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EFFECT OF ELEVATOR-PROFILE MODIFICATIONS AND TRAILING-

EDGE STRIPS ON ELEVATOR HINGE-MOMENT AND

OTHER AERODYNAMIC CHARACTERISTICS OF A

FULL-SCALE HORIZONTAL TAIL SURFACE

By Carl F. Schueller, Peter F. Korycinski,
and H. Kurt Strass

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EDGE STRIPS ON ELEVATOR HINGE-MOMENT AND

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SUMMARY

Results are presented of tests of a full-scale horizontal tail surface made to determine the effect of elevator-profile modifications and trailing-edge strips on the elevator hinge-moment characteristics for elevators having fixed plan form and constant balance.

A reduction of $6°$ in the trailing-edge angle of the elevator produced incremental changes in the slopes of the curves of hinge moment against angle of attack and elevator angle of approximately -0.0026 and -0.0013, respectively. The incremental changes in C_{h_δ} (slope of curve of hinge moment against elevator deflection) due to elevator nose-shape modifications were of about the same magnitude as those predicted by the method presented in NACA ACR No. L4E13; whereas the nose-shape changes had little effect on the values of C_{h_α} (slope of curve of hinge moment against angle of attack). By use of a more blunt nose and a reduced trailing-edge angle, the values of C_{h_α} for the elevator could be reduced from the unsatisfactorily high value of 0.0020 to 0 without affecting the values of C_{h_δ}. Trailing-edge strips were found to be very effective in reducing a positive value of C_{h_α} but produced an adverse increase in C_{h_δ}. No appreciable loss in trailing-edge-strip effectiveness in producing changes in hinge-moment coefficient occurred up to the maximum test Mach number of 0.65

INTRODUCTION

The design of highly balanced control surfaces has not been sufficiently developed for the desired control characteristics to be obtained in the first design and, for that reason, the control surfaces of most new airplanes usually must be modified.

In an investigation in the Langley 16-foot high-speed tunnel of a typical full-scale semispan horizontal tail surface of a proposed fighter airplane, a number of systematic profile modifications had to be made to produce the desired aerodynamic characteristics. The present report shows the effect of elevator nose shape, trailing-edge angle, and trailing-edge strips on the aerodynamic characteristics of the tail surface, the elevator of which had a fixed plan form and a constant ratio of balance area to elevator area.

COEFFICIENTS AND SYMBOLS

C_D drag coefficient $\left(\dfrac{D}{qS}\right)$

C_h hinge-moment coefficient $\left(\dfrac{H}{q\bar{c}_e{}^2 b_e}\right)$

C_L lift coefficient $\left(\dfrac{L}{qS}\right)$

C_m pitching-moment coefficient $\left(\dfrac{M_{c'/4}}{qSc'}\right)$

D drag of entire model

H hinge moment

L lift of entire model

$M_{c'/4}$ pitching moment about quarter-chord point of mean aerodynamic chord

b span, feet

c chord, feet

c' mean aerodynamic chord

$\bar{c}_e$ root-mean-square of elevator chord behind hinge line

q   dynamic pressure $\left(\frac{1}{2}\rho V^2\right)$

S   total model area, square feet

M   Mach number

R   Reynolds number

V   velocity of air, feet per second

x   horizontal distance along chord from leading edge, percent chord

y   vertical distance from chord, percent chord

α angle of attack of stabilizer, degrees

ρ mass density of air, slugs per cubic foot

δ angle of elevator chord with respect to stabilizer chord (positive when trailing edge is down), degrees

ϕ_i included angle at elevator trailing edge, degrees

Parameters:

$$C_{L_\alpha} = \left(\frac{\partial C_L}{\partial \alpha}\right)_\delta$$

$$C_{L_\delta} = \left(\frac{\partial C_L}{\partial \delta}\right)_\alpha$$

$$C_{h_\alpha} = \left(\frac{\partial C_h}{\partial \alpha}\right)_\delta$$

$$C_{h_\delta} = \left(\frac{\partial C_h}{\partial \delta}\right)_\alpha$$

(The subscripts outside the parentheses represent the factors held constant during the measurement of the parameters.)

Subscripts:

b   balance

e   elevator (back of hinge line)

f   flap (balance and elevator)

DESCRIPTION OF MODEL

For the present tests, the left side of the horizontal
tail surface of a modern fighter airplane was used as a
model. The airfoil was made according to the profile of
the NACA 66-009 airfoil. For the metal elevator (the orig-
inal elevator), this airfoil was modified to have a
straight contour behind the 0.72c station. The general
arrangement and geometrical characteristics of the model
are presented in figure 1. Figure 2 is a photograph of
the model installed in the Langley 16-foot high-speed tunnel.

Stabilizer.- The stabilizer was of metal construction
and metal covered. All rivets were flush and the surface
had been filled, rubbed with abrasive cloth, and waxed to
increase the surface smoothness; however, considerable
surface waviness existed. The gap between the elevator
and the stabilizer was approximately 1/4 inch and was con-
stant for all elevator angles. In order to reduce undesir-
able air flow through the elevator hinge pockets, cover
plates attached to the top and bottom of each stabilizer
hinge bracket were included.

Elevators.- Four modifications of the metal elevator
were tested. The plan-form dimensions of all elevators
were the same. The hinge line was located at 0.72c and
the elevator balance was $0.48c_e$ ($c_b/c_e = 0.48$). No trim
tab is used on the elevator because the angle of incidence
of the stabilizer is adjustable in flight.

The metal elevator was constructed of aluminum and
had a semielliptical nose and a straight taper behind the
hinge line; this arrangement resulted in a trailing-edge
angle of approximately 13°.

The coordinates of elevators 1 to 4 are given in
table I. These elevators were constructed of spruce and
incorporated systematic modifications to the elevator pro-
file as shown in figure 3. Elevator 1 had a blunt nose
and a straight taper behind the hinge line with a trailing-
edge angle of 13°, the same as the metal elevator.

Elevator 2 had the same blunt nose as elevator 1 and a cusped contour behind the hinge line $(\emptyset_1 = 7^\circ)$. Elevator 3 had a modified blunt nose and the same cusped contour behind the hinge line $(\emptyset_1 = 7^\circ)$ as elevator 2. Elevator 4 had the semielliptical nose profile of the original elevator and the same cusped contour behind the hinge line $(\emptyset_1 = 7^\circ)$ as elevators 2 and 3.

Examination of the model showed that the stabilizer brackets were approximately 3/32 inch above the chord line. The center line of the hinge pins for the metal elevator, however, was found to be slightly above the chord line. The net effect of these constructional defects was to cause the upper surface of the metal elevator to project approximately 1/16 inch above the contour of the tail when the elevator was in the neutral position. These defects caused the hinge-moment curves to be asymmetrical, but the incremental changes of a given coefficient, which result from the elevator modifications described herein, are believed to be correct.

Trailing-edge strips.- Strips of $\frac{1}{8}$-inch- or $\frac{1}{16}$-inch-diameter tubing were attached to both surfaces of the metal elevator at the trailing edge. The method of attaching the tubing to the elevator is shown in figure 4. The length of the trailing-edge strips was varied first by testing the full-span length and then by cutting equal lengths from the root and tip ends of the strips. (See fig. 4.)

APPARATUS AND METHODS

Model installation.- Inasmuch as a semispan model was used for the tests made in the Langley 16-foot high-speed tunnel, the center line of the horizontal tail surface had to be located in the plane of the tunnel-wall flat in order to produce air-flow conditions that approximated those of flight. (See figs. 1 and 2.) Labyrinth-type seals were used at the openings where the model support went through the tunnel-wall flat to minimize the leakage of air from the test chamber to the tunnel.

Hinge-moment measurement.- The elevator control tube was so extended that it passed through the tunnel-wall flat and two self-alining bearings mounted on the

tunnel-balance frame. The elevator hinge moment was transferred through the elevator torque tube to a 6-inch crank and then through a jackscrew to the platform of a scale. The jackscrew was also used to vary the elevator angle. The platform scale was rigidly attached to the tunnel-balance frame and, since all other related parts were also attached to the tunnel-balance frame, the elevator hinge-moment measurements could not interfere with the measurements of lift, drag, and pitching moment. All force and moment data were recorded simultaneously.

Elevator-angle measurement.- An Autosyn was used to measure the elevator angle. The transmitter of this Autosyn was rigidly attached to the stabilizer at the inboard hinge cut-out. A small pinion gear on the transmitter shaft was driven by a large sector gear that was rigidly attached to the root of the elevator. Any elevator deflection that occured was therefore multiplied by the gear ratio (approx. 12:1) and was electrically transmitted to the receiver. A calibrated dial attached to the receiver provided a continuous visual indication of the elevator angle. A template was used to check the zero reading of the Autosyn indicator. This arrangement is believed to have measured the elevator root angle within $\pm 0.1^\circ$.

Angle-of-attack measurement.- An inclinometer located on a reference surface of the model support system was used to measure the angle of attack of the chord line of the stabilizer root. The measurements are believed to be accurate within $\pm 0.05^\circ$.

TESTS

In general, test data were obtained for $\alpha = -3^\circ$, 0°, and 3°, $\delta_e = -8^\circ$ to 8°, and $M = 0.35$. Some combinations of the angle variables could not be tested because of the allowable load limitations on the model. One of the trailing-edge-strip modifications on the metal elevator was tested at Mach numbers as high as 0.65.

Tests to determine the aerodynamic characteristics of the original metal elevator and the effect of trailing-edge angle (elevators 1 and 2) were made with the original hinge location; whereas tests to determine the effect of nose shape (elevators 2, 3, and 4) were made with the

stabilizer hinge brackets lowered 3/32 inch in order to locate the hinge line exactly on the chord line of the tail section.

REDUCTION OF DATA

The data presented herein have been corrected for tunnel-wall effects by the use of the reflection-plane theory given in reference 1. The projected frontal area of the model was such a small part of the tunnel area that tunnel-constriction corrections were negligible. Corrections to pitching moment due to model deflection and balance-frame deflection also were found to be negligible. The corrected data were cross-plotted and the values used herein are for selected angles of attack, elevator angles, and Mach numbers. The average dynamic pressure and average Reynolds number corresponding to the test Mach number are shown in figure 5. The Reynolds number is based on the calculated mean aerodynamic chord of 4.27 feet. Tests in which the gap around the model support was varied from 1/4 inch to 0 showed that no corrections due to end leakage were necessary for this setup.

RESULTS AND DISCUSSIONS

Basic Data with Metal Elevator

The variation of hinge-moment, drag, lift, and pitching-moment coefficients with elevator angle at $M = 0.35$ and $\alpha = -3°$, $0°$, and $3°$ are presented in figures 6 to 9, respectively.

Hinge-moment coefficient.- For the data shown on figure 6, $C_{h_\delta} = -0.0015$ and $C_{h_\alpha} = 0.0020$. A constructional defect in the hinge-bracket locations (see section entitled "Description of Model") is the main cause of the asymmetry of the curves; a slight asymmetry in the elevator contour is probably also a contributing factor.

Drag Coefficient.- No unusual drag characteristics (fig. 7) occurred. The minimum value of C_D, however, is 0.011, which is a relatively high value as compared with the values for surfaces having less profile discontinuity.

Lift coefficient.- The lift coefficient varies
linearly with elevator angle for the range shown in
figure 8. The lift parameters $C_{L\alpha}$ and $C_{L\delta}$ are 0.058
and 0.0275, respectively.

Effect of Trailing-Edge Angle

Flight investigations have shown that the value of
$C_{h\alpha}$ should be approximately 0 in order to avoid adverse
effects on the stability and control characteristics, par-
ticularly in gusty air, and that the value of 0.0020
obtained for the original elevator was unsatisfactorily
high. Preliminary calculations based on unpublished data
indicated that a value of $C_{h\alpha} = 0$ could be obtained by
decreasing the trailing-edge angle from approximately
13° to 7°. This change in elevator shape is illustrated
in figure 3, and its effect was evaluated by a comparison
of the results obtained for elevators 1 and 2.

Hinge-moment coefficient.- The effect of trailing-
edge angle on the elevator hinge-moment coefficient is
shown in figure 10 for three angles of attack and for
$M = 0.35$. The nonlinearity of these curves prevents the
exact use of the usual parameters, but the 6° change in
elevator trailing-edge angle resulted in the following
changes in the parameters: $\Delta C_{h\delta} \approx -0.0013$ and
$\Delta C_{h\alpha} \approx -0.0026$. The change in $C_{h\alpha}$ due to a reduction
in trailing-edge angle was of the desired magnitude, but
the accompanying increase in $C_{h\delta}$ was undesirable because
the control moment was about doubled for the metal elevator.
The undesirable increase in $C_{h\delta}$ due to a reduction in
trailing-edge angle may be nullified with no appreciable
change in $C_{h\alpha}$ by changing the elevator nose shape
(discussed in section entitled "Effect of Nose Shape").
Figure 10(a) indicates a reversal in $C_{h\delta}$ at $\alpha = -3°$.
This undesirable variation is believed to be a result of
the asymmetry of the hinge-bracket location.

