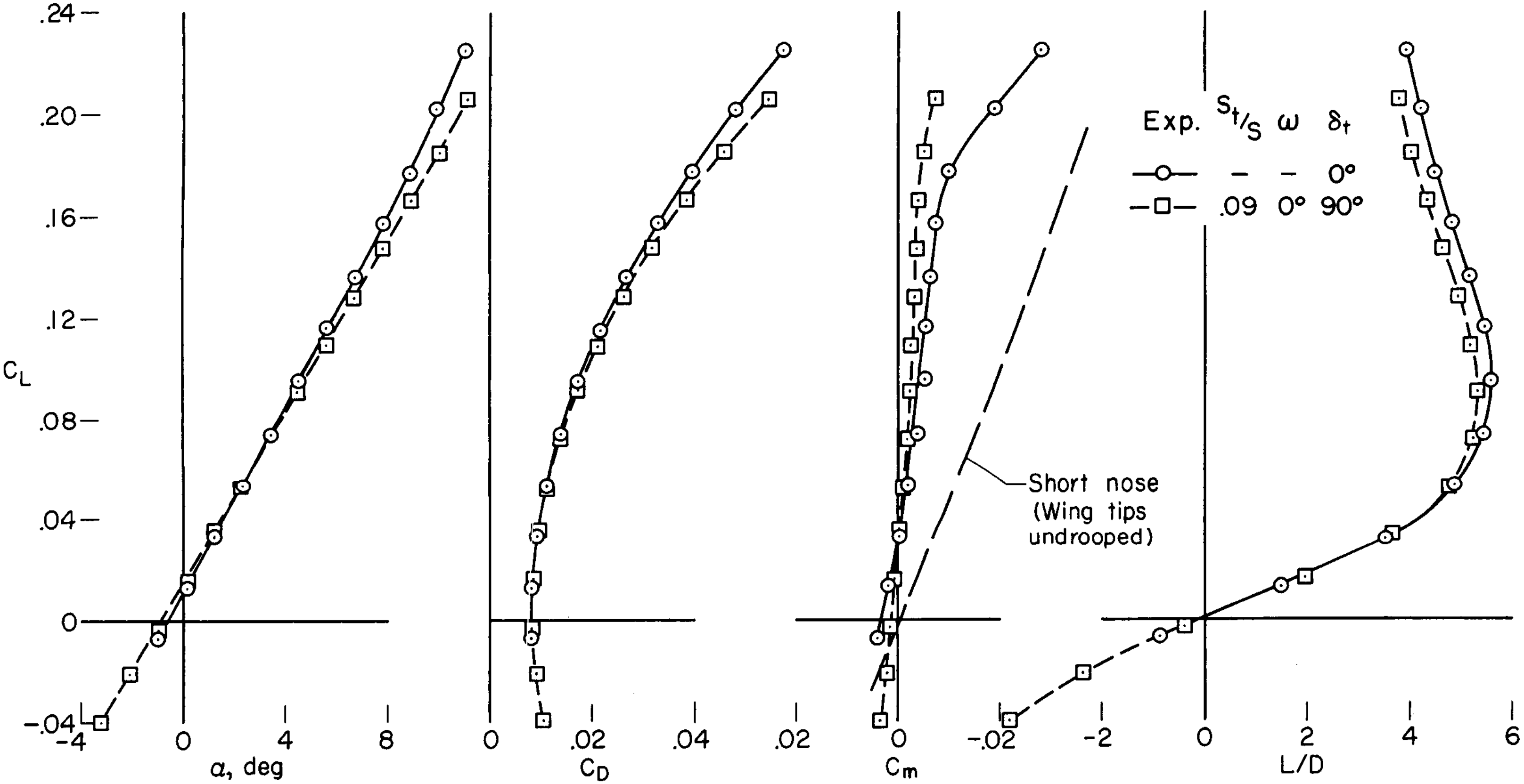


(c) M = 4.0

Figure 2.- Concluded.

