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MEMORANDUM

LOW-SPEED TESTS OF SEMISPAN-WING MODELS AT

ANGLES OF ATTACK FROM 0° TO 180°

By David G. Koenig

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Moffett Field, Calif.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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MEMORANDUM 2-27-59A

LOW-SPEED TESTS OF SEMISPAN-WING MODELS AT ANGLES OF ATTACK FROM 0° TO 180°

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SUMMARY

Semispan-wing models were tested at angles of attack from 0° to 180° at low subsonic speeds. Eight plan forms were considered, both swept and unswept with aspect ratios ranging from 2 to 6. Except for a delta-wing model of aspect ratio 2, all models had a taper ratio of 0.5 and an NACA 64A010 airfoil section. The delta-wing model had an NACA 0005 (modified) airfoil section. With two exceptions, the models were tested both with and without a full-span trailing-edge flap deflected 25°. The Reynolds numbers based on the mean aerodynamic chord were between 1.5 and 2.2 million.

Lift, drag, and pitching-moment coefficients are presented as functions of angle of attack. Approximate corrections for the effects of blockage were applied to the data.

INTRODUCTION

Recent development of some vertical take-off and landing aircraft has indicated the need for information concerning the aerodynamic characteristics of wings for angles of attack well above the point of wing stall. An abundance of results exists for two-dimensional airfoils through large angles of attack and some of these results are either presented or referred to in references 1 and 2. Some information on three-dimensional models are presented in references 3 through 8.

The present test program was undertaken in order to augment existing results to the extent of considering larger ranges in aspect ratios and angles of sweep. Wing plan forms were chosen for the tests for which data at low angles of attack were already available. Except for an aspect ratio 2 delta wing, all wings had a taper ratio of 0.5 and aspect ratios ranging from 2 to 6. Data at low angles of attack for these wings may be found in references 9 through 14. The models were tested through an angle-of-attack range of from 0° to 180°. Results with a full-span trailing-edge flap deflected 25° were also obtained, for six of the eight models investigated.

NOTATION

A aspect ratio

$\bar{c}$ mean aerodynamic chord, ft

C cross-sectional area of the wind-tunnel test section, sq ft (67.8 sq ft for the present case)

C_L, C_D, C_m lift, drag, and pitching-moment coefficients, respectively, corrected for blockage by multiplying C_{L_t}, C_{D_t}, and C_{m_t}, respectively, by K

C_{L_t} uncorrected lift coefficient, $\frac{\text{lift}}{q_t S}$

C_{D_t} uncorrected drag coefficient, $\frac{\text{drag}}{q_t S}$

C_{m_t} uncorrected moment coefficient, $\frac{\text{pitching moment}}{\bar{c} q_t S}$

K blockage correction factor

$K_{ref\ 3}$ blockage factor presented in reference 3

q_t dynamic pressure measured at a point slightly ahead of the model and corrected for the normal pressure gradient existing in the test section without the model installed between the point of measurement and the $\bar{c}/4$ point on the model, lb/sq ft

S wing semispan area, sq ft

α angle of attack, deg

δ flap deflection, deg

Λ sweep of the quarter-chord line, deg

MODELS

Geometric data for the eight semispan models tested are presented in figure 1. The models used for the tests were identical to those for which results for the unstalled angle-of-attack range are presented in references 9 through 14.

Aspect ratios of the models ranged from 2 to 6. Except for the aspect-ratio-2 delta wing, all the wings had a taper ratio of 0.5 and the NACA 64A010 airfoil section. The delta wing had an NACA 0005 (modified) airfoil section. With the exception of the delta wing, and the unswept aspect ratio 4.5 wing models, a full-span 30-percent-chord trailing-edge flap was installed on the models. A small gap existing between the wing and the trailing-edge flap was sealed for all the tests.

TESTS

All tests were made in one of the Ames 7- by 10-foot wind tunnels. Lift, drag, and pitching-moment data were obtained through an angle-of-attack range between 0° and 180°. For those models provided with trailing-edge flaps, the tests included measurements with the flaps deflected about 25°.

The data were obtained with a dynamic pressure, q_t, of approximately 25 pounds per square foot. The Reynolds numbers corresponding to this dynamic pressure ranged between 1.5 and 2.2 million.

CORRECTIONS

Corrections which were essentially blockage corrections were made to all data presented herein as follows:

$$C_D = C_{D_t} K$$

$$C_L = C_{L_t} K$$

$$C_m = C_{m_t}$$

where K was obtained from the solid faired curve presented in figure 2.

The values of K presented in figure 2 were obtained as follows: Two models identical in plan form and wing section to the aspect-ratio-3 unswept wing and the aspect-ratio-2 swept-wing models, but having one-half their wing area, were constructed and tested. The resulting values of C_{L_t} and C_{D_t} as obtained from these smaller models were reduced by the blockage correction factor presented in reference 3 (and shown in fig. 2 as $K_{ref\ 3}$) for corresponding values of $(S \sin \alpha)/C$. These modified values of C_D and C_L were then divided by the corresponding values of C_{D_t} and C_{L_t} for the two larger models (for a given α and model plan form) and plotted against $(S \sin \alpha)/C$, as shown in figure 2. The curve faired through the mean of the resulting values shown in figure 2 was employed, as indicated above, to correct the force and moment data for the effects of blockage.

The corrections made can only be held approximate since the wind-tunnel cross section was circular for the tests of reference 3 as contrasted to the rectangular cross section of the wind tunnel of the present tests. It should also be emphasized that possible wind-tunnel boundary effects were not considered in correcting the data.

RESULTS

Drag, lift, and pitching-moment data are presented in figures 3, 4, and 5, respectively. As was described in the previous section, approximate corrections for wind-tunnel model blockage have been applied to all force and moment data.

There are some differences between the present data and those presented in references 9 through 14. If the wind-tunnel wall correction factors are taken into account, the present data are practically identical to those of the reference reports for angles of attack below wing stall. However, for some models, differences exist after stall takes place. These differences seem explainable from the standpoint of slight variations in test conditions and the blockage corrections made to the data for the present tests.

Ames Research Center
National Aeronautics and Space Administration
Moffett Field, Calif., Nov. 26, 1958