Drag coefficient.- The variation of the drag coef-
ficient for elevators 1 and 2 ($\phi_1 = 13°$ and 7°, respec-
tively) with elevator angle is presented in figure 11 for
three values of α and for $M = 0.35$. The drag coef-
ficient for a given increment of elevator deflection is
slightly greater for elevator 2 ($\phi_1 = 7°$) than for
elevator 1 ($\phi_1 = 13°$).

Lift coefficient.- A decrease in elevator trailing-edge angle was usually accompanied by a slight increase in lift. A reduction in trailing-edge angle from 13° to 7° increased C_{L_α} from 0.061 to 0.064 and increased C_{L_δ} from 0.031 to 0.032.

Pitching-moment coefficient.- Reducing the trailing-edge angle from 13° to 7° caused a rearward shift of the center of lift. When the lift was varied by changing the angle of attack at $\delta = 0°$, the center of lift shifted from 22.6 to 24.2 percent of the mean aerodynamic chord; when the lift was varied by changing the elevator angle for $\alpha = 0°$, the center of lift was shifted from 56 to 57.7 percent of the mean aerodynamic chord.

Effect of Nose Shape

Hinge-moment data obtained for the various trailing-edge modifications indicated that the desired value of C_{h_α} could be obtained with a trailing-edge angle of approximately 7°. The reduction in trailing-edge angle, however, caused C_{h_δ} to increase from -0.0015 to about -0.0028. Since the original value of C_{h_δ} obtained for the metal elevator (-0.0015) was considered satisfactory, it was believed desirable to reduce the new value of C_{h_δ}. Reference 3 shows that the value of C_{h_δ} can be changed, without appreciably affecting the value of C_{h_α}, by altering the elevator nose shape. Two alterations were accordingly made to the nose profile (see fig. 3) in an attempt to obtain a satisfactory value of C_{h_δ}. Comparison of elevators 2 and 3 with elevator 4 shows the changes in elevator contour.

Hinge-moment coefficient.- The effect of the nose modifications on the hinge-moment coefficient at M = 0.35 is shown in figures 12 and 13. Because of the difference in structural stiffness between the wooden and metal elevators and because of the asymmetry of the metal elevator (see section entitled "Description of Model"), elevator 4, which had a semielliptical nose profile the same as that of the metal elevator, was used as a reference. Figures 12 and 13 indicate that modifying the nose profile of the metal elevator to the modified-blunt shape (elevator 3) would result in $\Delta C_{h_\delta} \approx 0.0010$ and $\Delta C_{h_\alpha} \approx 0.0002$; these figures indicate also that modifying the nose profile of the metal elevator to the blunt shape (elevator 2) would

result in $\Delta C_{h_\delta} \approx 0.0020$ and $C_{h_\alpha} \approx 0.0004$. An elevator
with a balance-moment area intermediate between elevators
2 and 3 would provide the desired decrease of 0.0013 in
C_{h_δ} and would thus nullify the adverse effect of reducing
the trailing-edge angle to 7°. The tests of the wooden
elevators therefore indicate that the desired values of
$C_{h_\alpha} \approx 0$, $C_{h_\delta} \approx -0.0015$ at $M = 0.35$ may be obtained if the
profile of the metal elevator is so modified that it has
a more blunt nose (intermediate between elevators 2 and 3)
and a cusped contour behind the hinge line (elevator 2)
with a trailing-edge angle of about 7°.

An exact quantitative check of the experimental and
predicted effects (reference 3) of the elevator-nose modi-
fications cannot be made because of the nonlinearity of
the curves of hinge-moment coefficient against elevator
angle. The incremental changes in C_{h_δ} due to modifica-
tions of the elevator nose, however, are of about the same
magnitude as changes calculated by the method of refer-
ence 3. Very poor agreement is obtained when the value of
C_{h_δ} for any one elevator is calculated from unbalanced
section flap data and corrected for balance effects by the
method of reference 3.

Lift coefficient.- The effect of elevator-nose con-
tour on C_{L_δ} is shown in figure 14 for $\delta = 0^\circ$, $M = 0.35$,
and $\alpha = -3^\circ$ to 3°. Figure 14 shows that C_{L_δ} increases
slightly as the surface discontinuity between the rearward
portion of the stabilizer and the elevator nose is reduced
by making the elevator nose more blunt because, as the
contour of the tail surface approaches that of the true
airfoil, optimum pressure distribution and lift are
obtained.

Drag coefficient.- The effect of elevator-nose con-
tour on drag is also shown in figure 14. The drag
decreased slightly as the surface discontinuity between
the rearward portion of the stabilizer and the elevator
nose was reduced.

Pitching-moment coefficient.- The effect of elevator-
nose contour on the pitching moment was not appreciable
and no data are presented.

Effects of Trailing-Edge Strips

Tests were made also to determine combinations of length and diameter of trailing-edge strips that could be used on the metal elevator as a temporary expedient to obtain $C_{h_\alpha} = 0$ for flight tests of the first experimental airplane having this tail surface. Various lengths of $\frac{1}{8}$-inch- and $\frac{1}{16}$-inch-diameter strips were tested at $M = 0.35$ and $\alpha = -3^\circ$, 0°, and 3°.

Hinge-moment coefficient.- Figures 15 and 16 show the variation of hinge-moment coefficient with elevator angle for various lengths of $\frac{1}{8}$-inch- and $\frac{1}{16}$-inch-diameter trailing-edge strips, respectively, at $M = 0.35$ and at $\alpha = -3^\circ$, 0°, and 3°. Decreasing the length of the strip decreases the slope of the hinge-moment curves, and no abrupt changes in the trend of the curves occur. The data presented in these figures have been used to obtain the hinge-moment parameters C_{h_α} and C_{h_δ} shown in figure 17. The desired value of $C_{h_\alpha} = 0$ can be obtained by using $\frac{1}{8}$-inch-diameter strips 24 percent of the span in length or $\frac{1}{16}$-inch-diameter strips 38 percent of the span in length, but with an accompanying adverse increase in C_{h_δ} over the desired value of -0.0015. The effect of speed on the effectiveness of the trailing-edge strips is shown in figure 18. No serious reduction of hinge-moment coefficient C_h occurs up to the maximum test Mach number $(M = 0.65)$ with the full-span $\frac{1}{8}$-inch-diameter strips on the elevator trailing-edge.

Lift coefficient.- Figures 19 and 20 show the effect of the length of the trailing-edge strips on lift coefficient for $\frac{1}{8}$-inch- and $\frac{1}{16}$-inch-diameter strips, respectively. The use of strips of either diameter usually results in an increase in lift at the higher elevator angles.

Drag coefficient.- Figures 21 and 22 show the effect of the length of trailing-edge strips on the drag coefficient for $\frac{1}{8}$-inch- and $\frac{1}{16}$-inch-diameter strips, respectively. The increase in drag due to lengthening the $\frac{1}{8}$-inch-diameter strips is usually twice the increase which

occurred with the $\frac{1}{16}$-inch-diameter strips. The maximum increase measured with $\frac{1}{8}$-inch-diameter full-span strips was 13 percent.

<u>pitching-moment coefficient</u>.- The change in pitching-moment coefficient due to trailing-edge strips was negligible and no figures are presented herein. The center of lift, however, was shifted from 23 percent to 25 percent of the mean aerodynamic chord for $\delta = 0°$ when the lift was increased by changing the angle of attack for $\frac{1}{8}$-inch-diameter full-span strips. The maximum shift in the aerodynamic center was from 52 percent to 58 percent of the mean aerodynamic chord for $\alpha = 0°$ when the lift was increased by changing the elevator angle.

CONCLUSIONS

From tests made in the Langley 16-foot high-speed tunnel of a full-scale horizontal tail surface to determine the effect of elevator-profile modifications and trailing-edge strips on the elevator hinge-moment characteristics. for elevators having fixed plan form and constant balance, the following conclusions were reached:

1. A reduction of 6° in the trailing-edge angle resulted in incremental changes in the slopes of curves of hinge moment against angle of attack and against elevator angle of approximately -0.0026 and -0.0013, respectively.

2. The incremental changes in $C_{h\delta}$ (slope of curve of hinge moment against elevator angle) due to elevator-nose modifications were of the same magnitude as the changes predicted by the use of methods given in NACA ACR No. L4E13. These nose-profile changes had virtually no effect on $C_{h\alpha}$ (slope of curve of hinge moment against angle of attack).

3. A reduction in trailing-edge angle and an increase in the bluntness of the nose profile reduced the values of $C_{h\alpha}$ for the metal elevator from 0.0020, which was unsatisfactorily high, to 0 without affecting the value of $C_{h\delta}$.

4. Trailing-edge strips were found to be very effective in reducing a positive value of $C_{h\alpha}$, but an adverse

increase in the values of C_{h_δ} accompanied the use of
these strips. No appreciable loss in the effectiveness
of the trailing-edge strips in producing changes in
hinge-moment coefficient was apparent up to the maximum
test Mach number of 0.65.

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        1944.

TABLE I

COORDINATES FOR ELEVATORS 1 TO 4 IN PERCENT c

x	Elevator 1 y (a)	Elevator 2 y	Elevator 3 y	Elevator 4 y
0	0	0	0	0
.51	3.91	3.91	3.19	2.47
1.03	5.04	5.04	4.19	3.33
2.06	6.26	6.26	5.33	4.40
3.09	7.10	7.10	6.19	5.27
4.12	7.61	7.61	6.71	5.80
5.14	8.03	8.03	7.20	6.38
6.17	8.23	8.23	7.47	6.71
7.20	8.46	8.46	7.75	7.04
8.23	8.62	8.62	7.95	7.28
9.26	8.75	8.75	8.16	7.57
10.29	8.85	8.85	8.31	7.78
11.32	8.91	8.91	8.43	7.94
12.35	8.93	8.93	8.50	8.07
13.37	8.95	8.95	8.59	8.23
14.40	8.99	8.99	8.63	8.27
16.46	8.95	8.95	8.69	8.44
18.52	8.87	8.87	8.65	8.44
20.58	8.76	8.76	8.60	8.44
22.63	8.64	8.64	8.54	8.44
24.69	8.44	8.44	8.38	8.31
28.81	8.03	8.03	8.01	7.99
32.92	----	7.57	7.55	7.53
37.04	----	7.10	7.10	7.10
41.15	----	6.59	6.59	6.59
45.27	----	6.13	6.13	6.13
49.38	----	5.58	5.58	5.58
53.50	----	5.04	5.04	5.04
57.61	----	4.53	4.53	4.53
61.73	----	3.93	3.93	3.93
65.84	----	3.48	3.48	3.48
69.96	----	3.01	3.01	3.01
74.08	----	2.47	2.47	2.47
78.19	----	2.02	2.02	2.02
82.31	----	1.56	1.56	1.56
86.42	----	1.13	1.13	1.13
90.54	----	.82	.82	.82
94.65	----	.52	.52	.52
98.77	----	.27	.27	.27
T.E. radius = 0.05 inch				