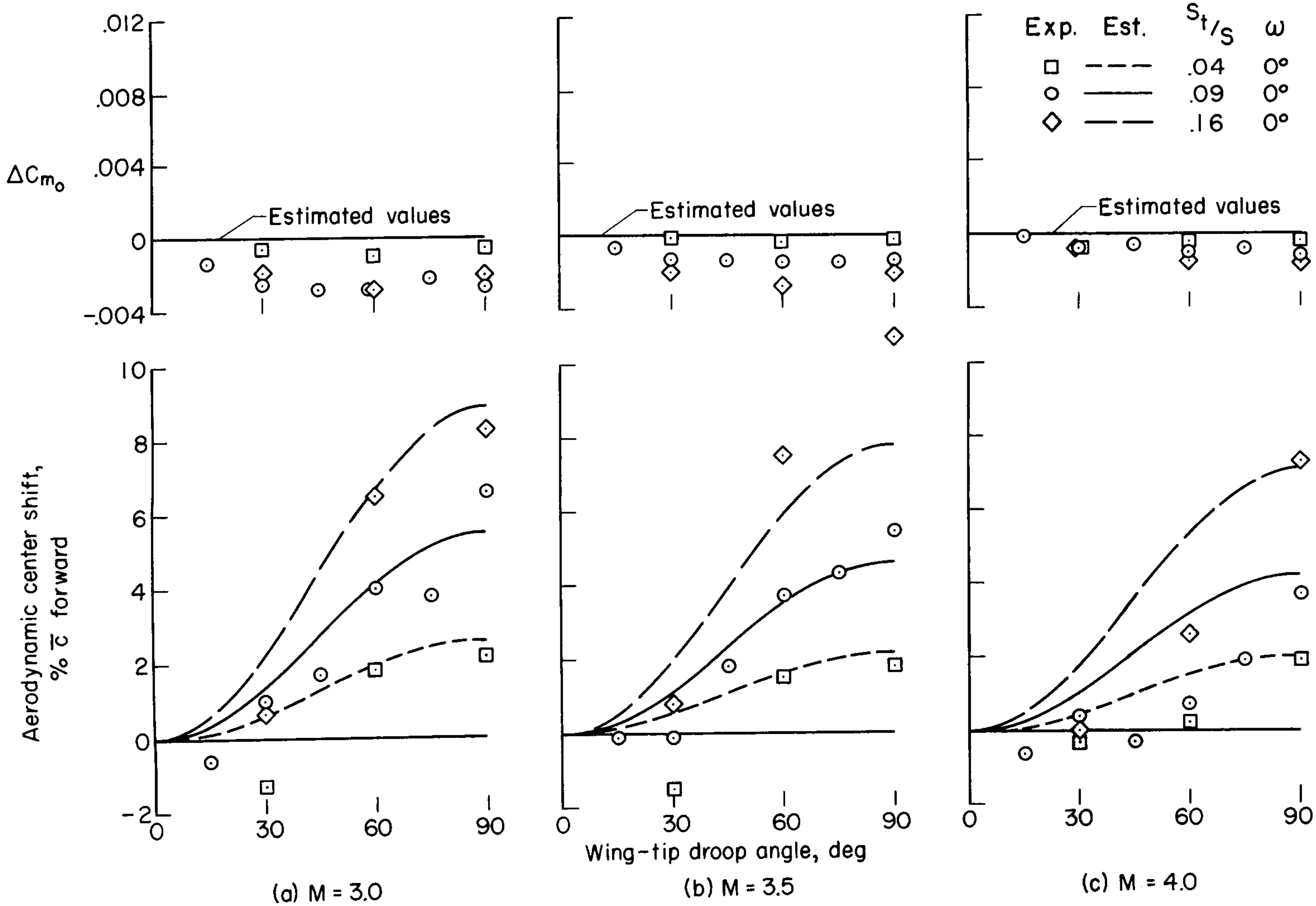


Figure 3.- Incremental changes in pitching-moment characteristics as a function of wing-tip droop angle for several spanwise hinge-line locations.

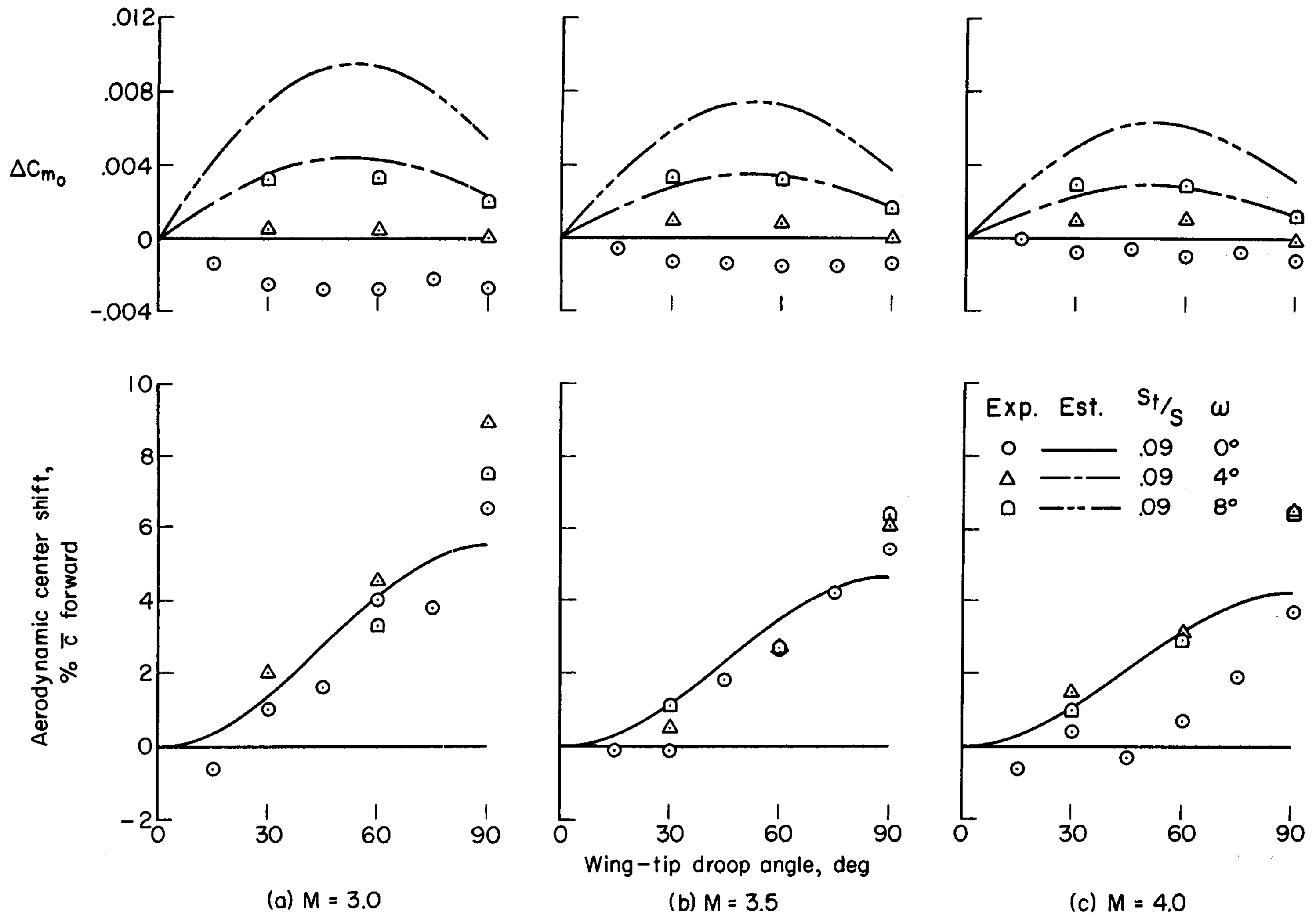


Figure 4.- Incremental changes in pitching-moment characteristics as a function of wing-tip droop angle for several values of hinge-line cant angle.