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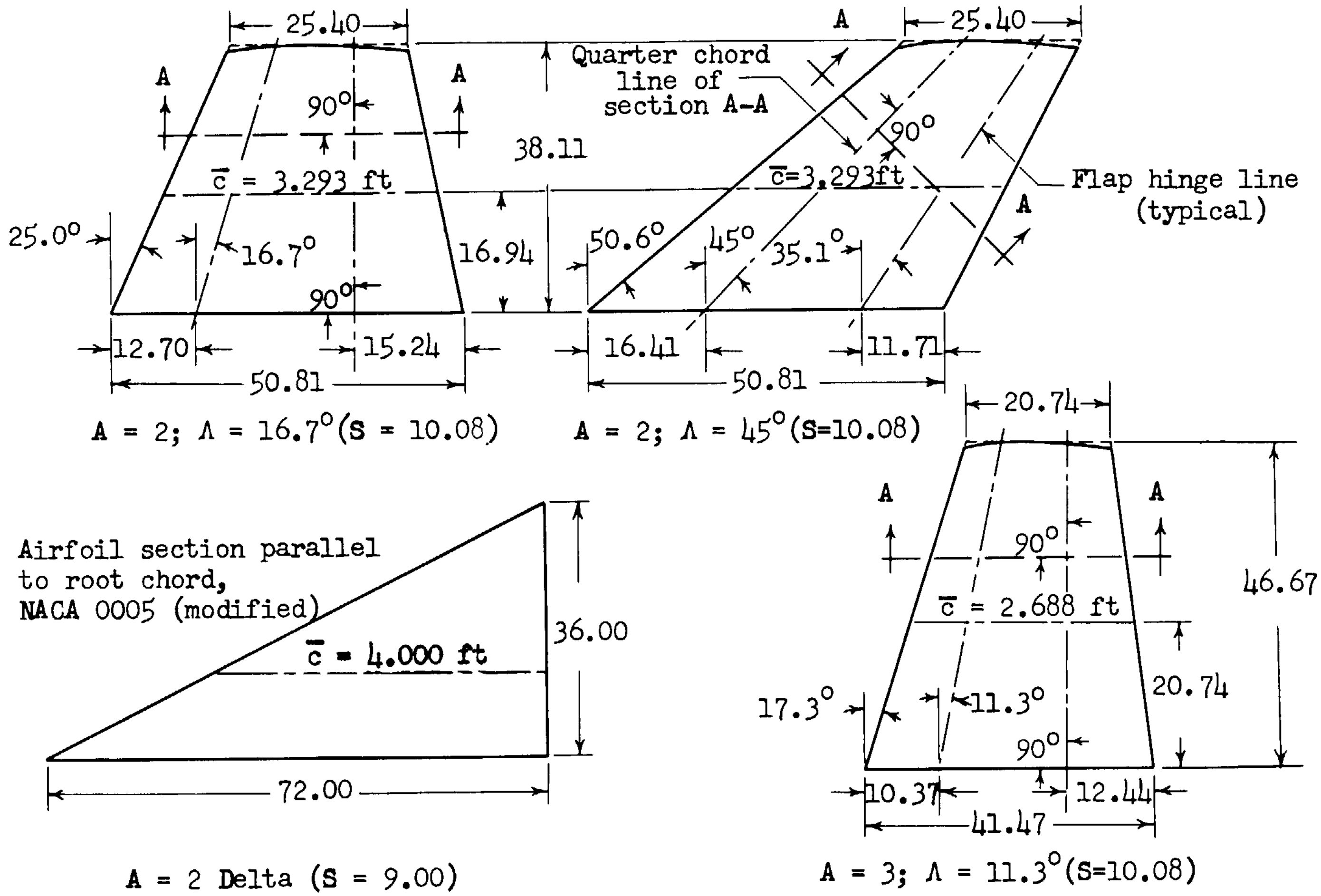
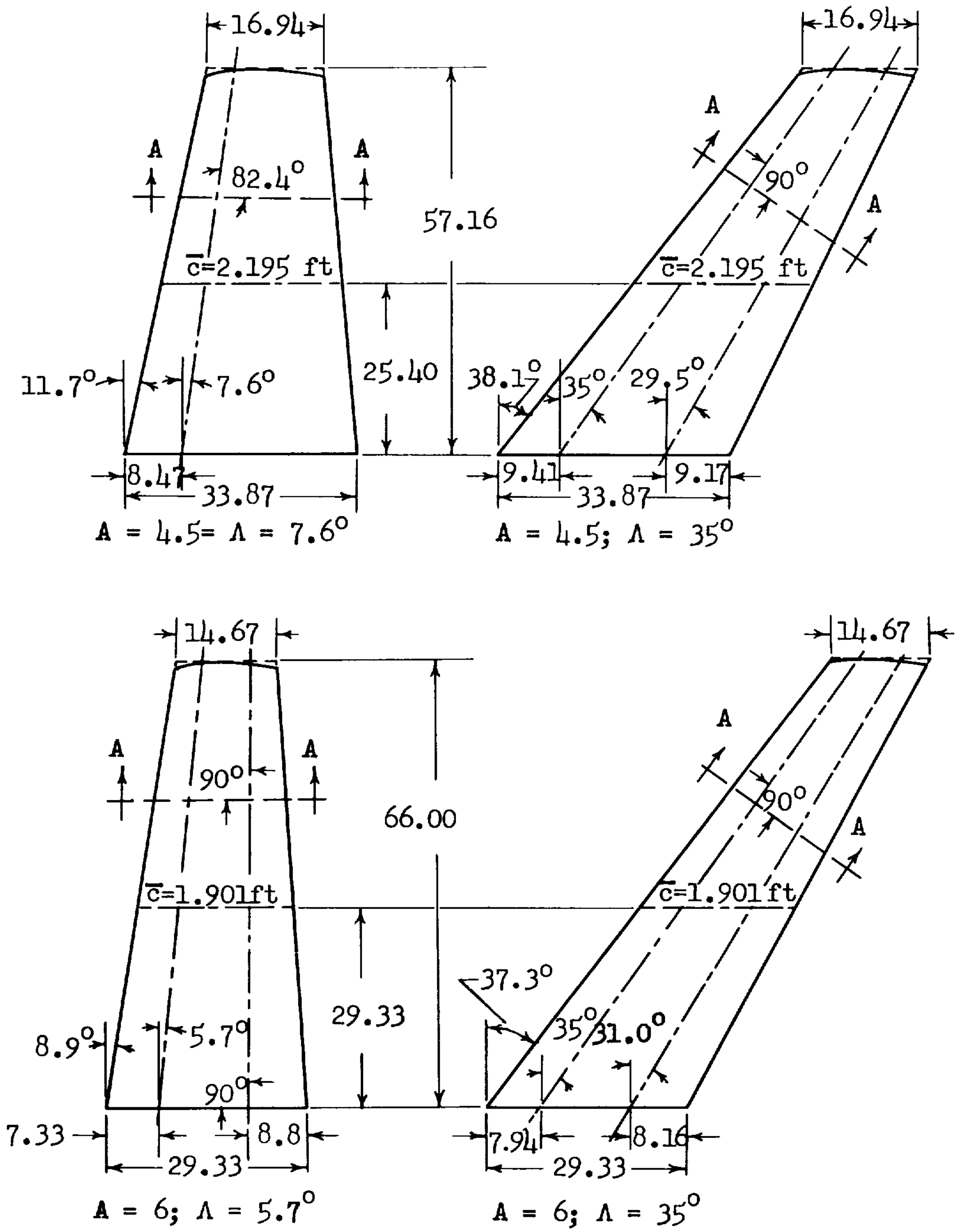


(a) Aspect ratio 2 and 3 models.

Figure 1.- Geometry of the models: Section A-A, NACA 64A010 airfoil section; all dimensions in inches.



(b) Aspect ratio 4, 5, and 6 models; S = 10.08 sq ft.

Figure 1.- Concluded.