aDashes indicate straight taper behind 0.324 c.
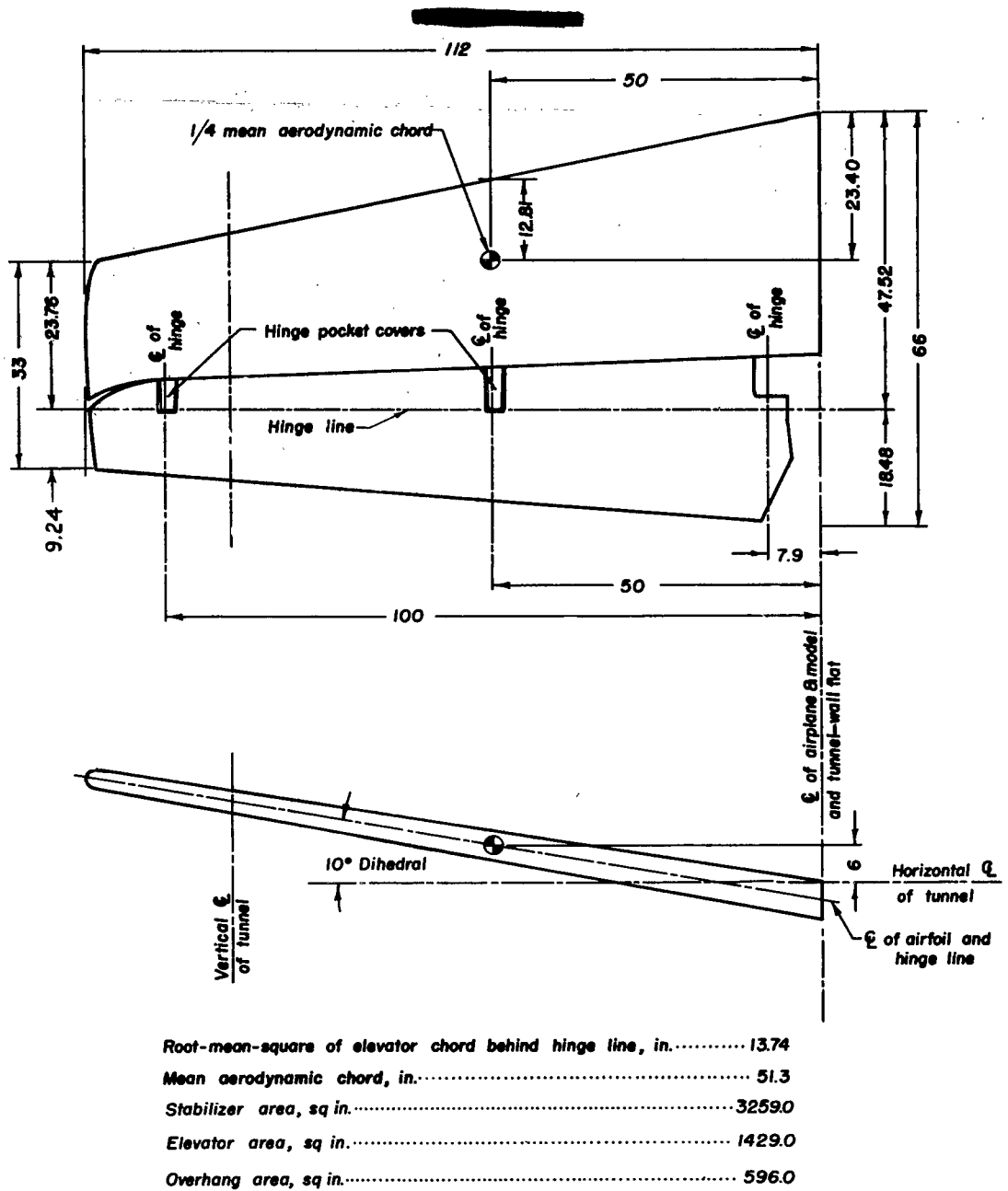
Figure 1.- General arrangement of the horizontal tail surface
in the Langley 16-foot high-speed tunnel. (All dimensions
in inches and measured in plane of section.)

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LMAL 39297
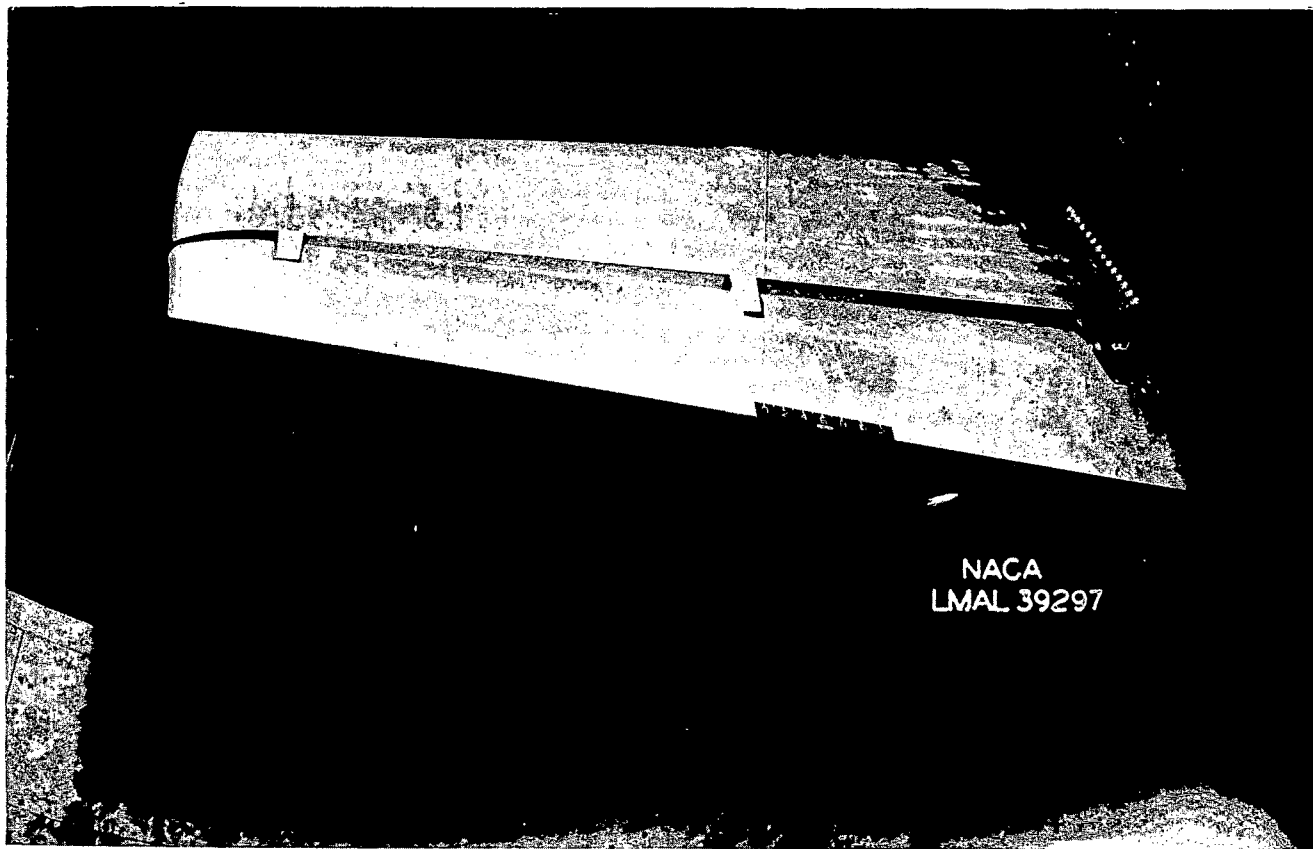
Figure 2.- Installation of model in tunnel.

Fig. 2
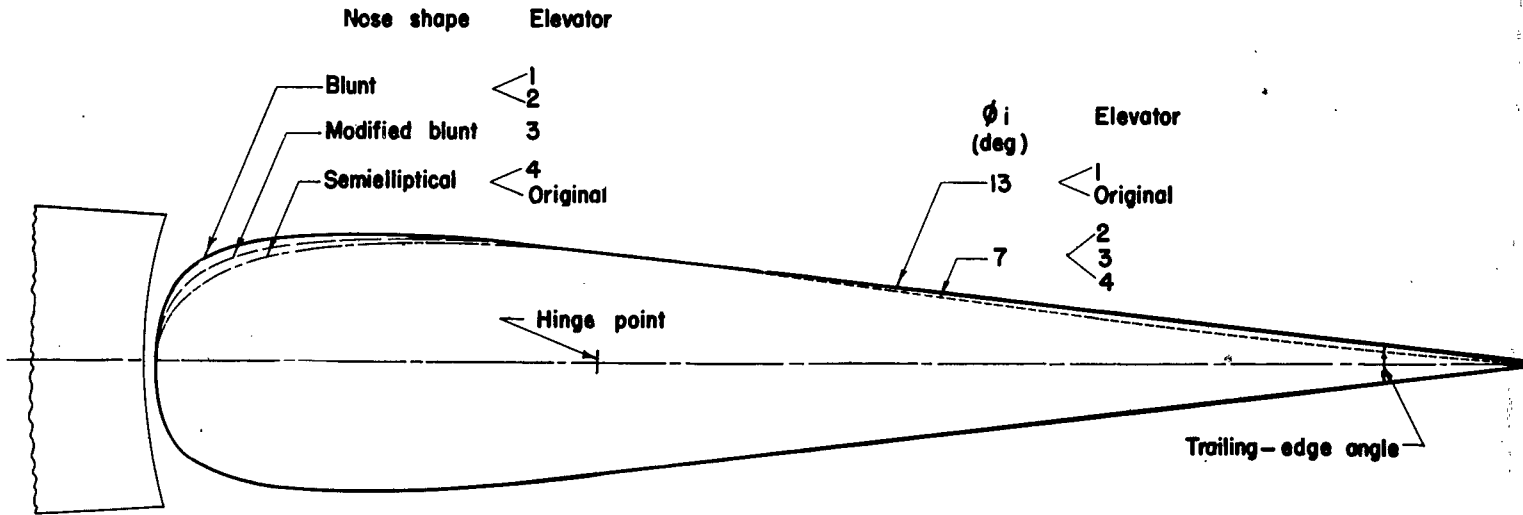
Figure 3.— Contours of original metal elevator and elevators 1 to 4.

Fig. 3

Quarter span

Half span

Full span

Elevator skin

Linen tape

Tubing

C_L

Typical section

Fig. 4
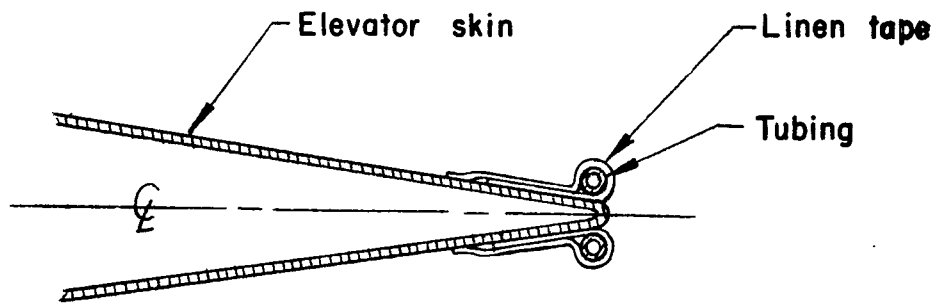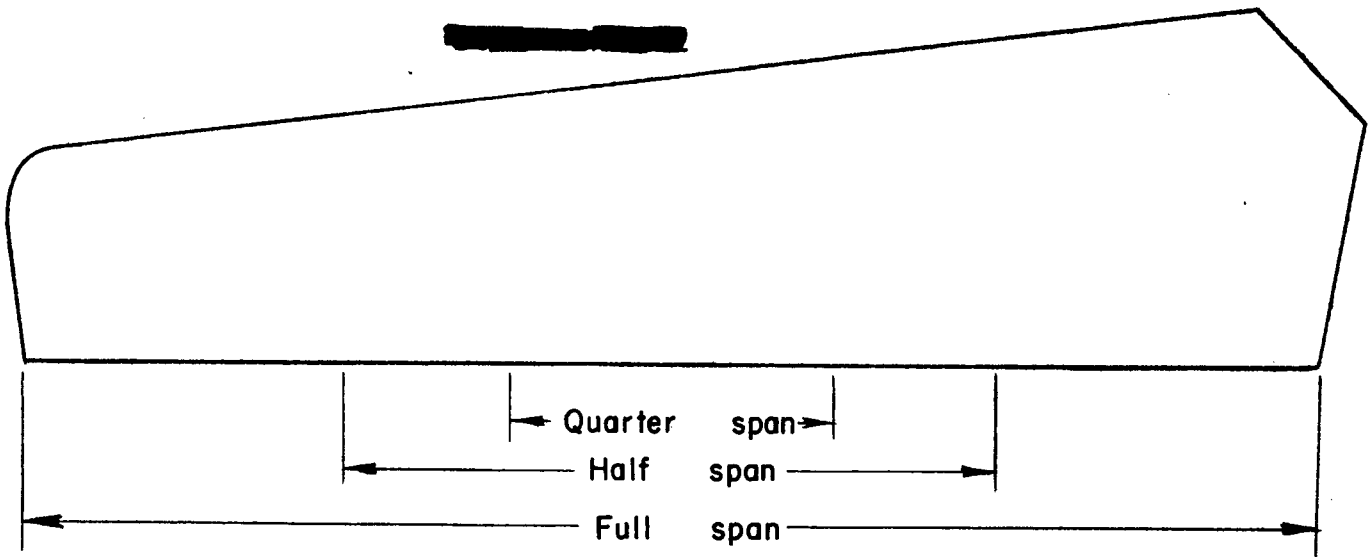
Figure 4 .—— Location and installation of trailing—edge strips on metal elevator.
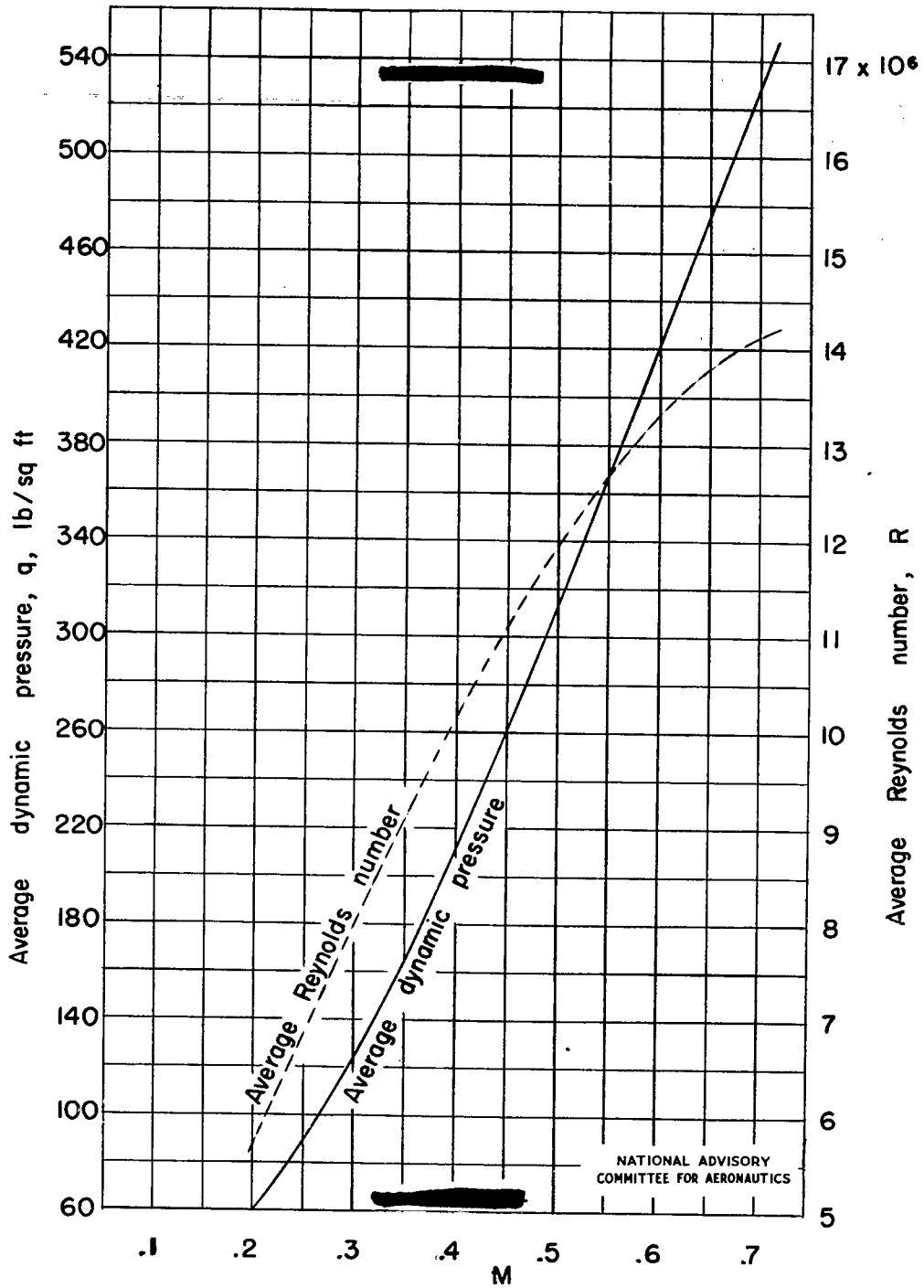
Figure 5 .—Variation of the average dynamic pressure
and average Reynolds number with test Mach number.