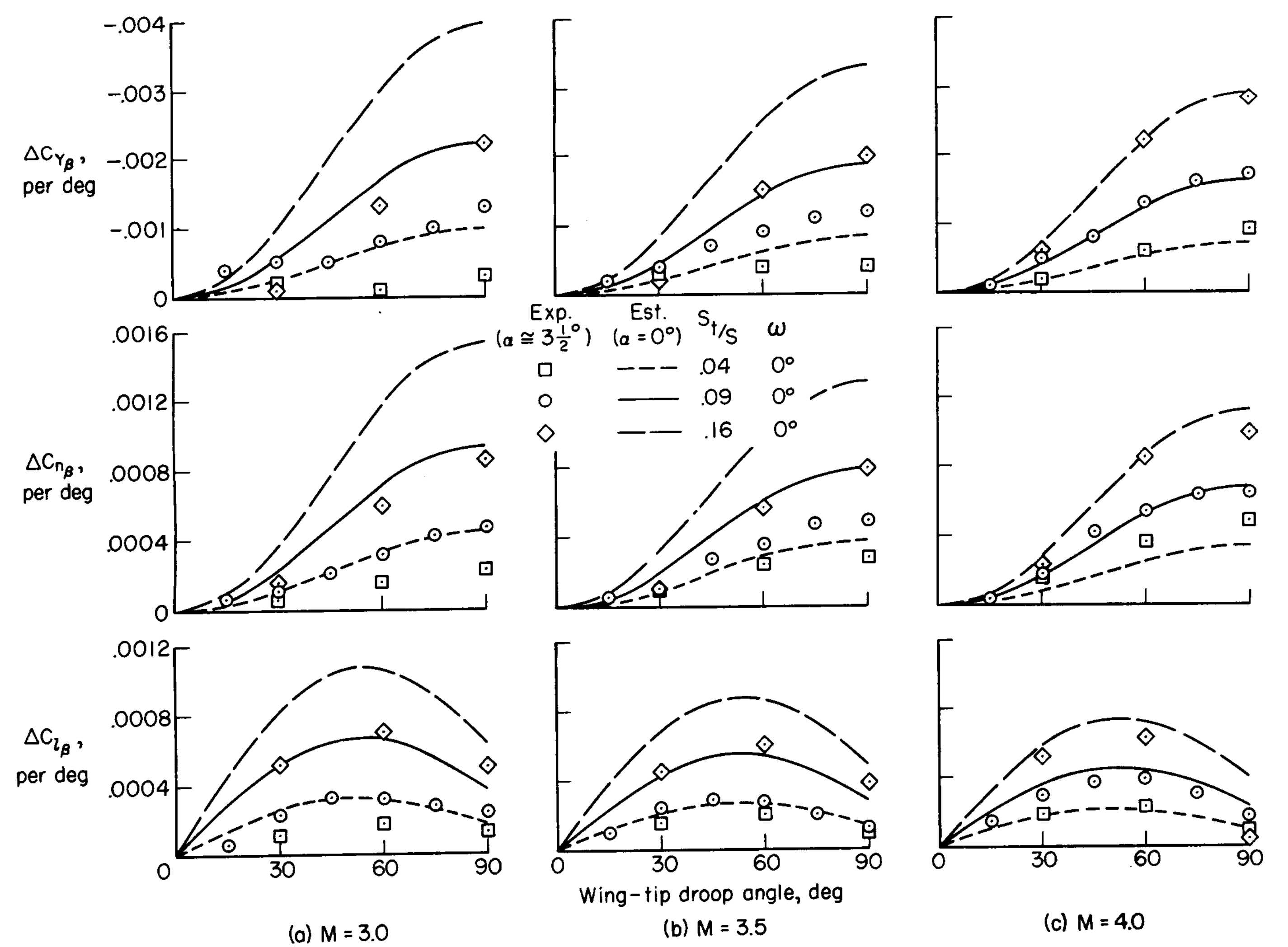


Figure 5.- Incremental changes in directional and lateral characteristics as a function of wing-tip droop angle for several spanwise hinge-line locations.

[redacted]

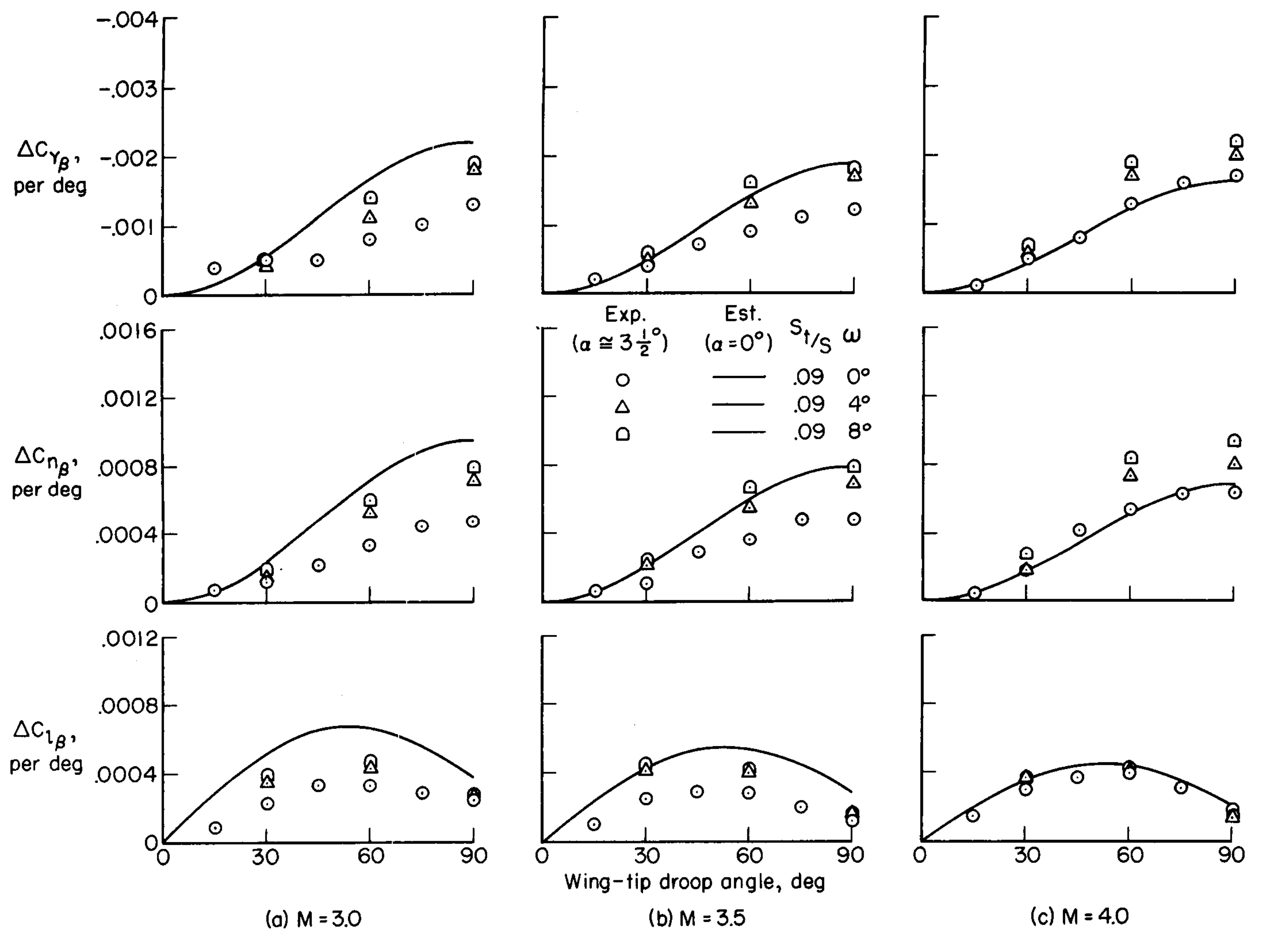


Figure 6.- Incremental changes in directional and lateral characteristics as a function of wing-tip droop angle for several values of hinge-line cant angle.