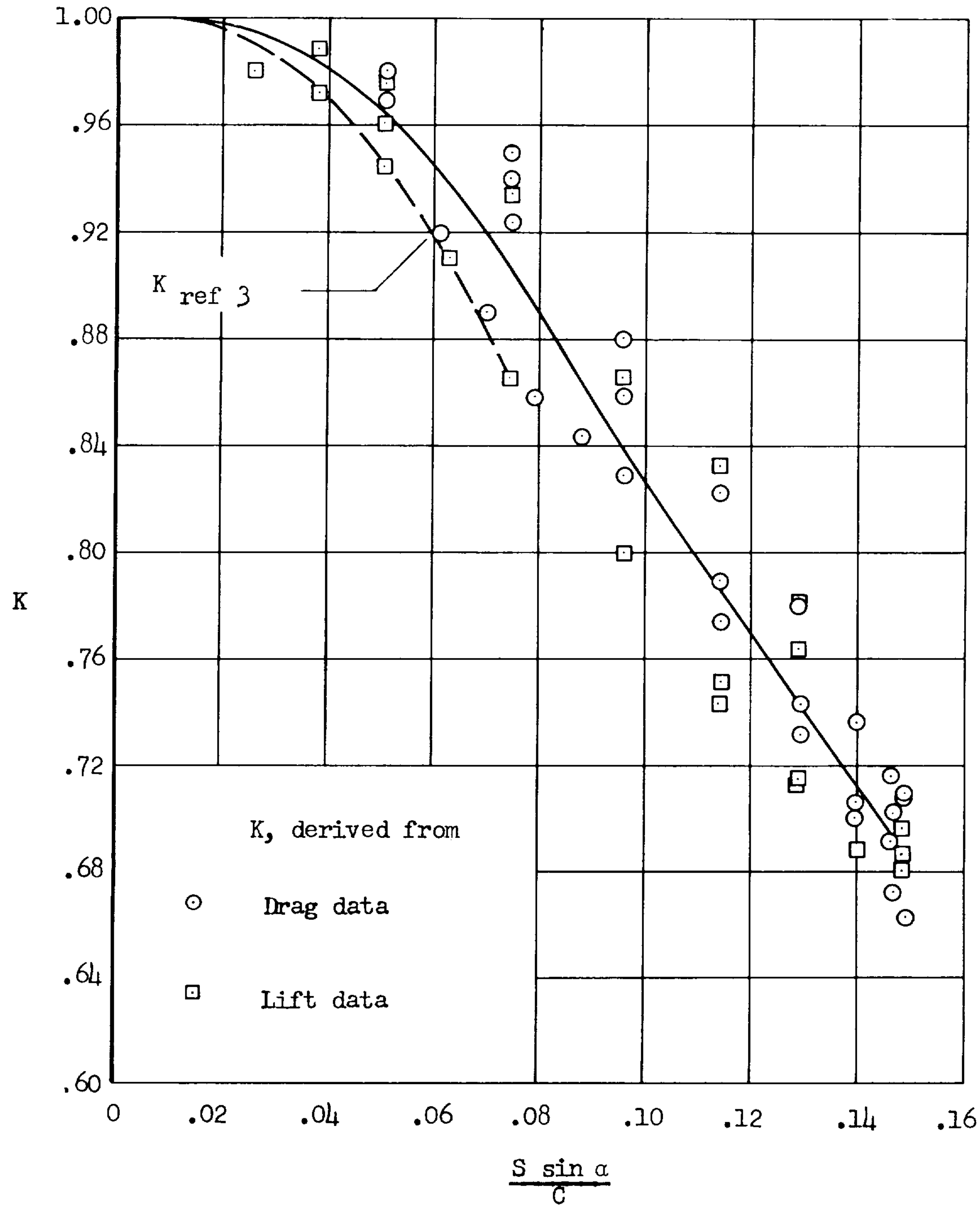
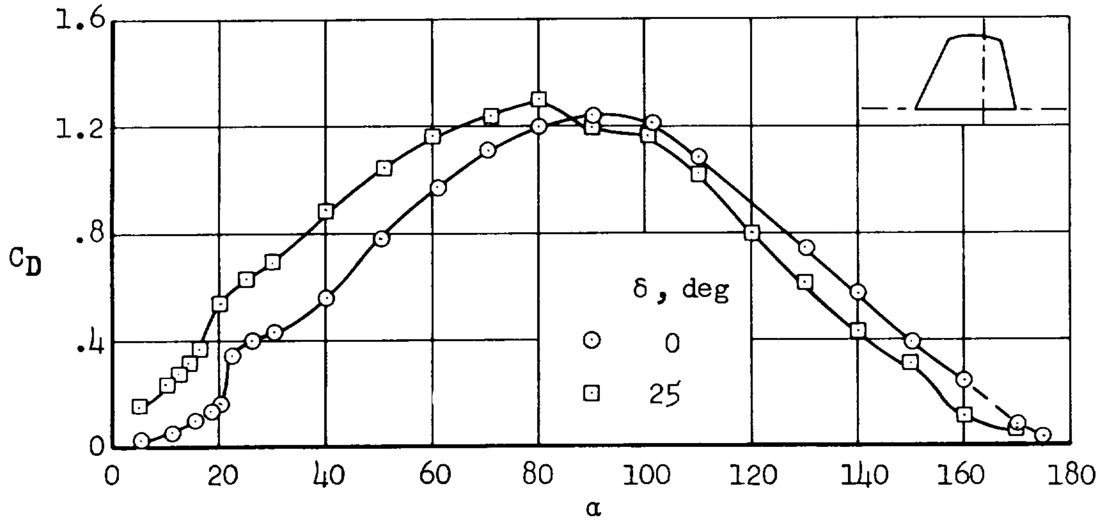
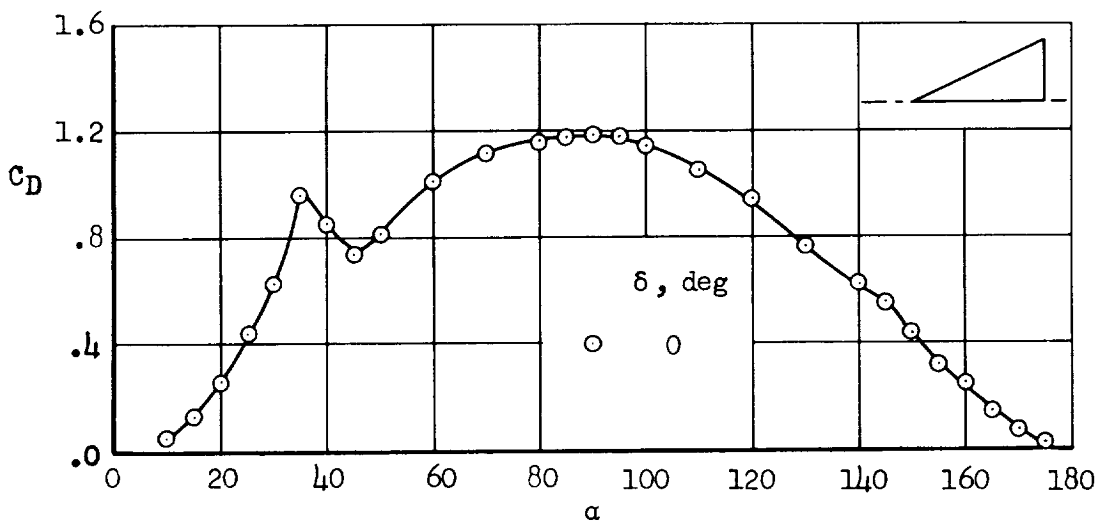


Figure 2.- Blockage correction used to correct force and moment data.

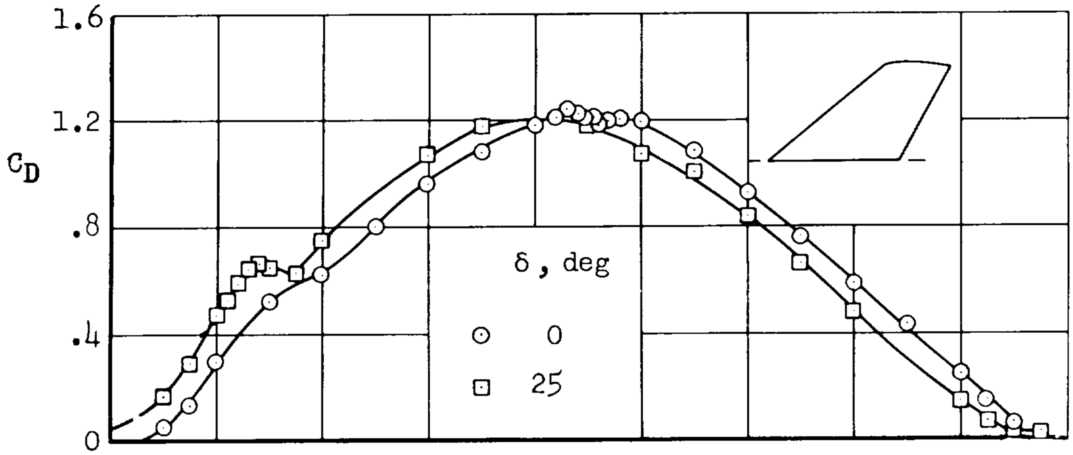


(a) A = 2; Λ = 16.7°

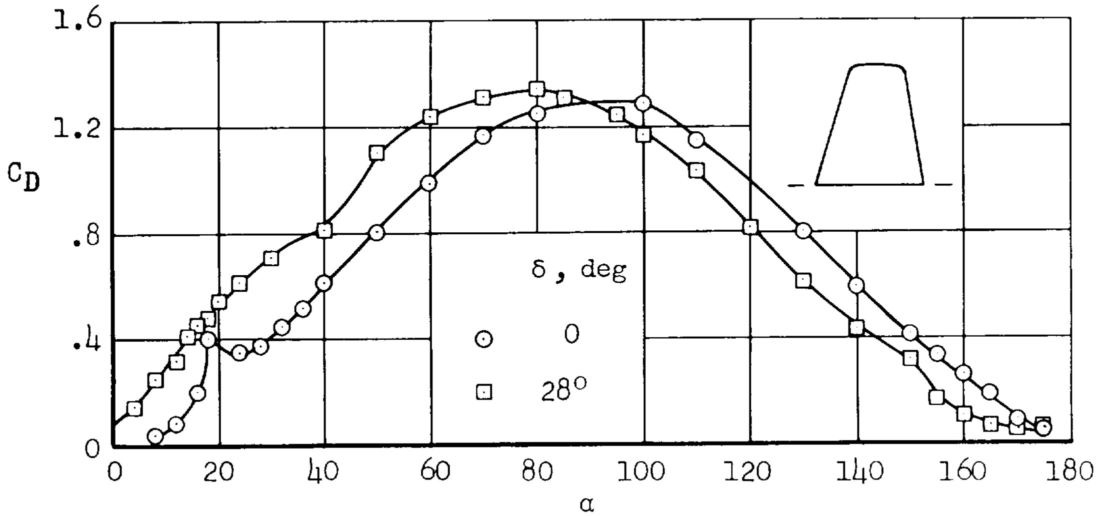


(b) A = 2; delta wing

Figure 3.- Drag characteristics of the models.