(a) $\alpha = -3°$.

(b) $\alpha = 0°$.

(c) $\alpha = 3°$.

Hinge-moment coefficient, C_h

δ, deg
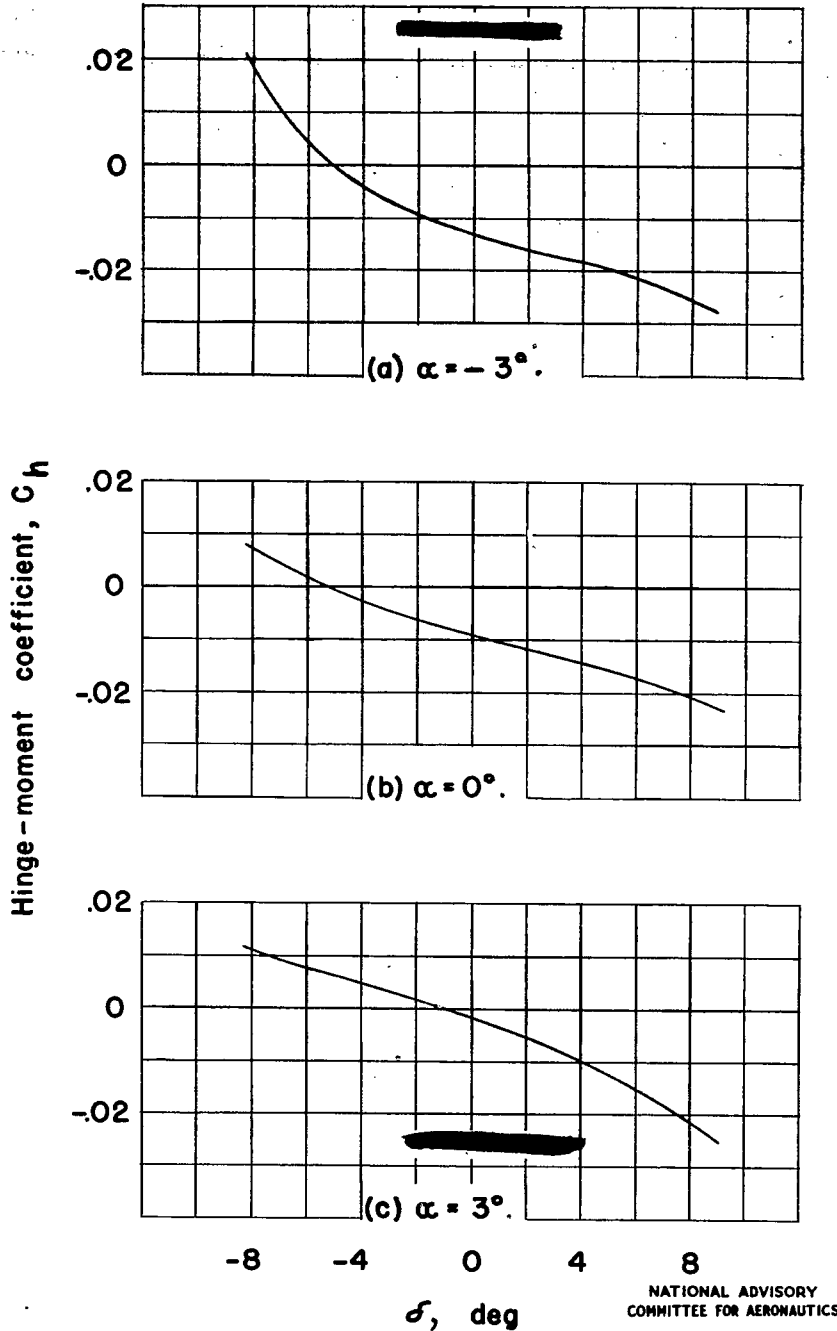
Figure 6 .— Variation of hinge-moment coefficient
with elevator angle; metal elevator.
M= 0.35.

(a) $\alpha = -3°$.

(b) $\alpha = 0°$.

(c) $\alpha = 3°$.