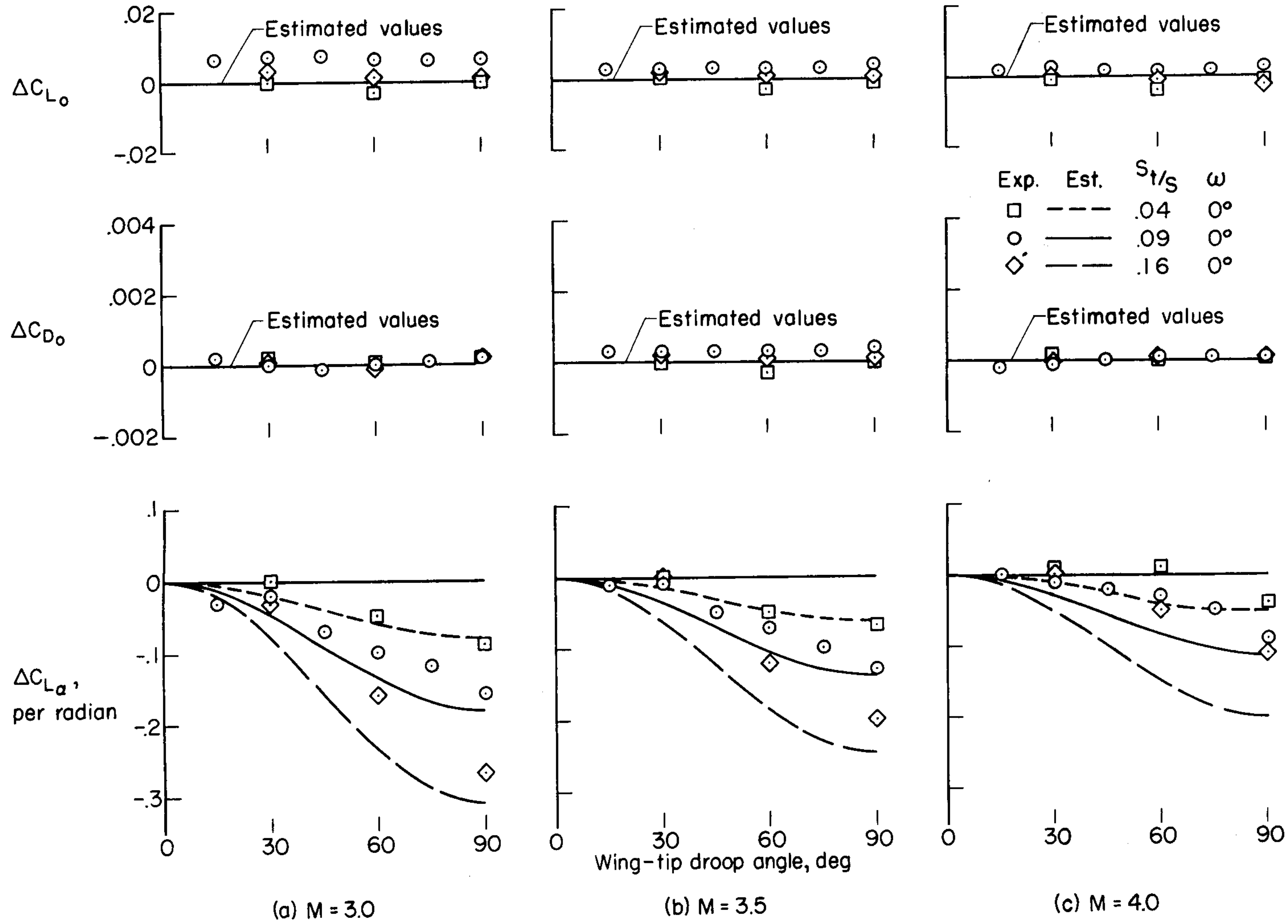


Figure 7.- Incremental changes in performance characteristics as a function of wing-tip droop angle for several spanwise hinge-line locations.