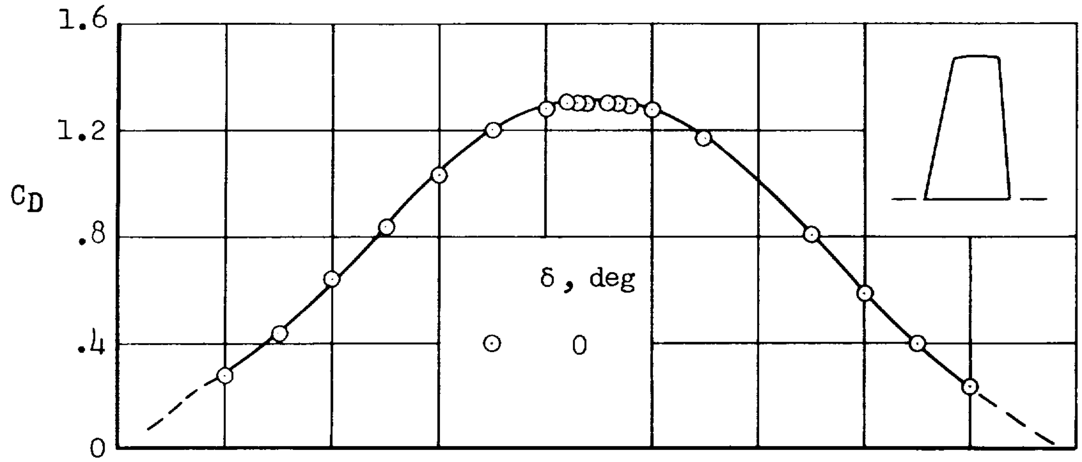


(c) A = 2; Λ = 45°

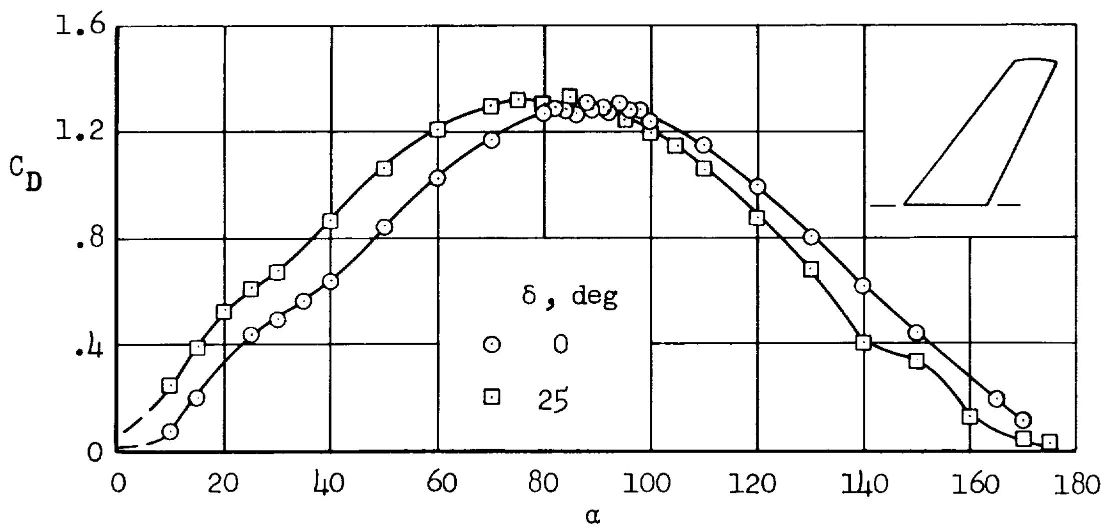


(d) A = 3; Λ = 11.3°

Figure 3.- Continued.

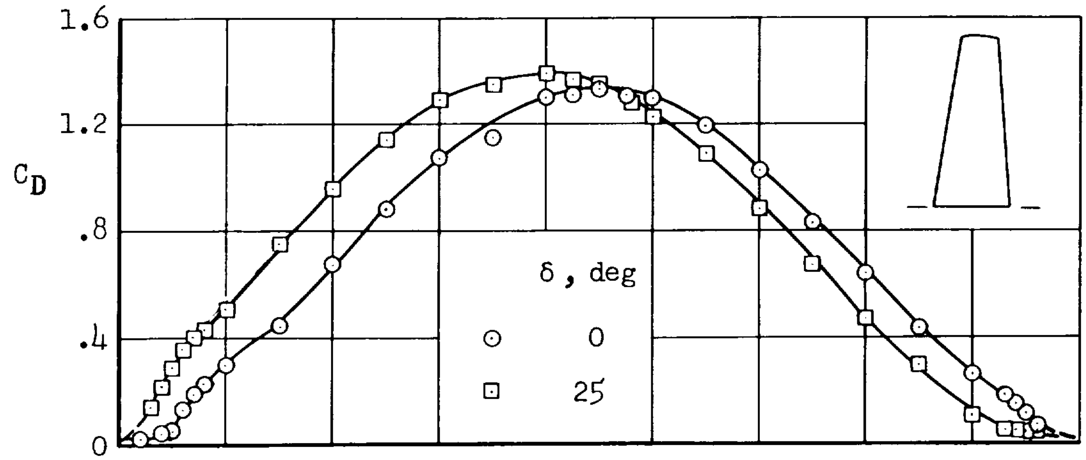


(e) A = 4.5; Λ = 7.6°

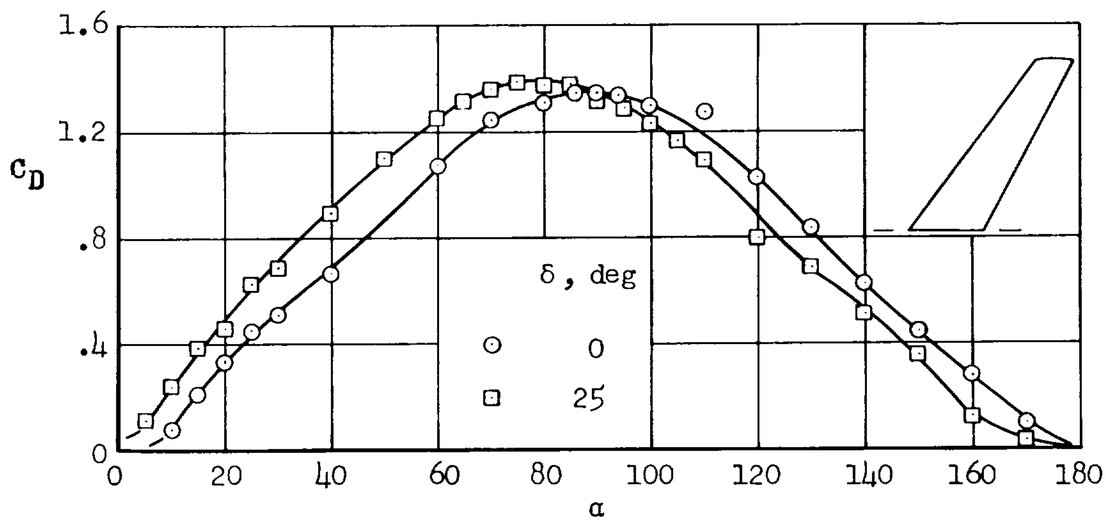


(f) A = 4.5; Λ = 35°

Figure 3.- Continued.



(g) A = 6; Λ = 5.7°



(h) A = 6; Λ = 35°

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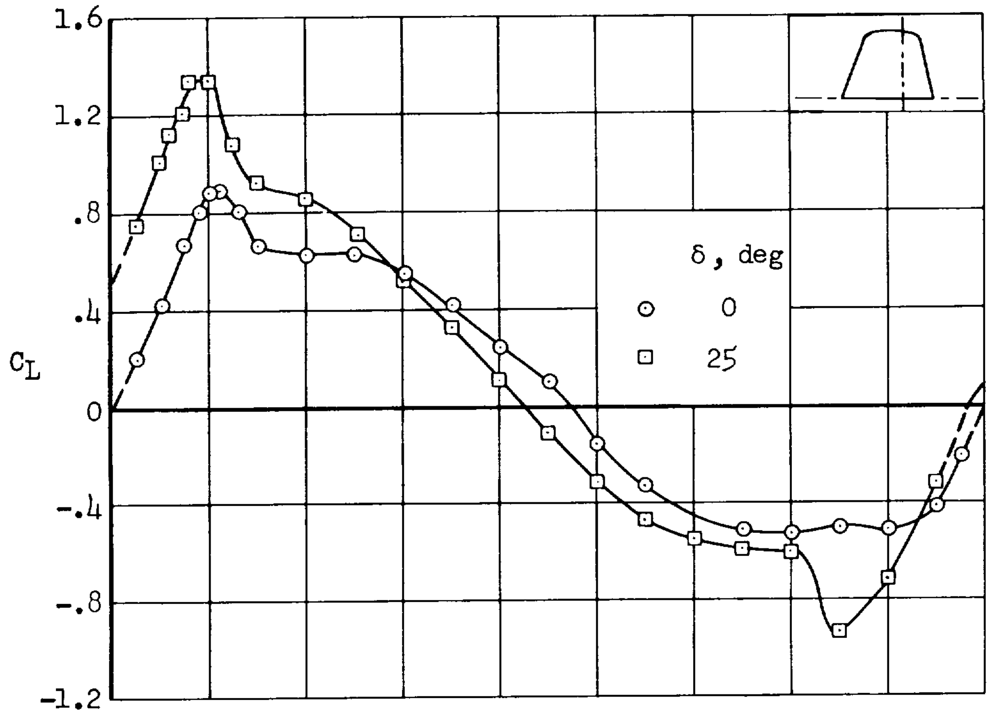