Drag coefficient, C_D

-8　　-4　　0　　4　　8

δ, deg
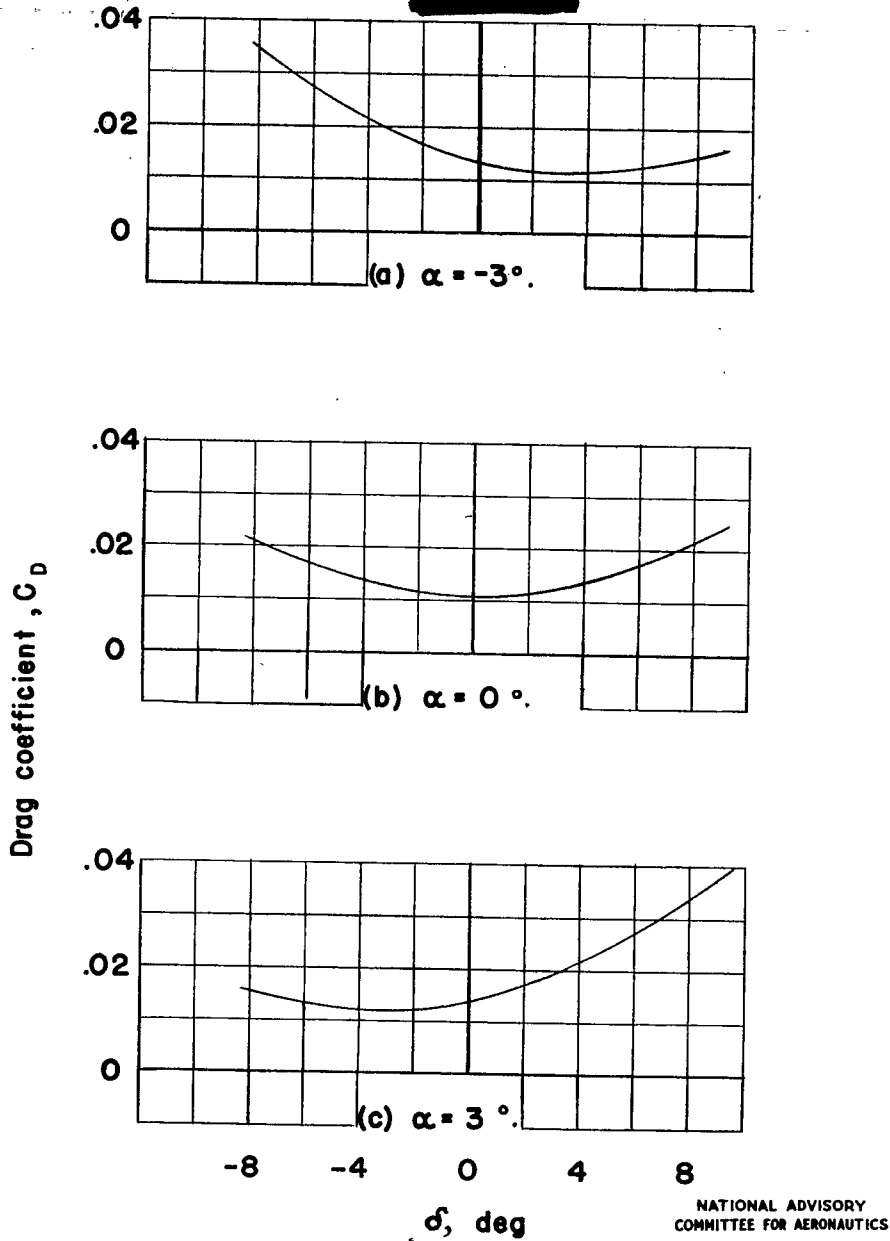
Figure 7.- Variation of drag coefficient with elevator angle; metal elevator. M = 0.35.
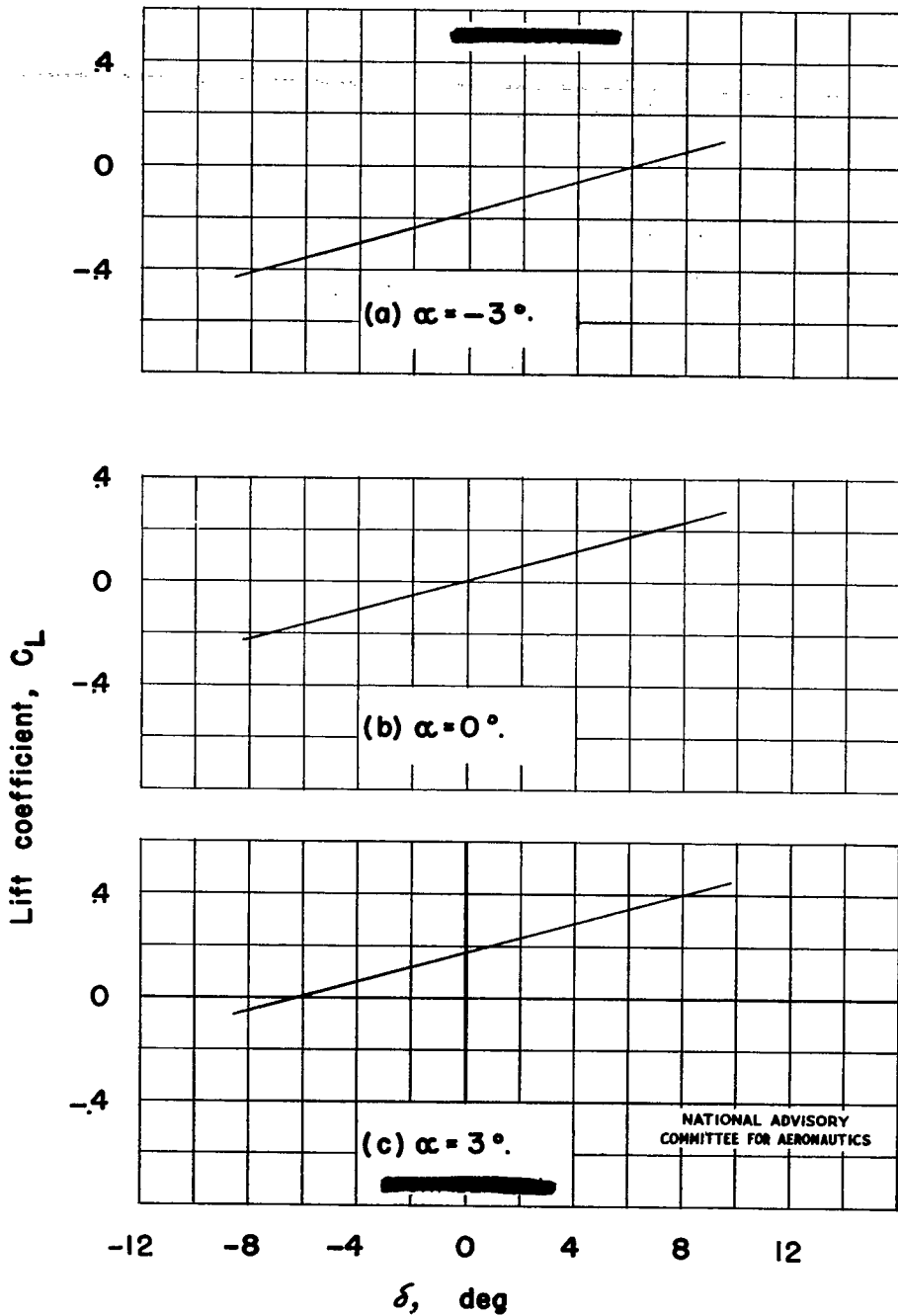
Figure 8 .— Variation of lift coefficient with elevator angle; metal elevator. M = 0.35.
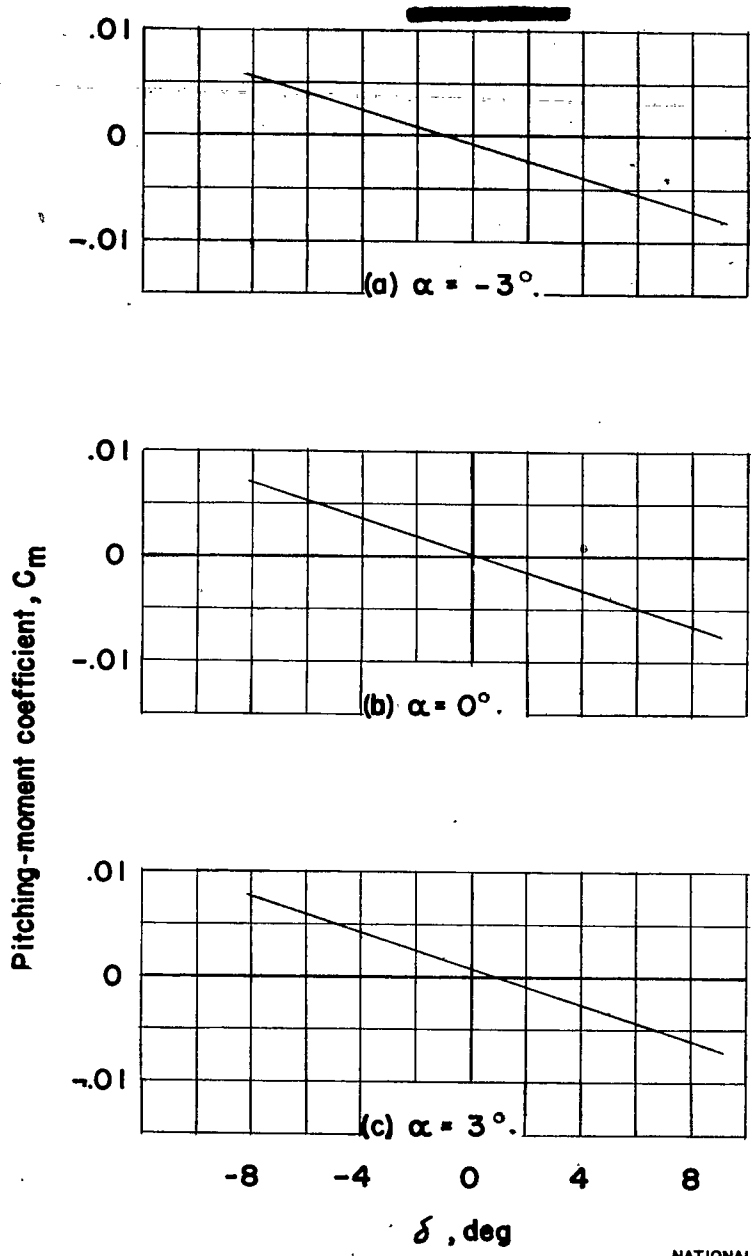
Figure 9.- Variation of pitching-moment coefficient
with elevator angle; metal elevator, M= 0.35.
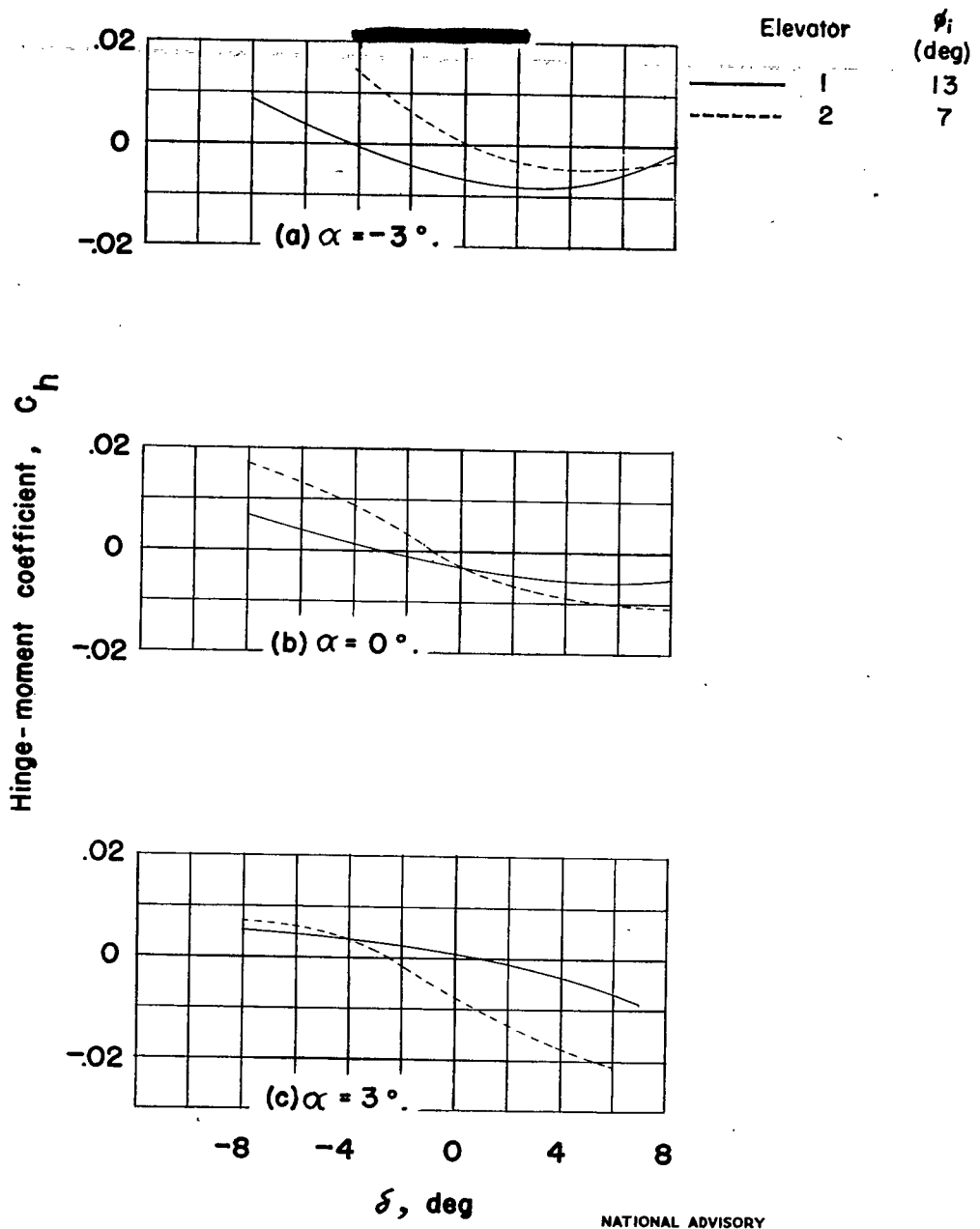
Figure 10.—Effect of elevator trailing-edge angle on elevator hinge-
moment coefficient. M= 0.35.
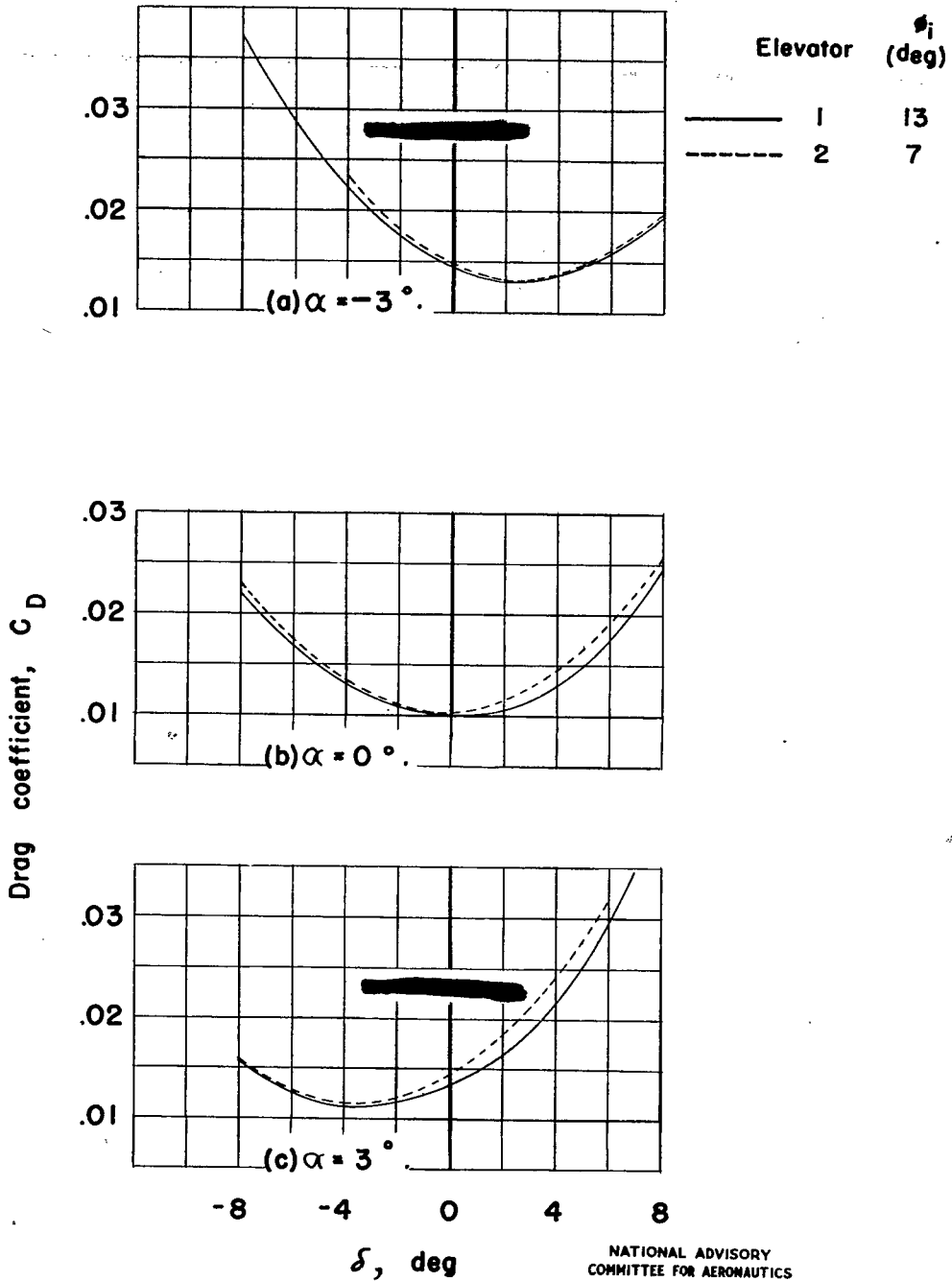
Figure 11.— Effect of elevator trailing-edge angle on drag coefficient. M= 0.35.
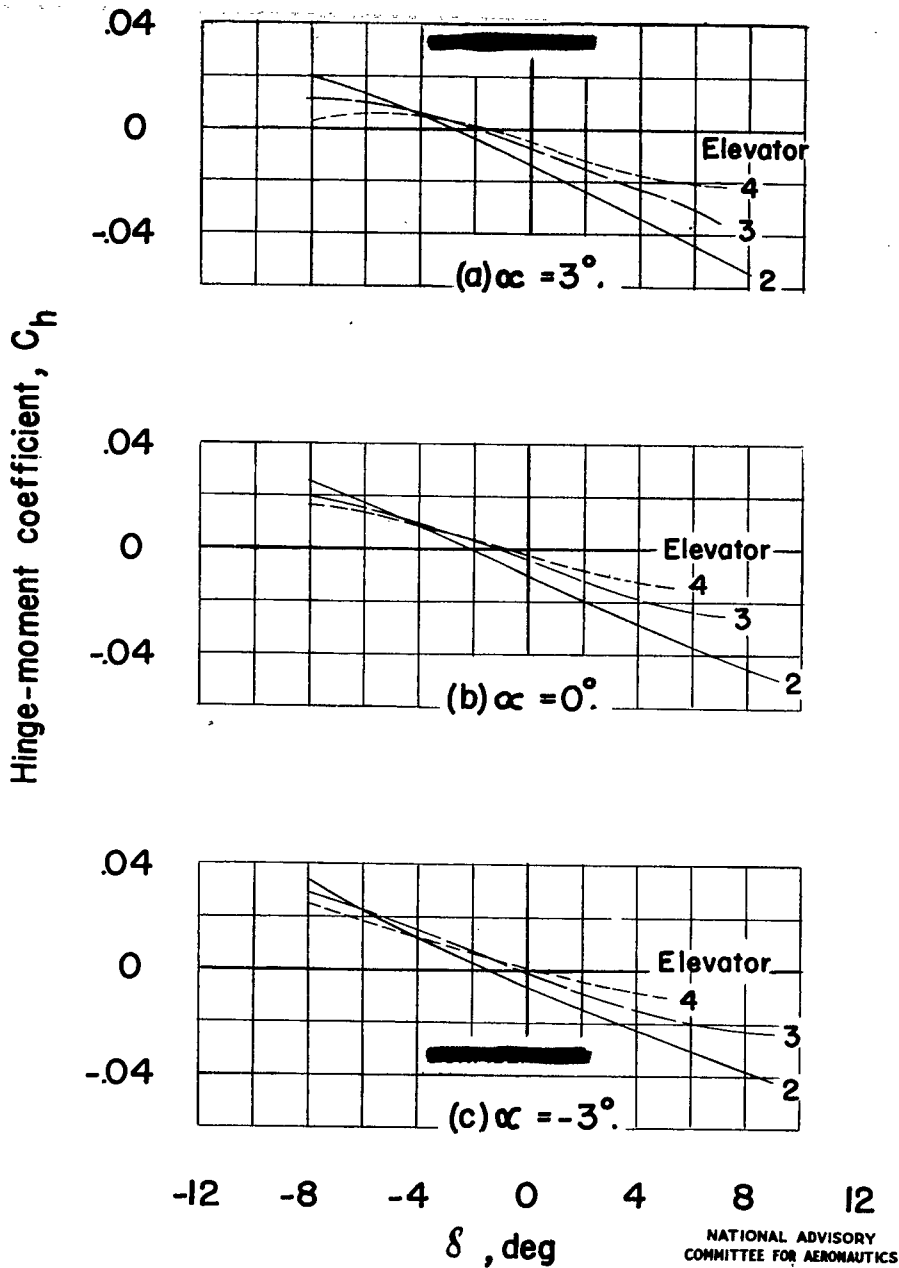
Figure 12.-Variation of hinge-moment coefficient with elevator angle for the three nose shapes. M= 0.35.
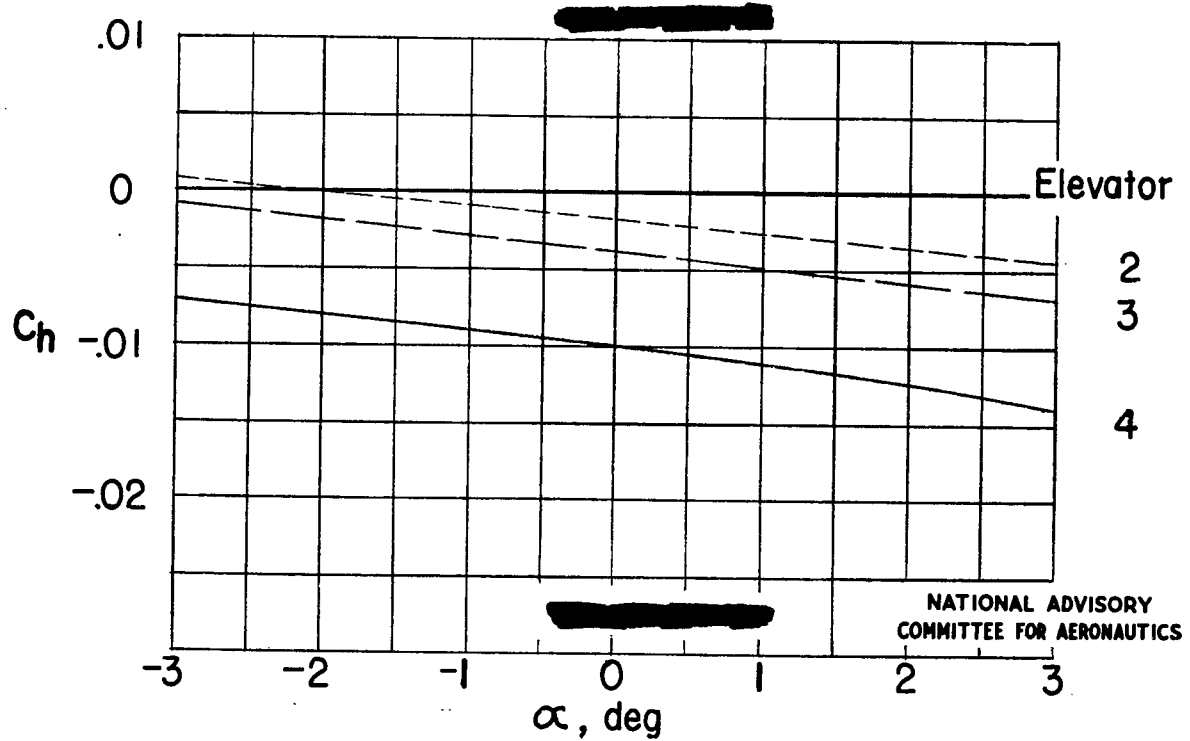
Figure 13 .— Effect of nose shape on hinge-moment coefficient. $\delta = 0°$; M = 0.35.