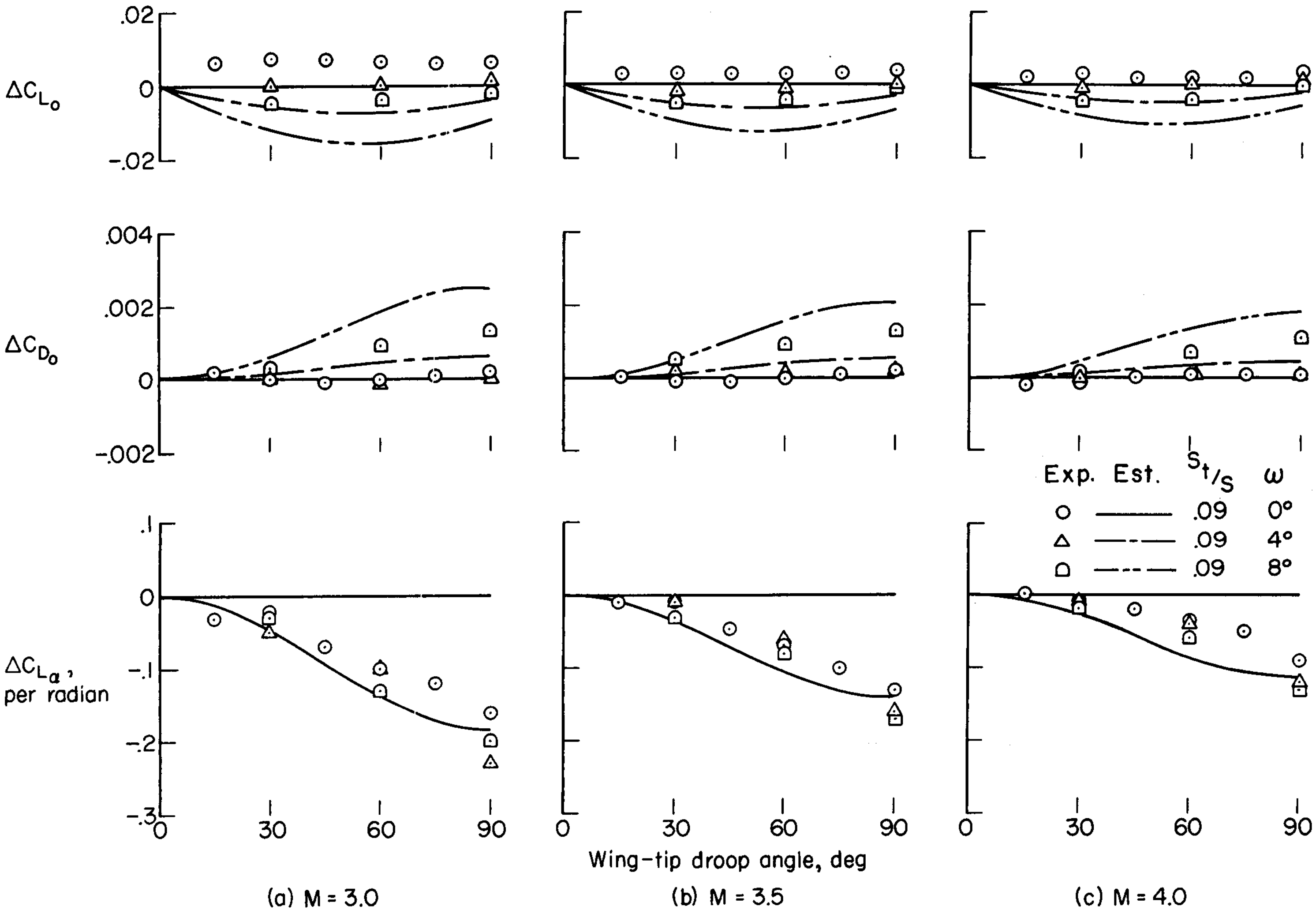


Figure 8.- Incremental changes in performance characteristics as a function of wing-tip droop angle for several values of hinge-line cant angle.

[redacted]

[redacted]

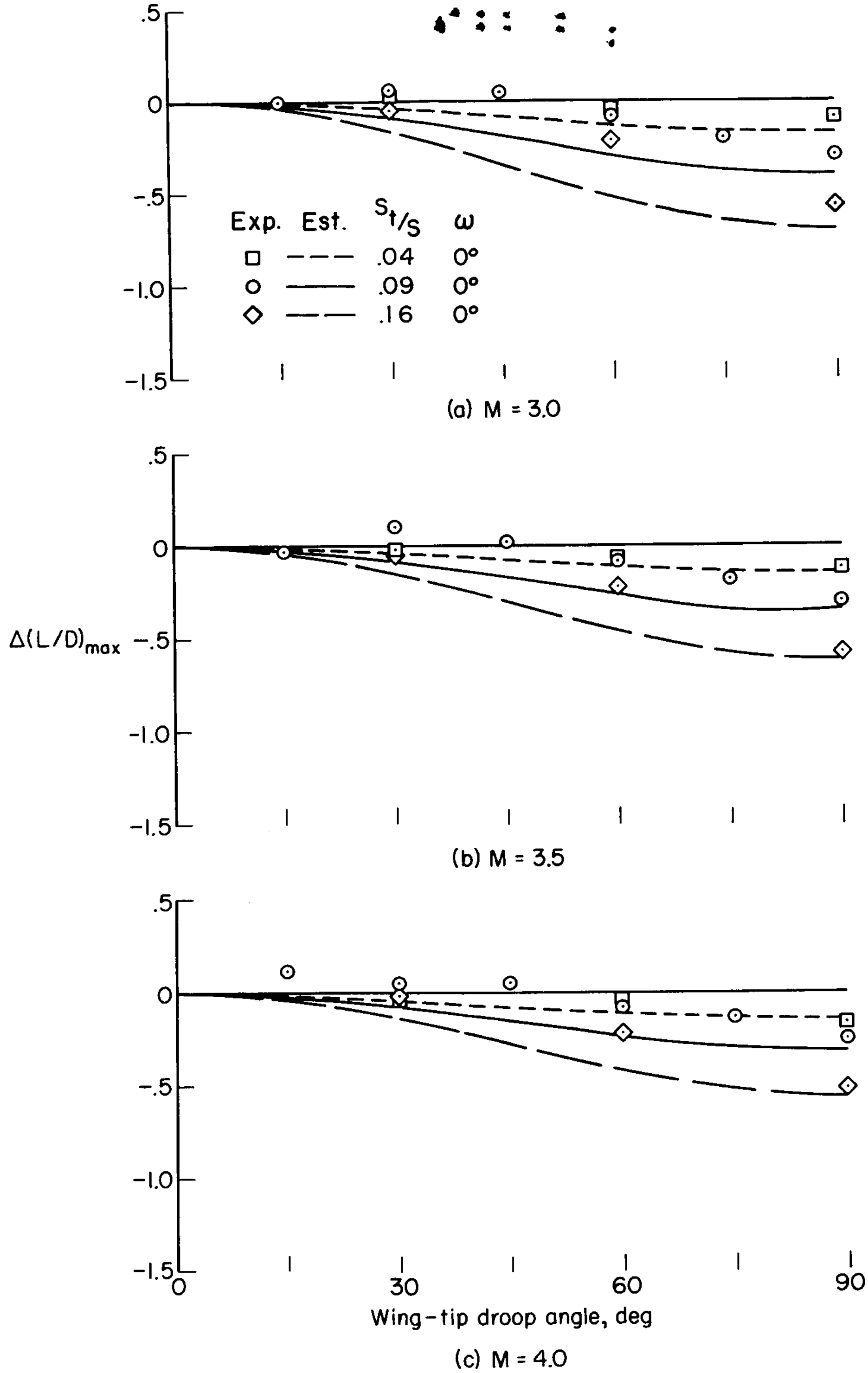


Figure 9.- Incremental changes in maximum lift-drag ratio as a function of wing-tip droop angle for several spanwise hinge-line locations.