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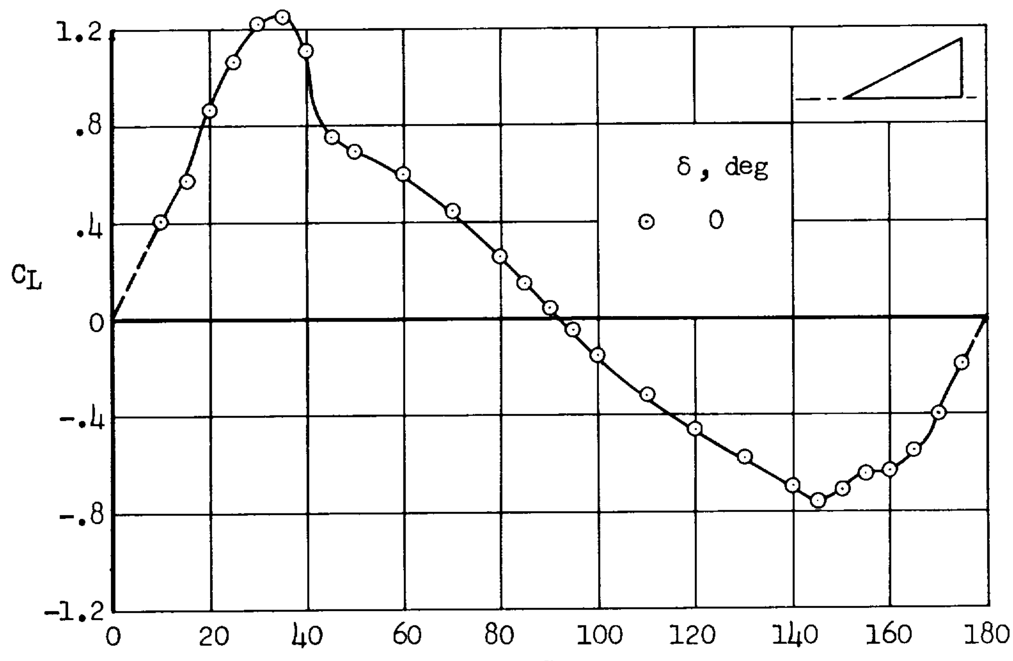
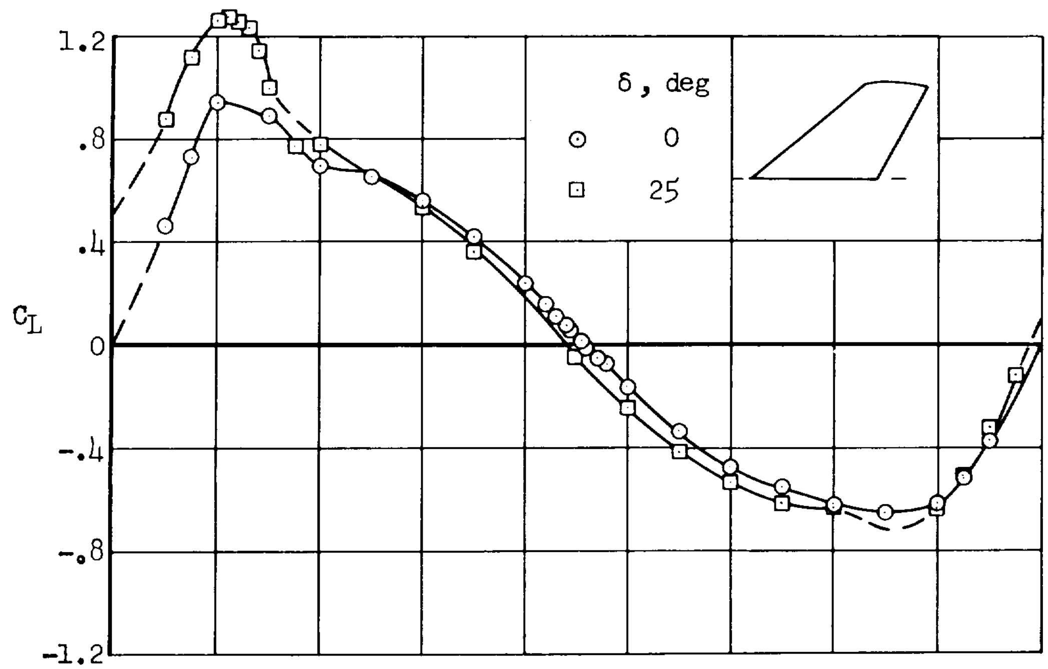
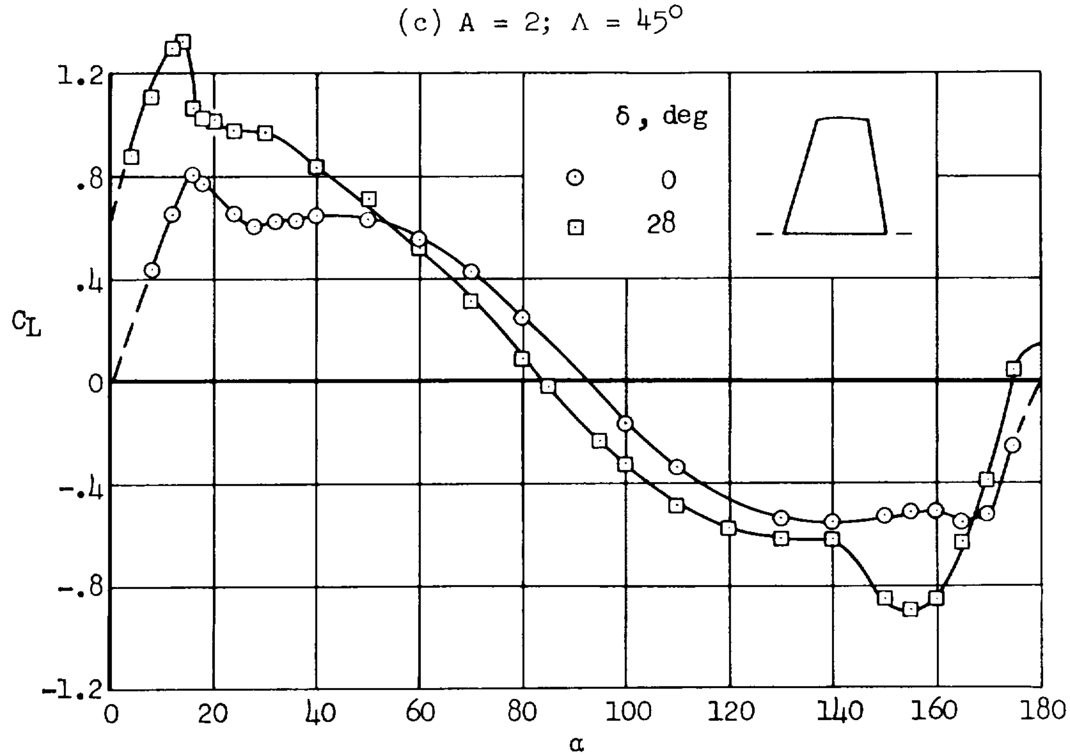


(b) A = 2; delta wing

Figure 4.- Lift characteristics of the models.

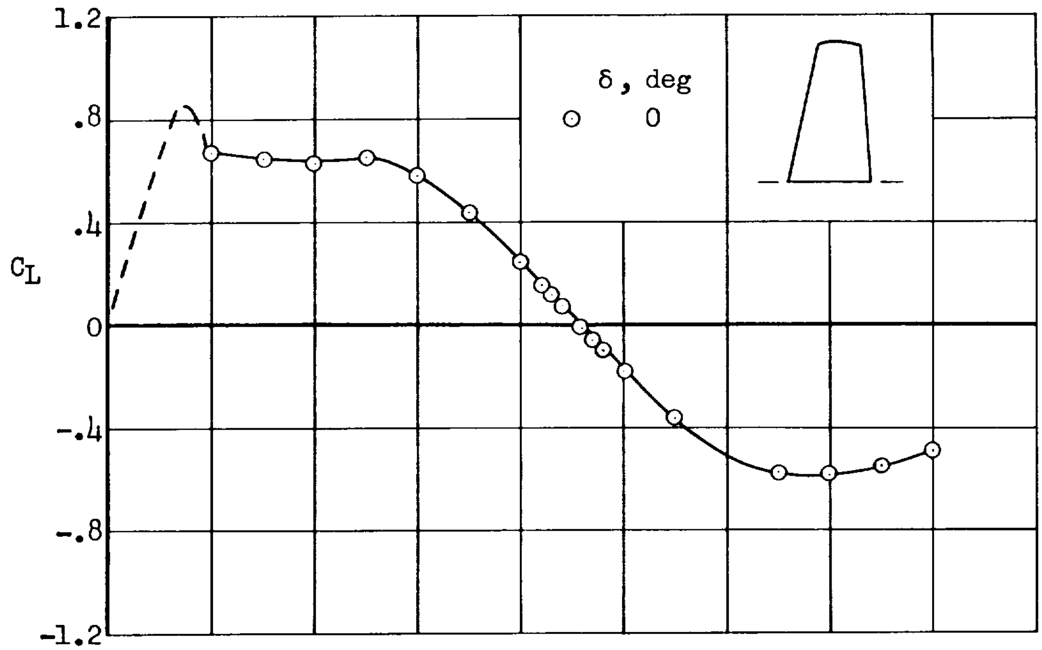


(c) A = 2; Λ = 45°



(d) A = 3; Λ = 11.3°

Figure 4.- Continued.