Fig. 13
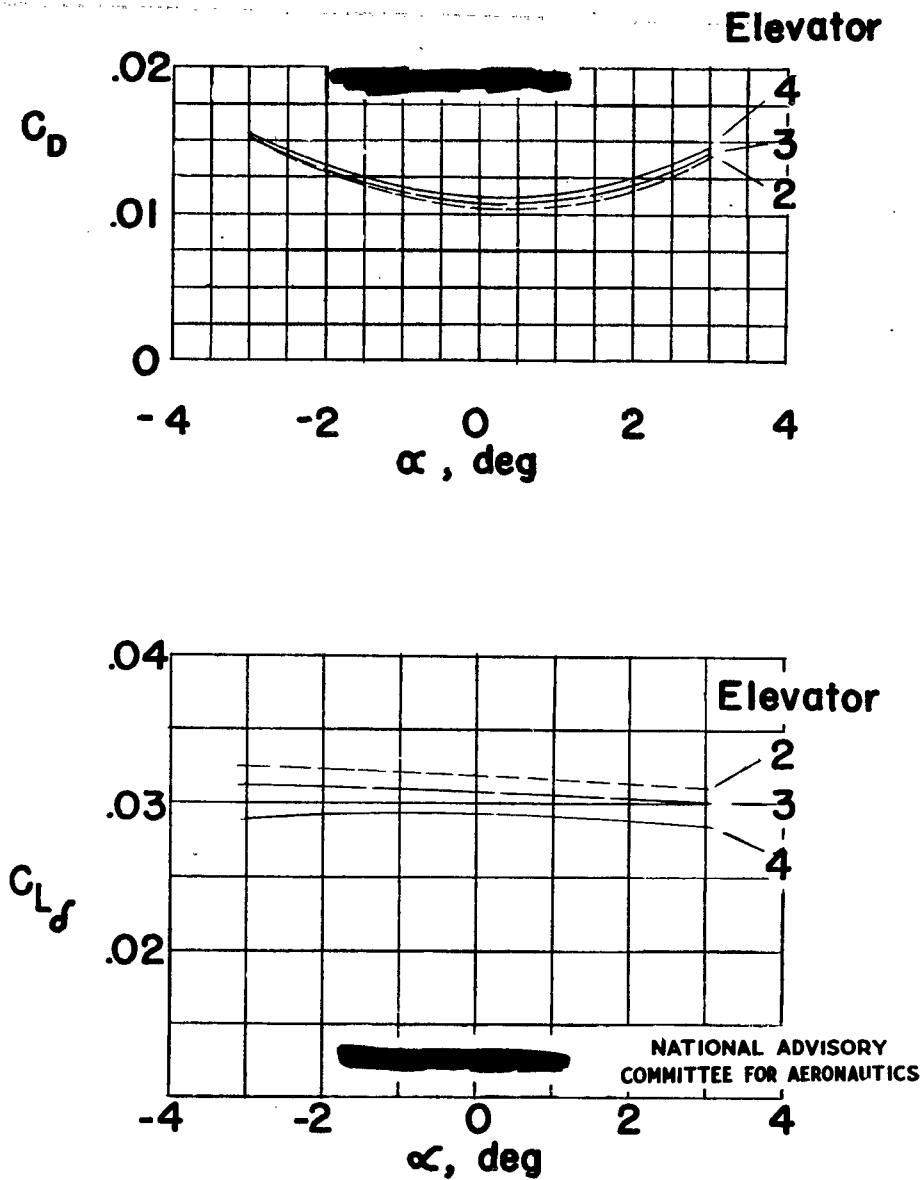
Figure 14.- Variation of C_D and C_{L_δ} with α for various nose shapes. $M = 0.35$; $\delta = 0°$.
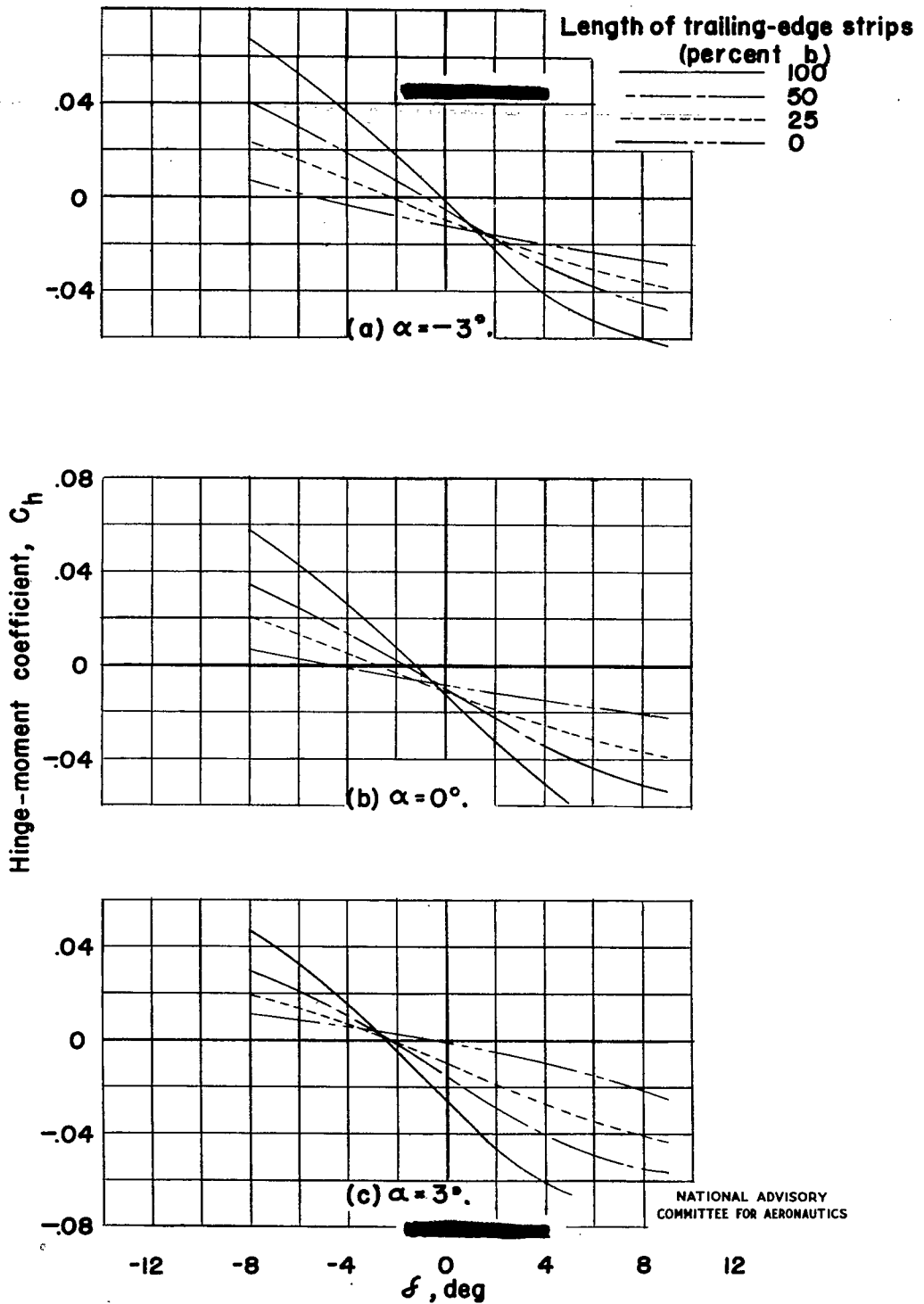
Figure 15.— Variation of C_h with elevator angle for four lengths of $\frac{1}{8}$-inch-diameter trailing-edge strips. M = 0.35.
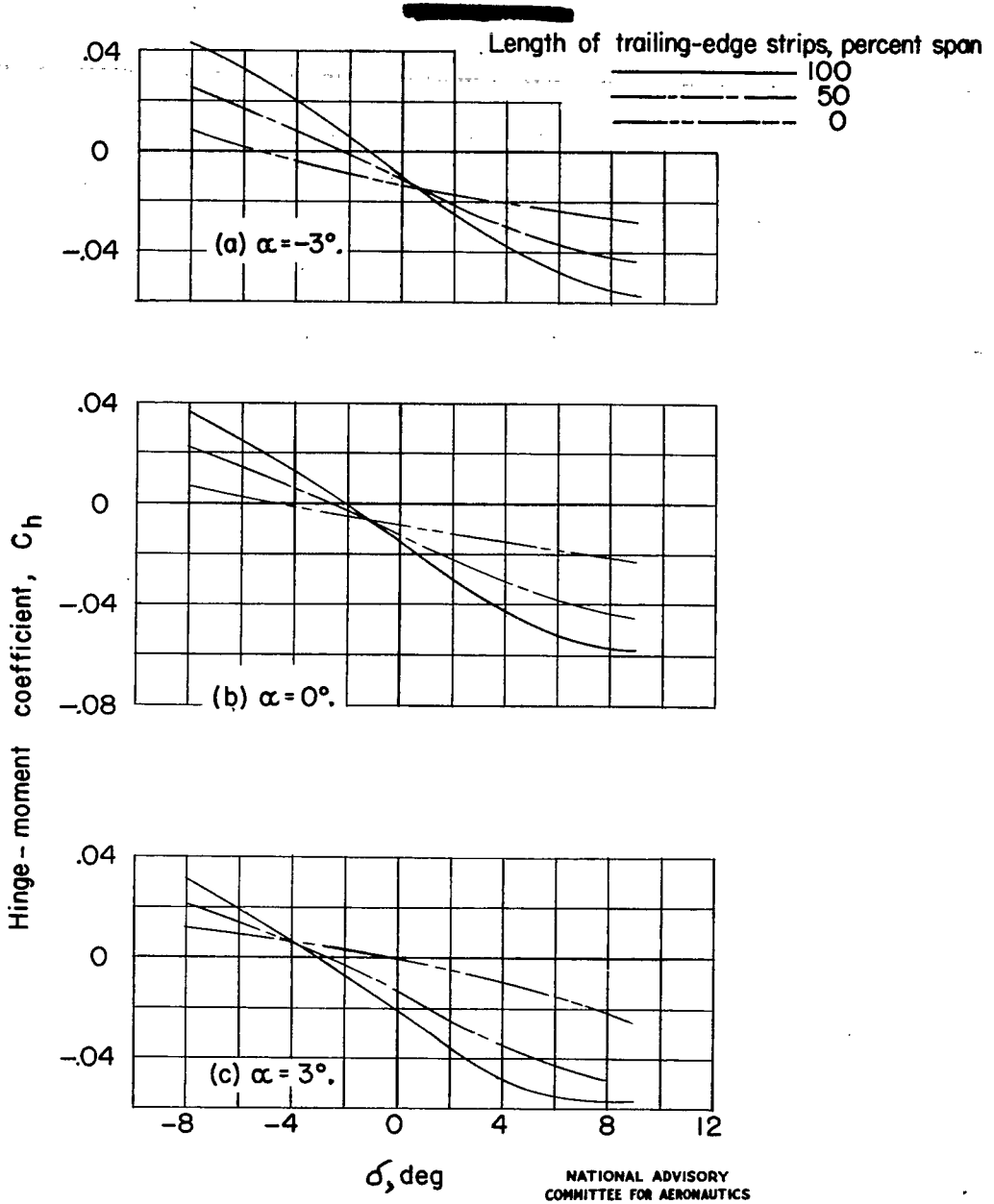
Figure 16.— Variation of C_h with elevator angle for three lengths of $\frac{1}{16}$–inch–diameter trailing–edge strips. M = 0.35.
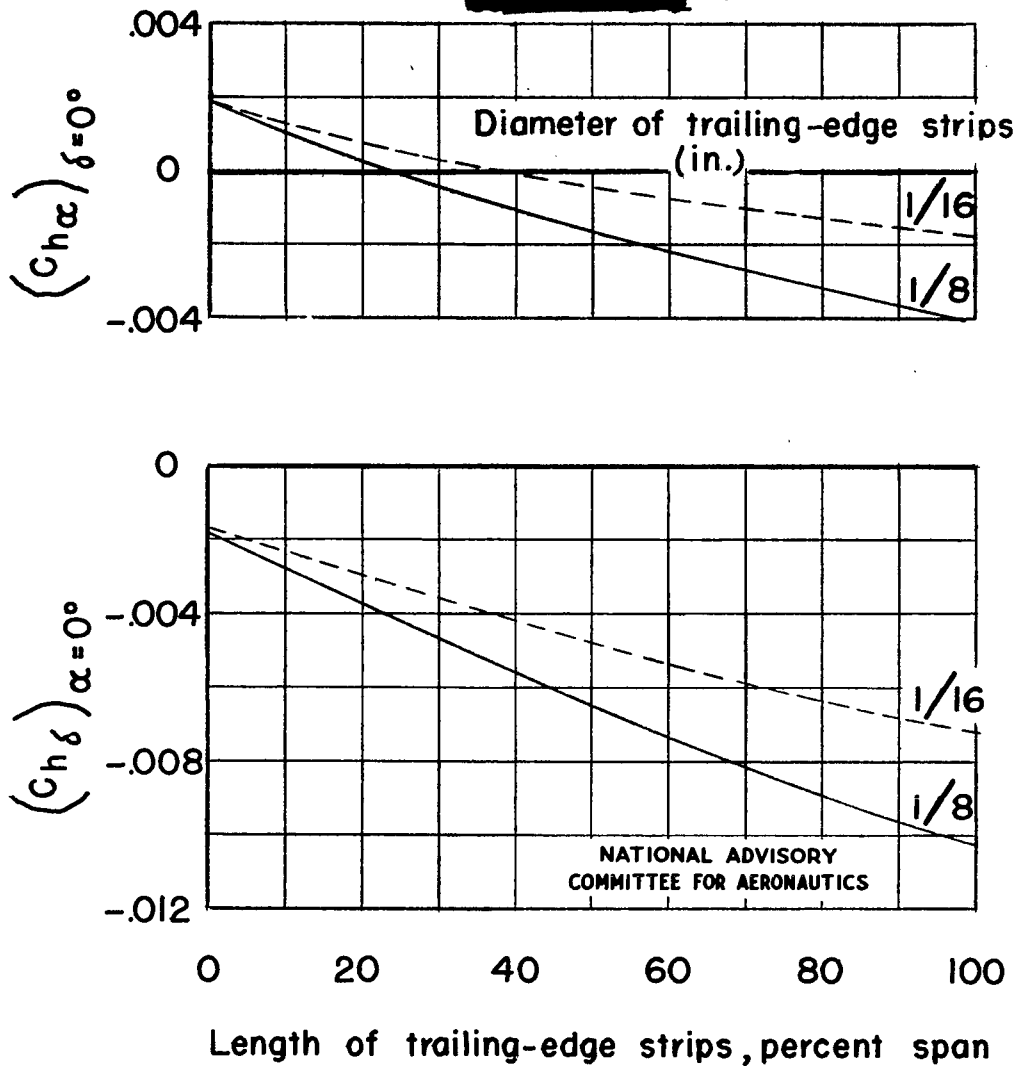
Figure 17.— Effect of length of trailing-edge strips of $\frac{1}{8}$-inch and $\frac{1}{16}$-inch diameter on C_{h_δ} and C_{h_α}. M = 0.35.
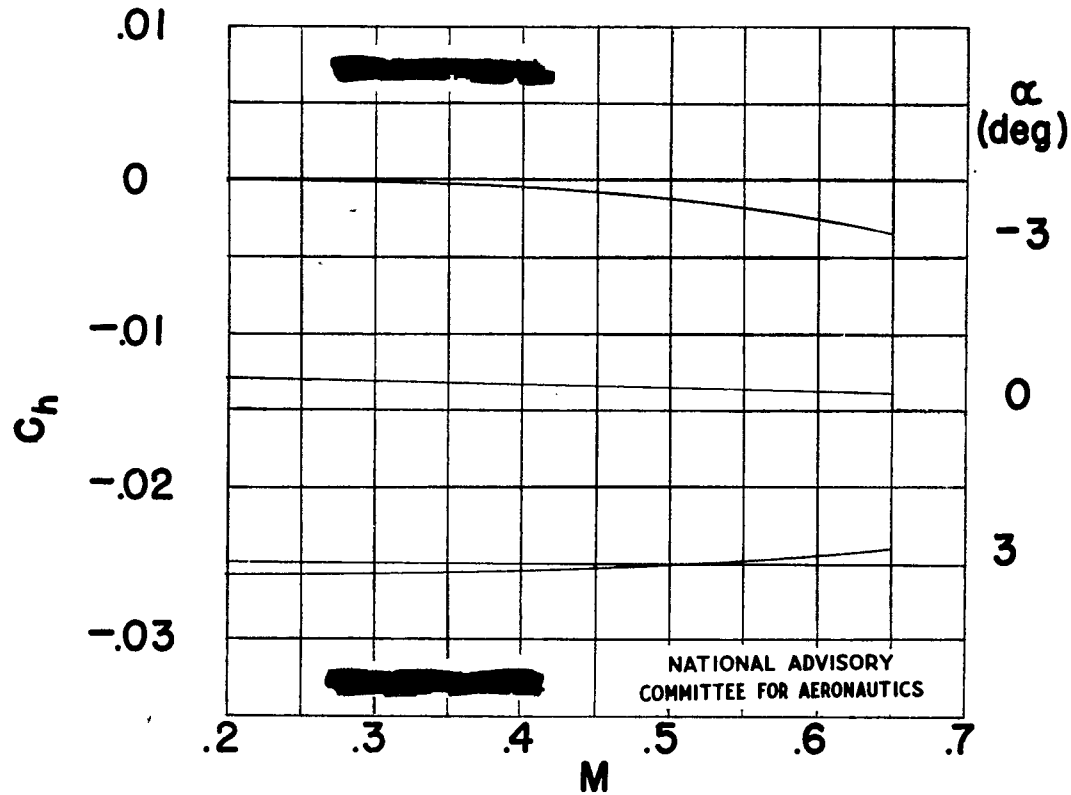
Figure 18.—Variation of elevator hinge-moment coefficient with Mach number for $\frac{1}{8}$-inch-diameter trailing-edge strips. Full span; $\delta = 0°$.
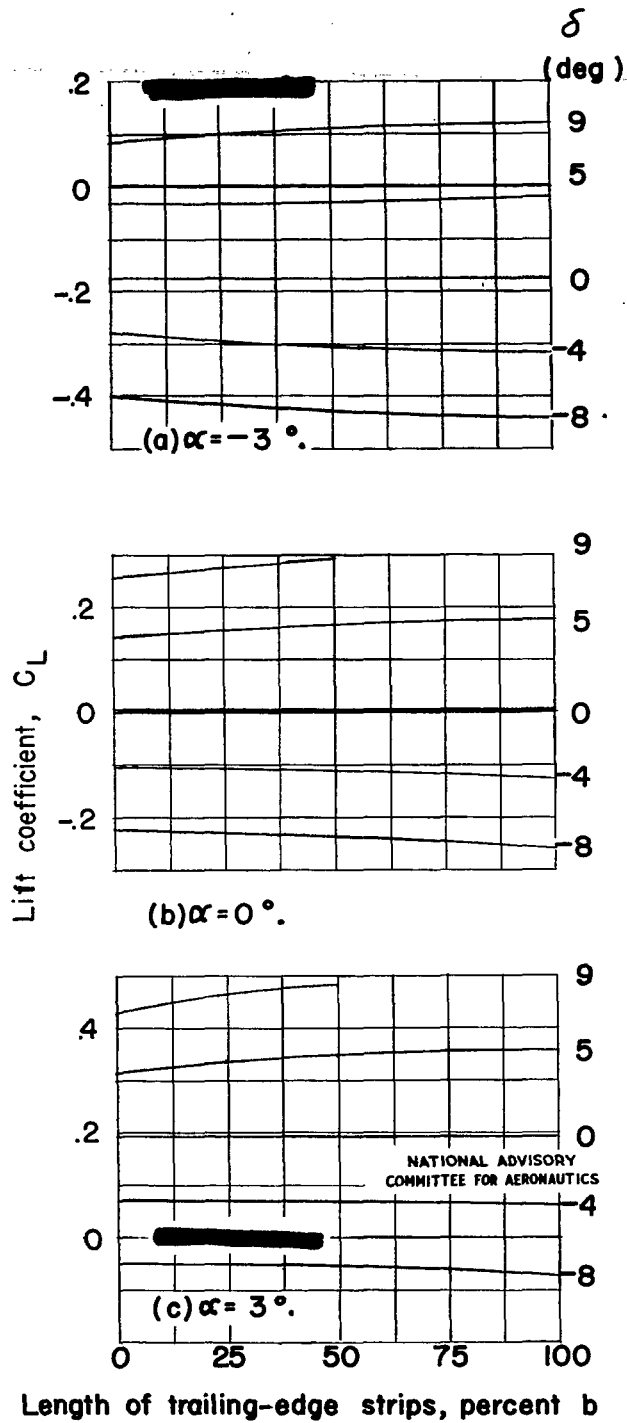
Fig. 18