A
2
5
6

[redacted]

[redacted]

A
2
5
5

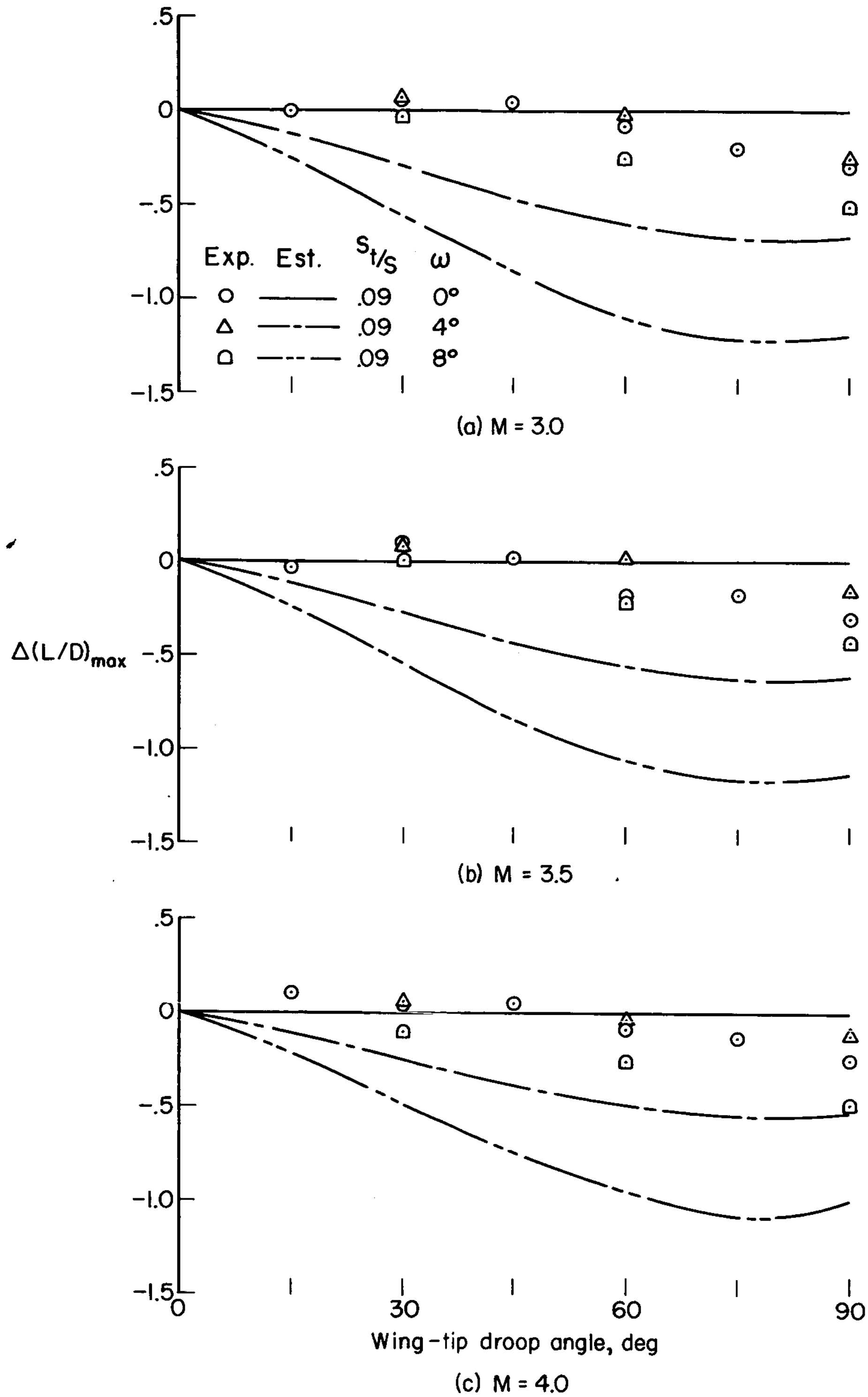


Figure 10.- Incremental changes in maximum lift-drag ratio as a function of wing-tip droop angle for several values of hinge-line cant angle.

[redacted]

[redacted]