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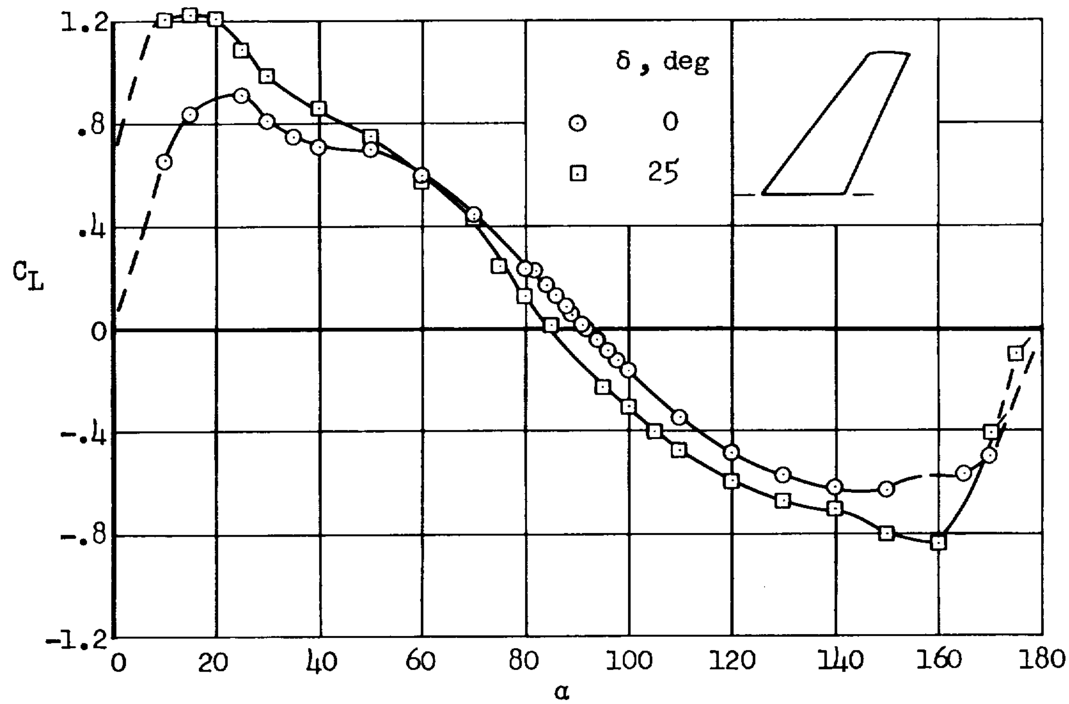

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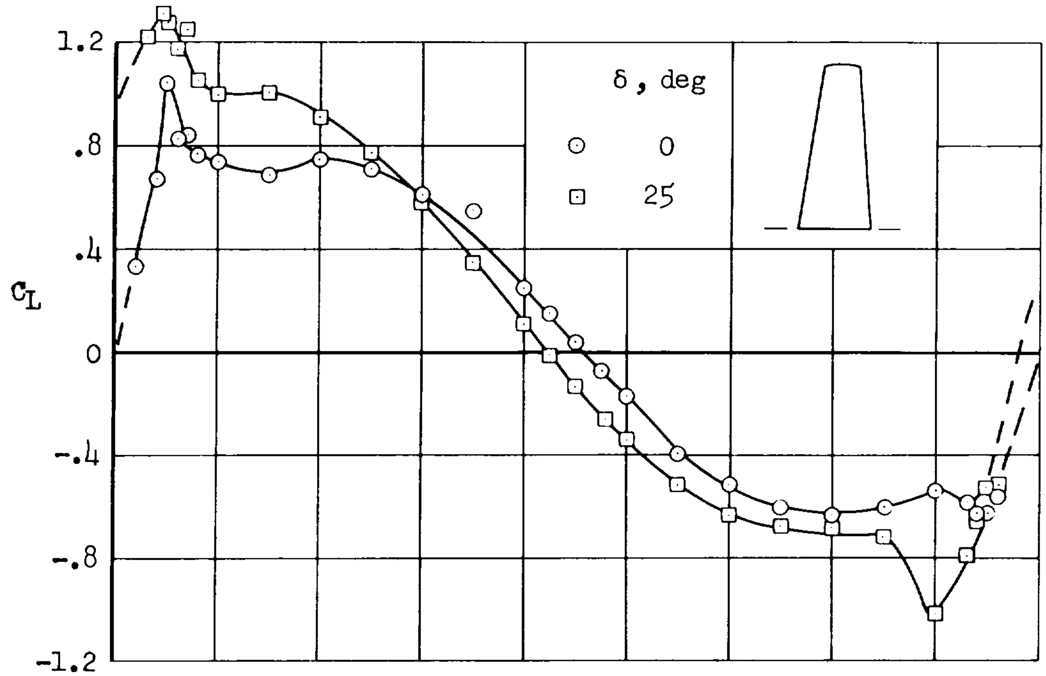
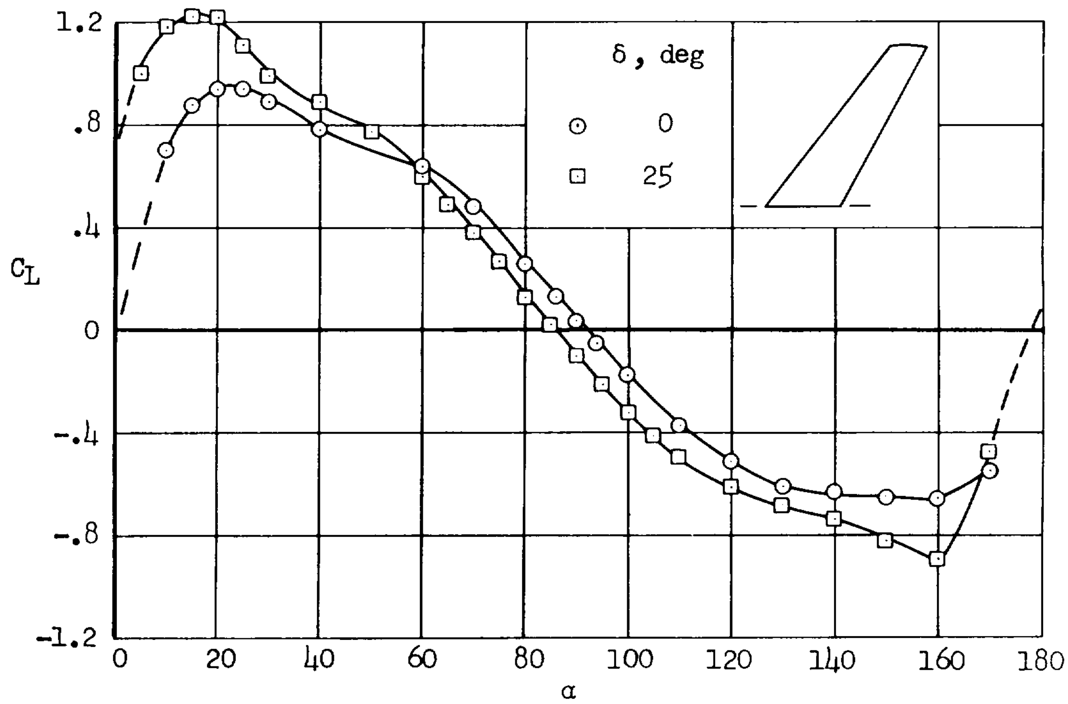