Figure 19.—Variation of lift coefficient with length of $\frac{1}{8}$-inch-
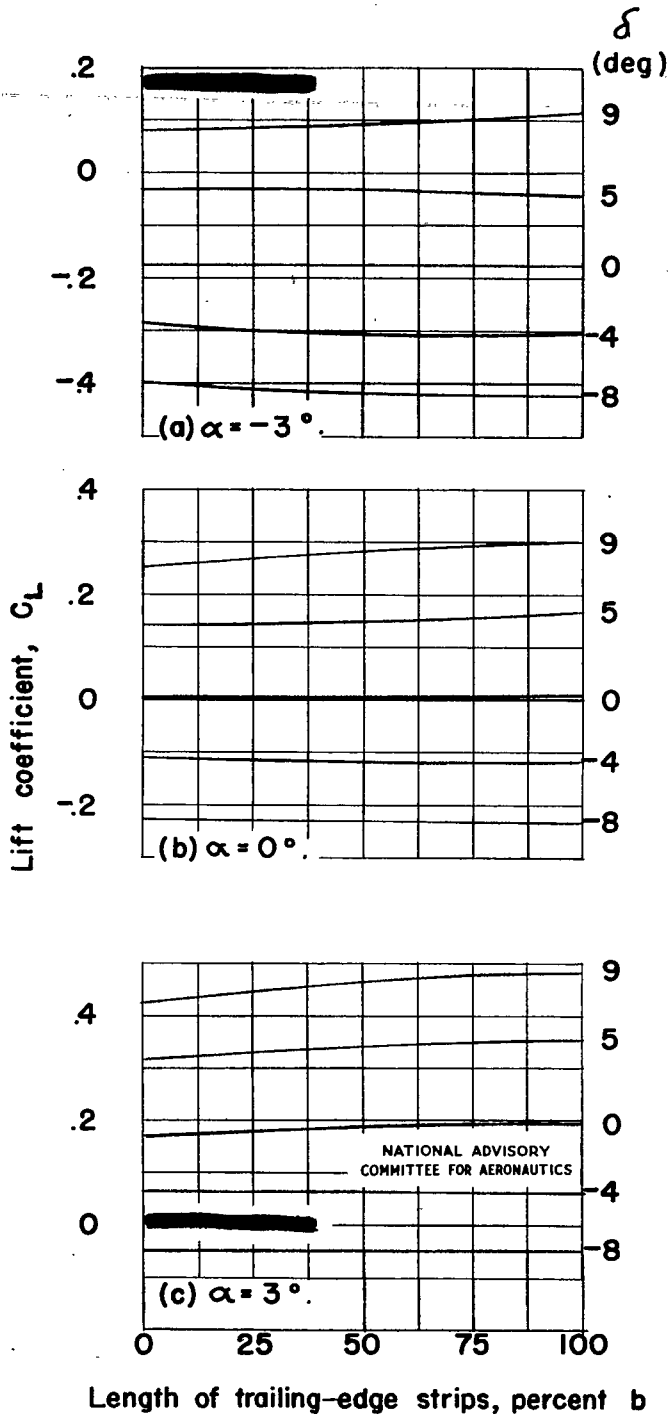diameter trailing-edge strips. M= 0.35.