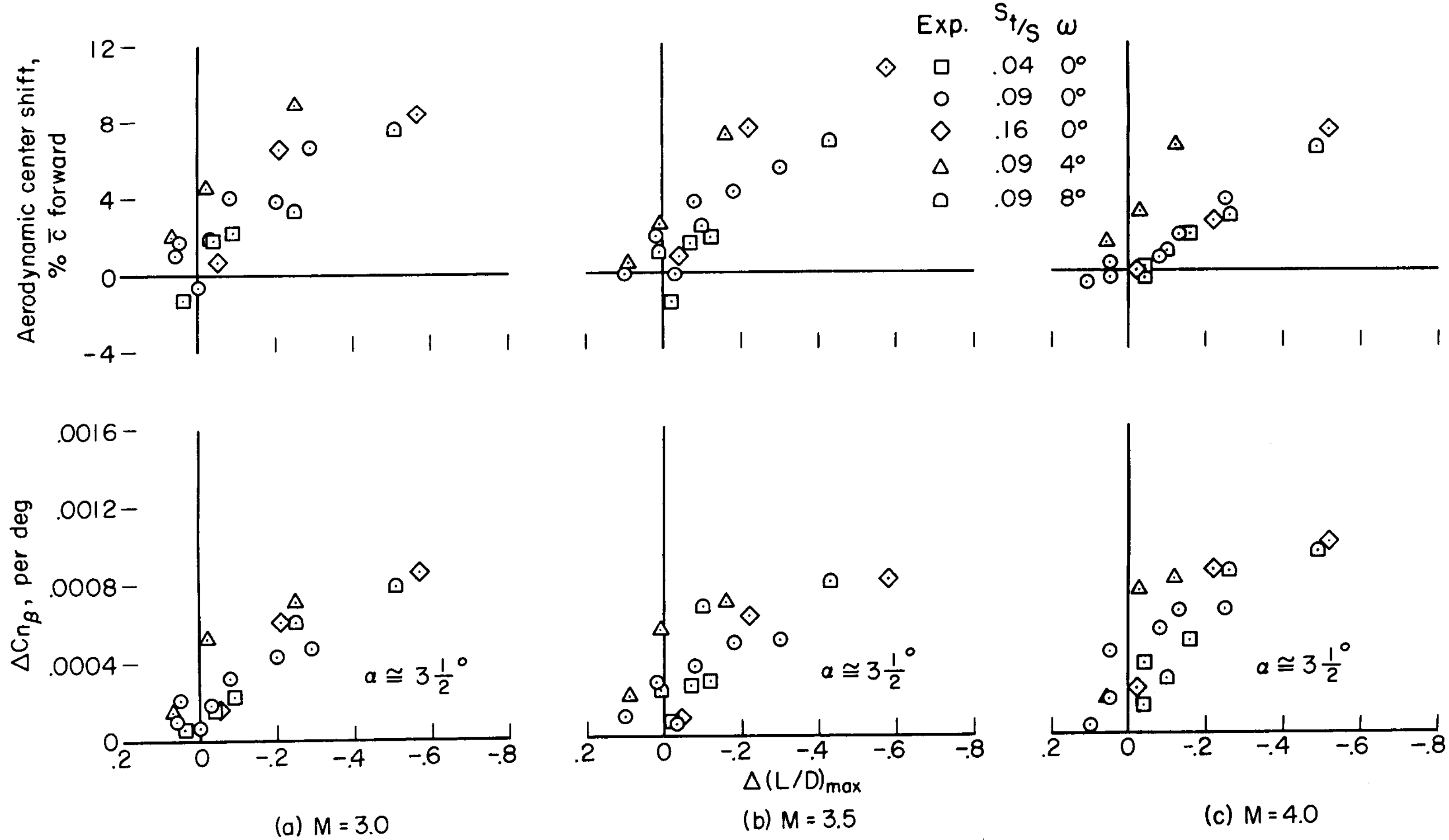
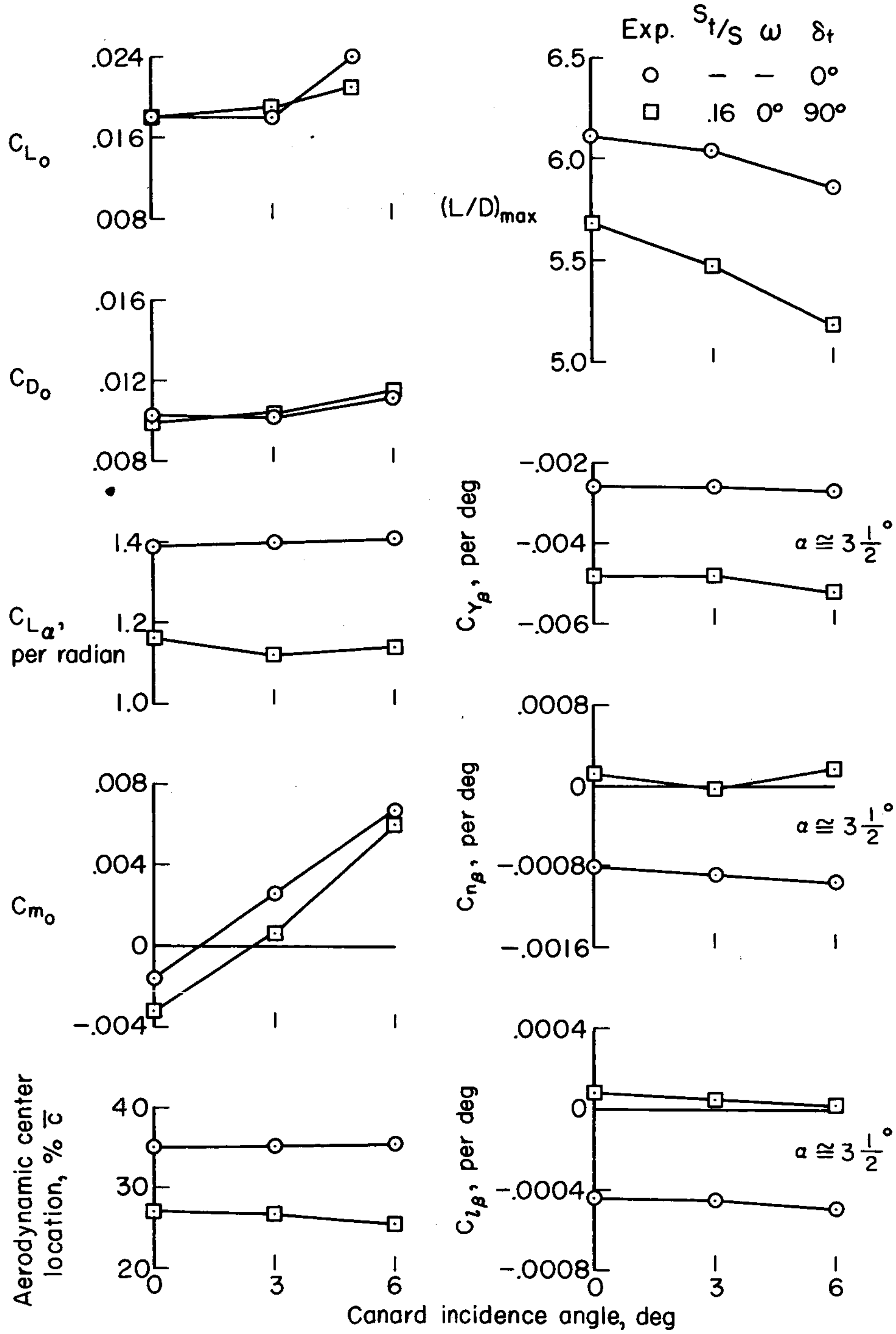


Figure 11.- Incremental changes in longitudinal and directional stability due to wing-tip droop as functions of the associated incremental change in maximum lift-drag ratio.