(g) A = 6; Λ = 5.7°



(h) A = 6; Λ = 35°

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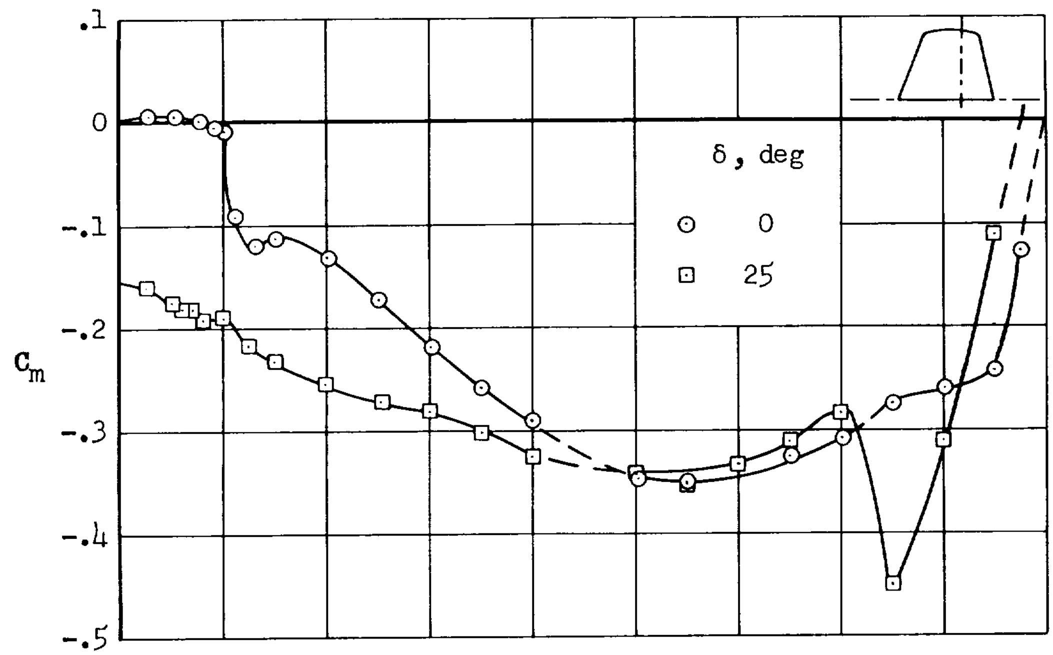

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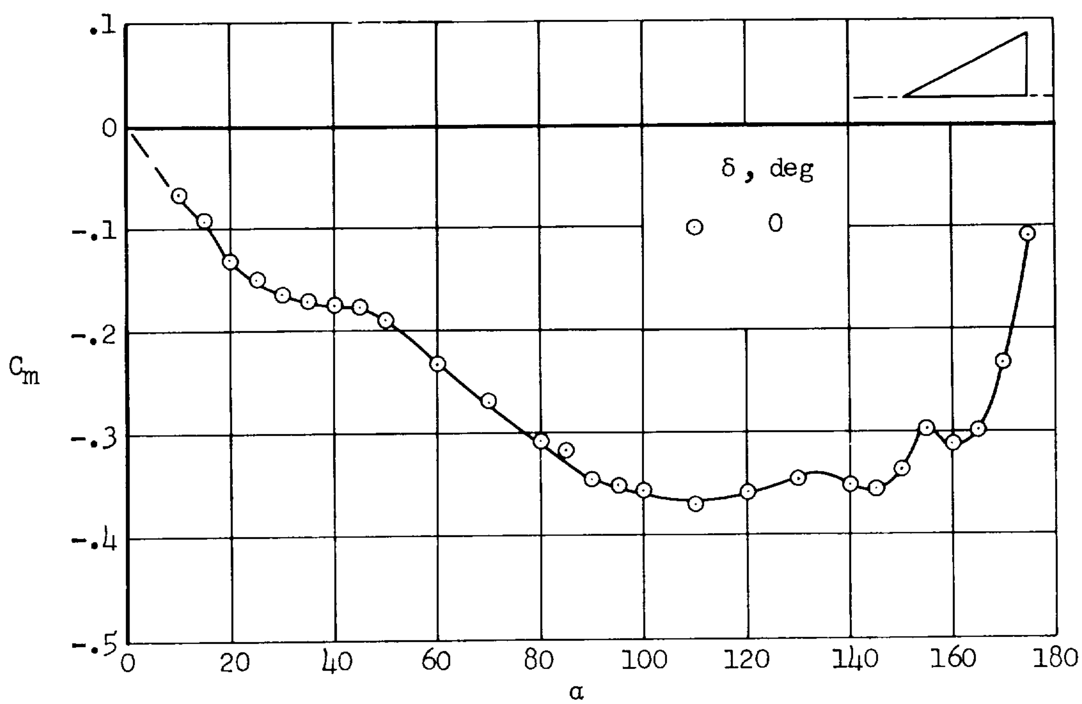
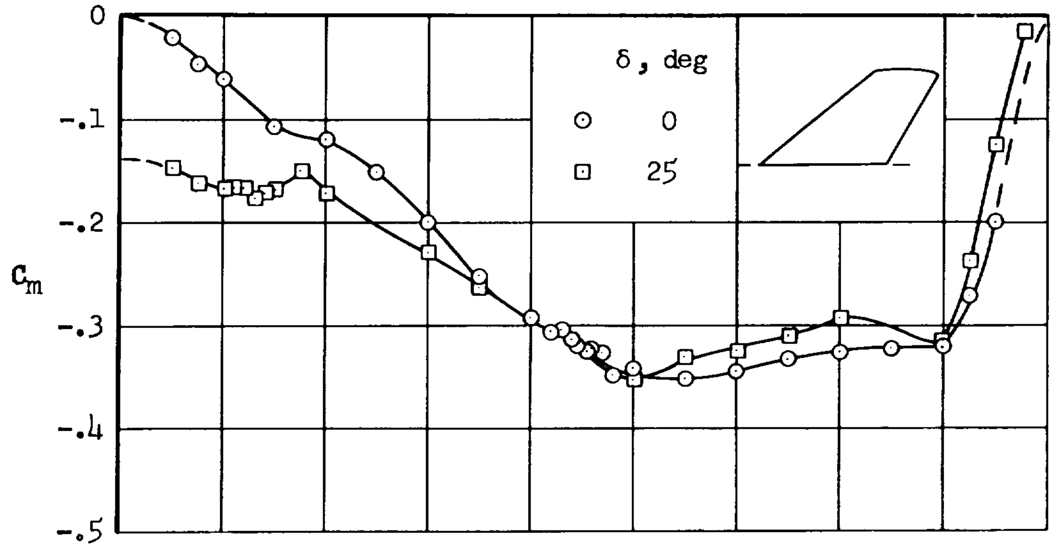


(b) A = 2; delta wing

Figure 5.- Pitching-moment characteristics of the wings.



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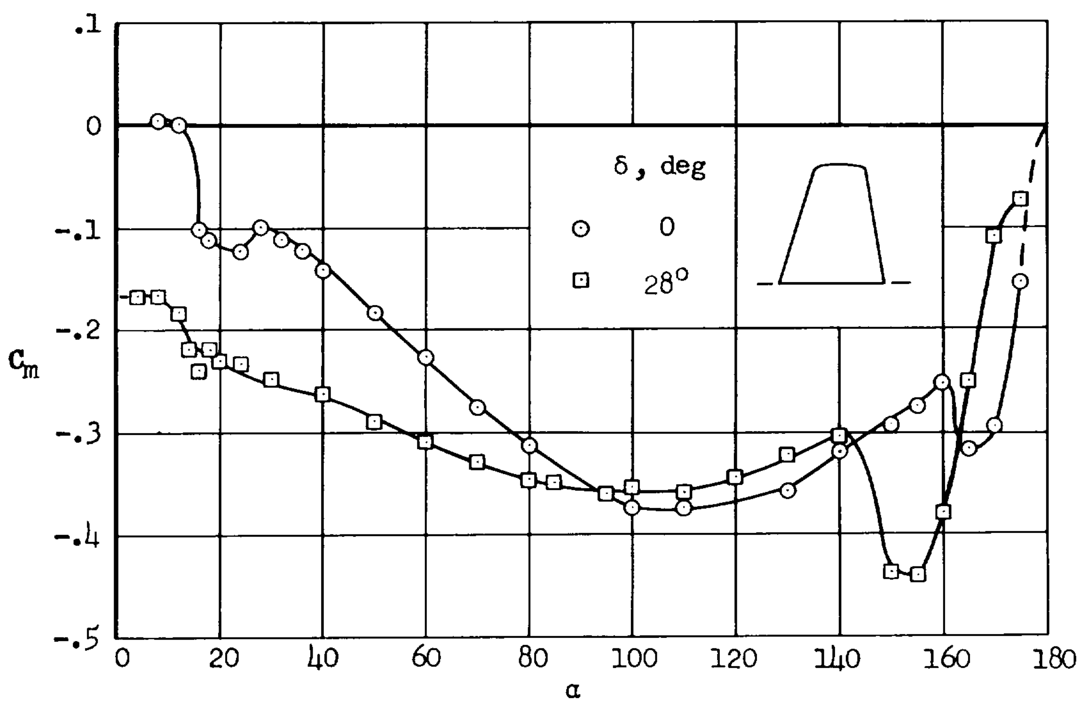
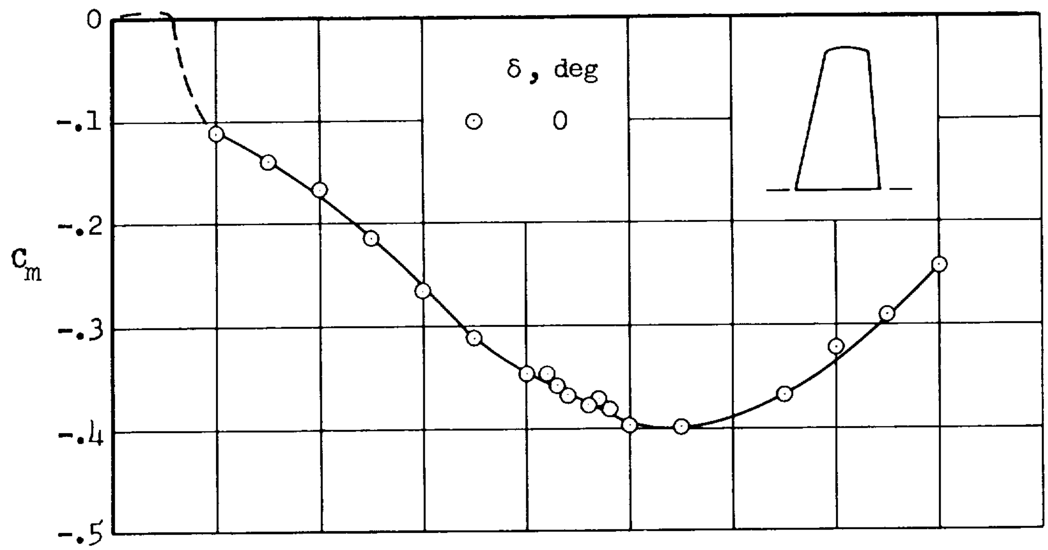