Length of trailing-edge strips, percent b

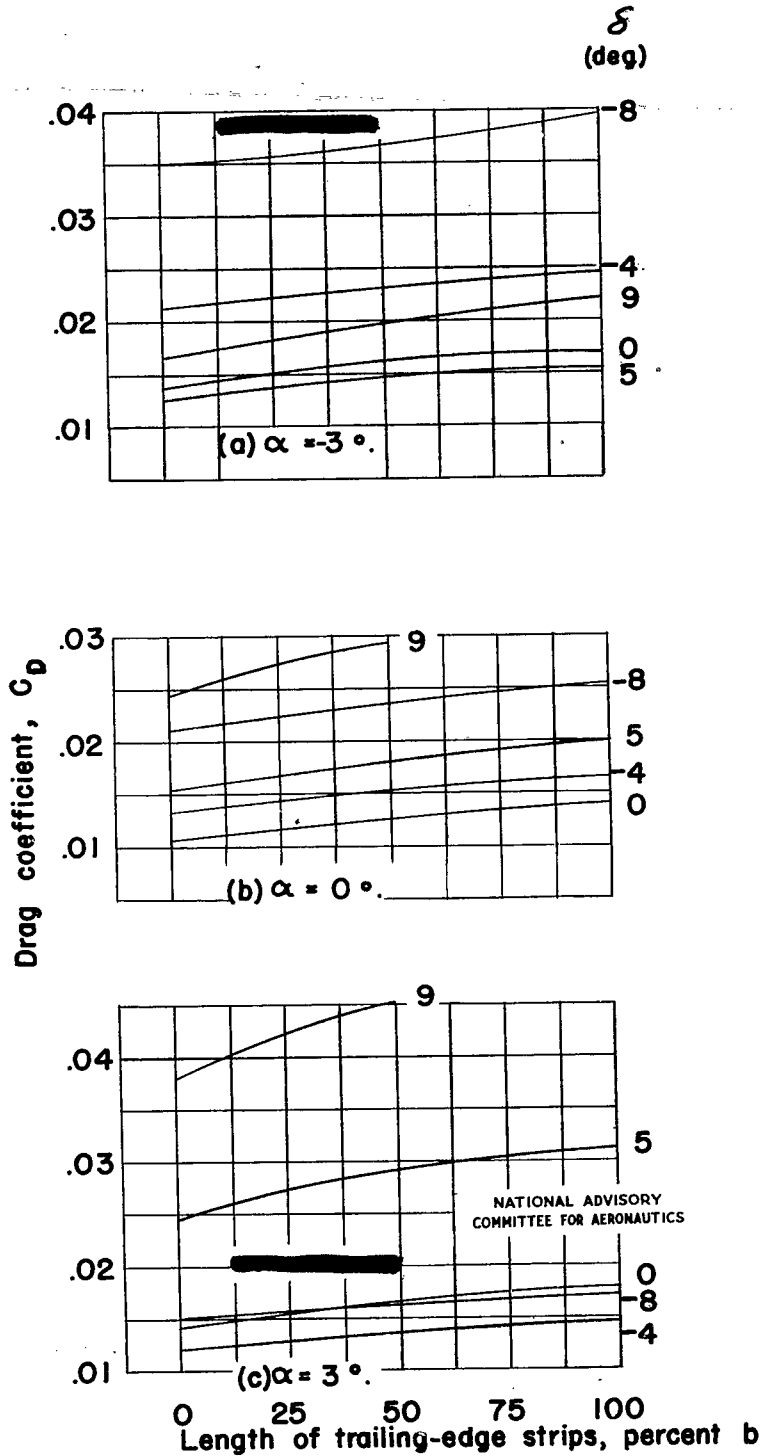Figure 20.—Variation of lift coefficient with length of $\frac{1}{16}$-inch-diameter trailing-edge strips. M = 0.35.

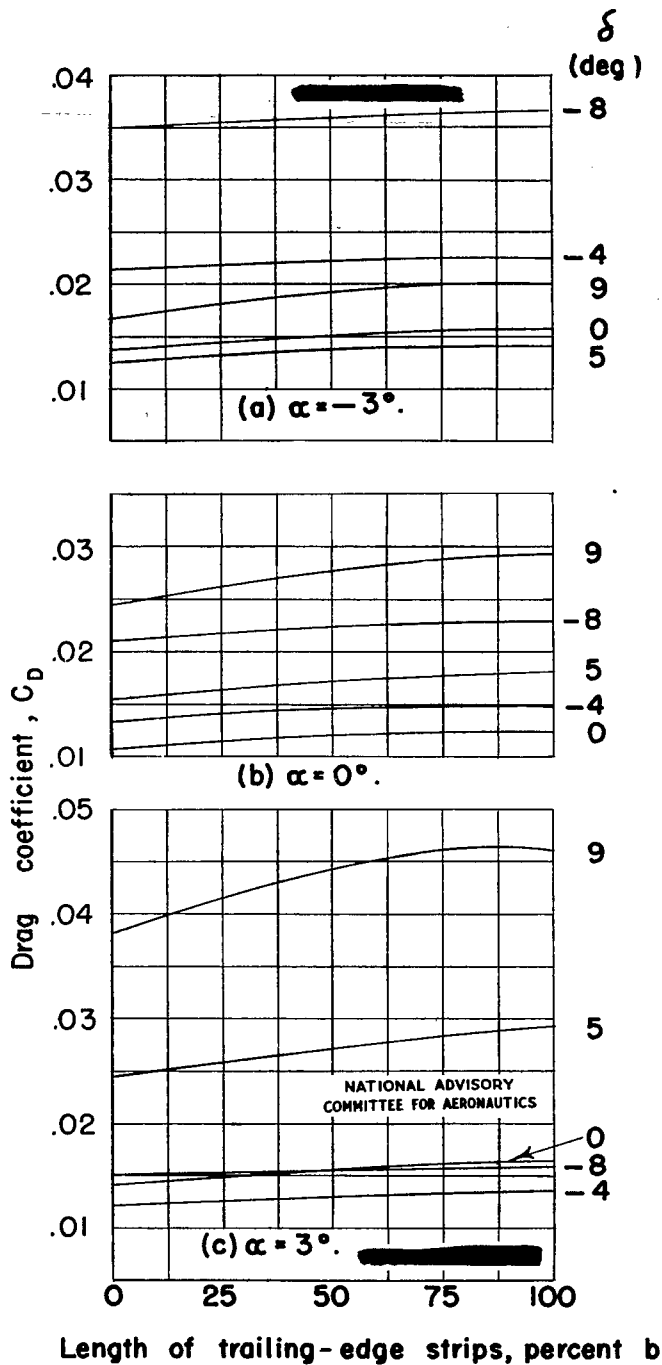Figure 21.—Variation of drag coefficient with length of $\frac{1}{8}$-inch-diameter trailing-edge strips. M=0.35.

Figure 22.—Variation of drag coefficient with length of $\frac{1}{16}$-inch-
diameter trailing-edge strips. M = 0.35.