A
2
5
6

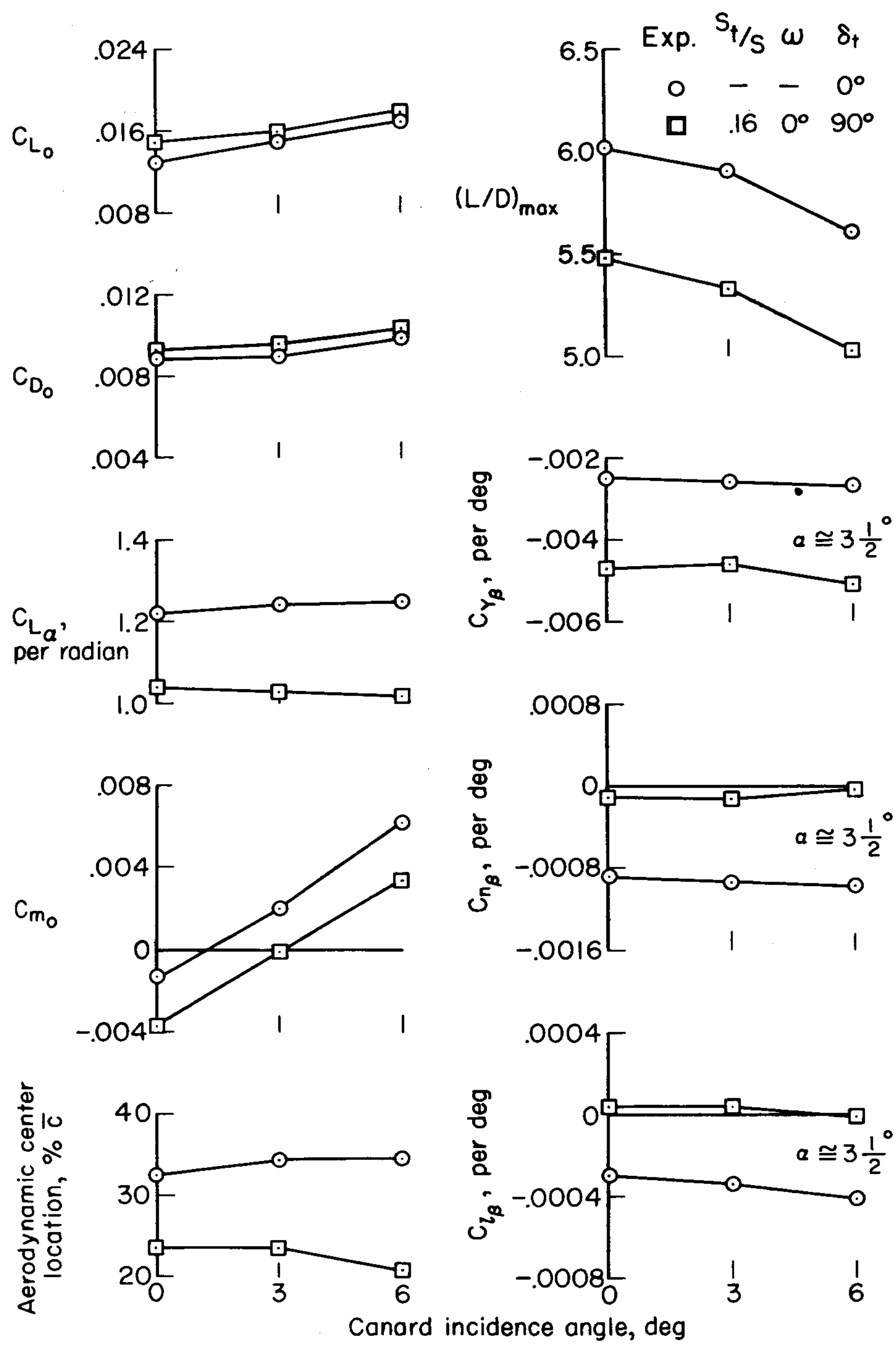


(a) M = 3.0

Figure 12.- Variation of the aerodynamic characteristics of the test model with varying canard incidence angle with tips undrooped and with $S_t/S = 0.16$, $\omega = 0^\circ$, $\delta_t = 90^\circ$.

[redacted]

[redacted]



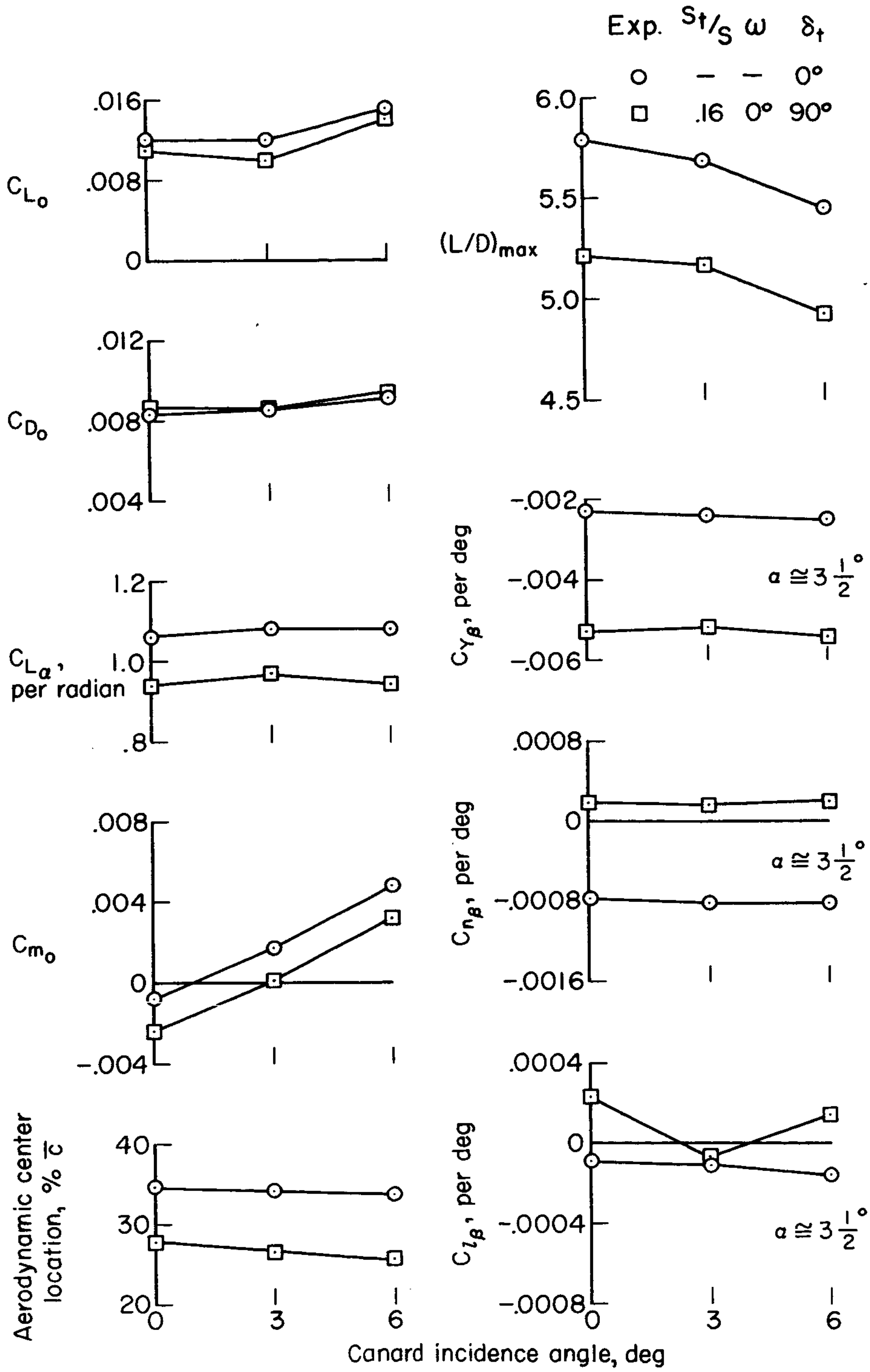
(b) M = 3.5

Figure 12.- Continued.

A
2
5
6

[redacted]

A
2
5
6



(c) M = 4.0

Figure 12.- Concluded.