(d) A = 3; Λ = 11.3°

Figure 5.- Continued.



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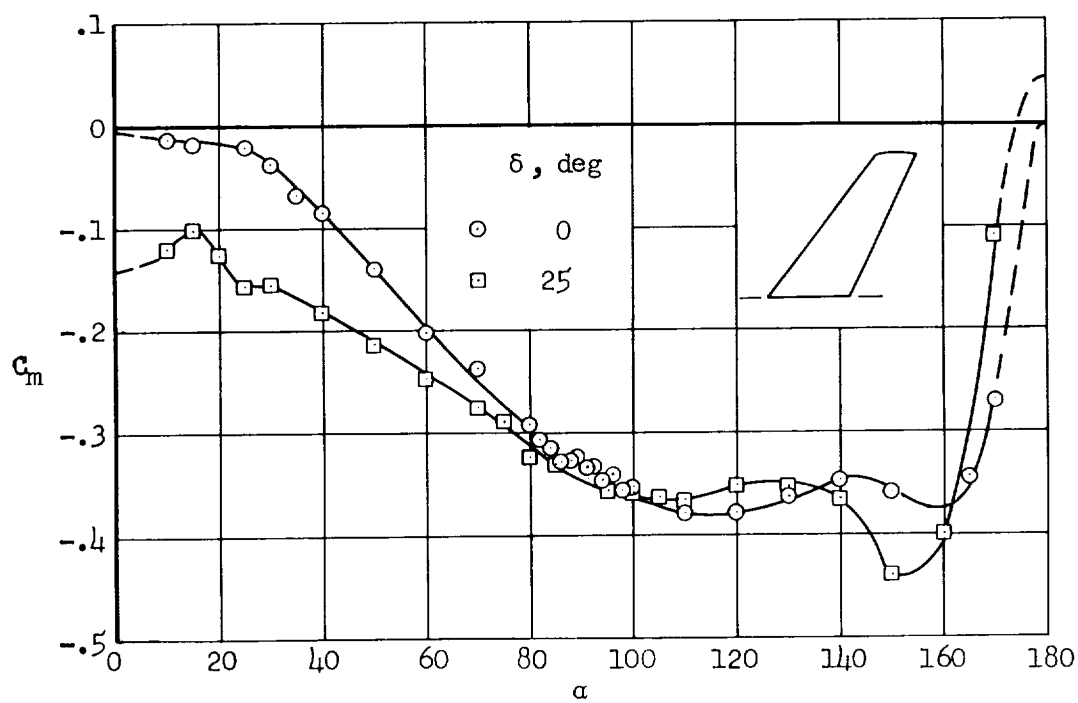

(f) A = 4.5; Λ = 35°

Figure 5.- Continued.

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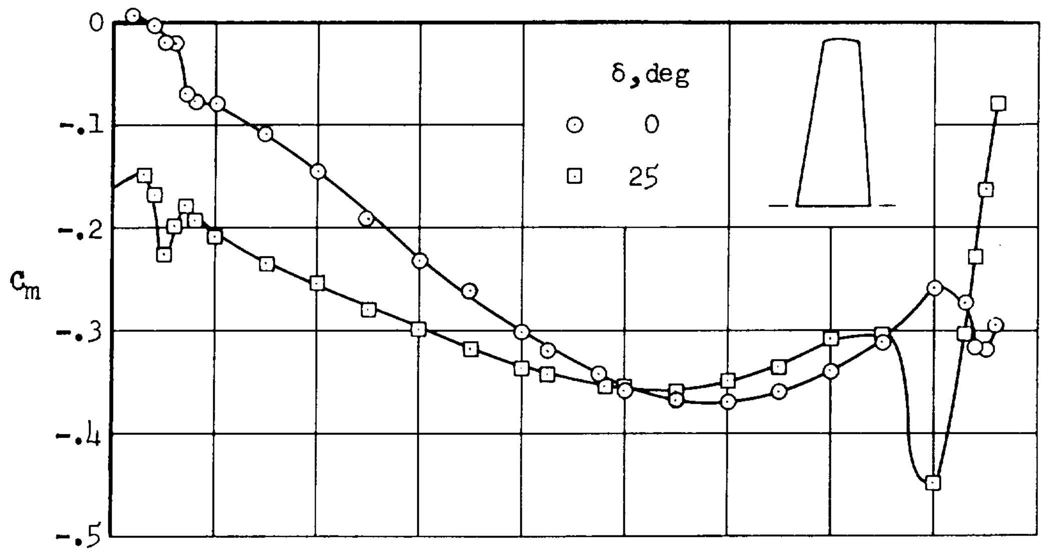

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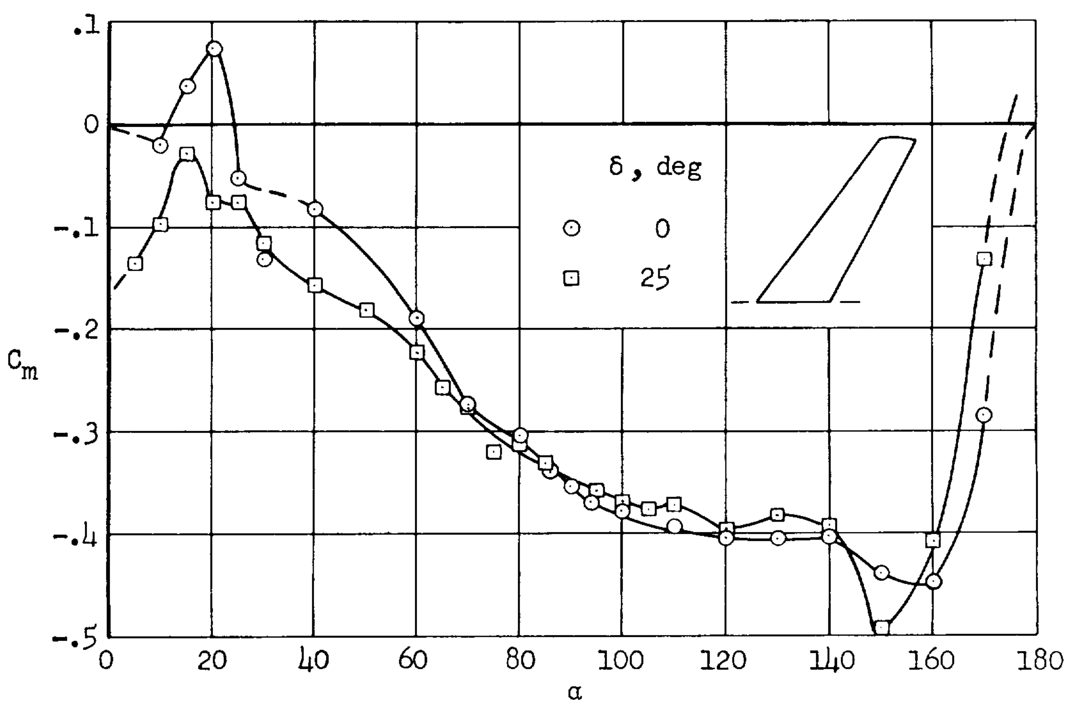

(h) A = 6; Λ = 35°

Figure 5.- Concluded.

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National Aeronautics and Space Administration.
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David G. Koenig. April 1959. 21p. diagrs.
(NASA MEMORANDUM 2-27-59A)

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1. Wings, Complete - Aspect Ratio (1.2.2.2.2)
2. Wings, Complete - Sweep (1.2.2.2.3)
3. Flaps, Trailing-Edge - Complete Wings (1.2.2.3.1)

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