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NACA

RESEARCH MEMORANDUM

LOW-SPEED INVESTIGATION OF A SMALL TRIANGULAR WING OF ASPECT RATIO 2.0. II - FLAPS ON FLAT-PLATE MODELS

By Leonard M. Rose

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Moffett Field, Calif.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON
August 9, 1948

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RESEARCH MEMORANDUM

LOW-SPEED INVESTIGATION OF A SMALL TRIANGULAR WING OF ASPECT RATIO 2.0. II – FLAPS

By Leonard M. Rose

SUMMARY

Low-speed wind-tunnel tests were made of flat-plate wings having an aspect ratio of 2.0 and their leading edges swept back 63.4°. Both plain and split flaps of several plan forms were investigated to provide qualitative information as to the relative merits of these flaps.

The constant-chord flap was found to be the most effective and a skewed wing-tip flap the least effective. In general, the effectiveness of both the split and plain flaps was reduced as the flap hinge axis was inclined from normal to the air stream. Although the results obtained with the split and plain flaps indicated qualitative agreement as to the effects of changes in flap plan form, the plain flaps were more effective.

Further tests of short-span constant-chord split flaps at several fore-and-aft locations on a triangular wing with 5-percent-thick double-wedge airfoil sections indicated the possibility of obtaining either balance without loss in lift or changes in lift without change in attitude or balance.

INTRODUCTION

As a part of a study of the aerodynamic characteristics of a triangular wing of aspect ratio 2.0, the effectiveness of various plain trailing-edge flaps in the transonic speed range has been investigated and reported in reference 1. Further low-speed test results for this wing in combination with constant-chord split flaps have been presented in references 2 and 3.

The low-speed investigation reported herein was made to provide a comparison of the relative effectiveness of split and plain flaps on wings of triangular plan form and further information as to the effects of flap plan form. Included in this investigation was a wing of the same vertex angle and aspect ratio with the plan form modified to include a 45° swept-back, constant-chord, plain flap. For convenience flat-plate models were used in making the investigation. Some further tests were made using the wing of reference 2 with short span split flaps at several chordwise locations.

MODELS AND TEST METHODS

The wings used in this investigation had the same plan forms as those of reference 1. The models were cut from 1/4-inch-thick aluminum plate and all edges were beveled to an included angle of approximately 15°. These models were mounted in the Ames 7- by 10-foot wind tunnel on a single strut as shown in figure 1.

The flap plan forms tested are shown in figure 2. Each of these flaps had an area equal to 20-percent of the total wing area. Split flaps and bent (i.e., plain) trailing-edge flaps of the various plan forms were investigated except that only bent flaps were tested on the wing that had a swept-back trailing edge. The split flaps were made of 1/16-inch aluminum sheet bent to the proper deflection.

Additional tests were made using the wing of reference 2 with a 43.4-percent-span split flap[1] at several chordwise locations as shown in figure 3.

The corrections and tares applied to the data were the same as those used in reference 2. No additional corrections were made to account for the deflection of the plates. As was the case for the previous tests, the data were obtained at a Reynolds number of approximately 1.8×10^6, based on the wing mean aerodynamic chord.

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[1]This is one-half the flap span used for the tests reported in reference 2.

SYMBOLS AND COEFFICIENTS

The pitching moments are presented about an axis in the plane of the wing perpendicular to the air stream. This axis is 18 inches aft of the vertex and passes through the 25-percent point of the mean aerodynamic chord of the triangular models and the 15.4-percent point of the mean aerodynamic chord of the model with a swept-back trailing edge. (See fig. 2.) The data are presented in the form of standard NACA coefficients which are defined as follows:

C_L lift coefficient $\left(\frac{\text{lift}}{qS}\right)$

C_m pitching-moment coefficient $\left(\frac{\text{pitching moment}}{qS\bar{c}}\right)$

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

V air-stream velocity, feet per second

S wing area, square feet

$\bar{c}$ mean aerodynamic chord of the wing, feet

ρ mass density of air, slugs per cubic foot

α angle of attack, degrees

δ flap deflection about hinge line, degrees

α_δ $-\frac{dC_L}{d\delta} \bigg/ \frac{dC_L}{d\alpha}$

RESULTS AND DISCUSSION

Flat-plate models afforded the simplest means for studying the flap plan forms under consideration. An indication of the effects of utilizing such models rather than models with double-wedge airfoil sections (reference 2) is provided in figure 4 which shows a comparison of the characteristics of the two wings with and without constant-chord split flaps. The difference in characteristics of the two models should not be attributed wholly to the difference in airfoil sections because the flat-plate model was considerably more flexible. It is believed that a large portion of the difference in results stems from the greater deflection of the flat-plate model under aerodynamic load. Further, the results shown in figure 4 for the flap-deflected conditions are not directly comparable, since the flap on the wing used in reference 2 extended over only 86.8 percent of the wing span. Although the results obtained with the flat-plate wings may not be directly applicable to the design of flaps on wings throughout the complete lift-coefficient range, it is believed that these results are useful qualitatively in the low lift-coefficient range for assessing the relative merits of various flap plan forms.

The experimental results for the various flaps are presented in figures 5 through 8, as follows:

Flap Type	Fig. No.
Skewed tip	5
Swept-back constant chord	6
Constant-percent chord	7
Constant chord	8

To afford a direct comparison of these results and those of the previous wing-flow tests (reference 1) the values of α_δ for the various flap configurations were evaluated for both the plain and split flaps. These values are as follows:

Flap type	Sweep of hinge line (deg)	Split flap		Plain flap	Plain flap
		$\delta = 10^\circ$	$\delta = 20^\circ$	$\delta = 20^\circ$	Reference 1, M = 0.5
Constant chord	0	-0.452	-0.330	-0.500	-0.42
Constant-percent chord	21.8	-.400	-.320	-.467	-.46
Swept-back constant chord	45	----	----	-.219	-.255
Skewed tip	63.4	-.141	-.112	-.167	-.27

Although some differences exist in the results of these tests and those of reference 1,[2] the results clearly indicate the greater effectiveness of the flaps with hinge lines nearly normal to the air stream. In this connection, it is interesting to note that for the present tests the flap effectiveness decreases in a consistent manner with increasing angle of sweep of the hinge axis.

Comparison of the results obtained with the plain and split flaps shows that although split flaps were less effective than the plain flaps, the results as indicated in the table are in qualitative agreement. For each flap plan form investigated the split flaps produced much smaller increments in lift and pitching moment for 20° deflection than the corresponding plain flaps. Because of this difference in split-flap and plain-flap effectiveness the data of references 2 and 3 should be considered only as an indication of the characteristics of split flaps rather than as representative of all flap types.

The results of tests of partial span split flaps on the 5-percent-thick double-wedge, triangular wing are presented in figure 9. For an angle of attack of 10° the increment in pitching moment and lift coefficient derived from 25° deflection of these flaps as a function of flap location is shown in figure 10. These results indicate that by locating the flap hinge line at approximately 76 percent of the root chord a lift-coefficient increment of 0.1 can be provided with no change in pitching moment. Further, locating the flap hinge line between 76 and 67 percent of the root chord will provide balancing pitching moments without loss of lift.

CONCLUDING REMARKS

Tests of several flaps on triangular flat-plate models produced results that are believed to be indicative of general trends which

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[2]Some of the discrepancies may be accounted for by the differences in methods of data reduction due to the difference in testing technique. In the wing-flow tests the values of α_δ were determined by dividing the wing floating angle by the flap deflection; whereas the values herein were determined by the ratio of $dC_L/d\delta$ to $dC_L/d\alpha$; thus,

$$\alpha_\delta = -\left(\frac{dC_L/d\delta}{dC_L/d\alpha}\right)$$

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would be obtained on other models having similar plan forms and aspect ratios. A constant-chord flap was found to be the most effective and a skewed-tip flap the least effective. In general, the results indicated that the effectiveness of both the split and plain flaps was reduced by sweep of the flap hinge axis.

Although the results obtained with split and plain flaps indicated qualitative agreement as to the effect of changes in flap plan form, the split flaps produced much smaller increments in lift and pitching moment with 20° deflection.

Some additional tests of a short-span flap at several chordwise locations indicated the possibilities of so locating these flaps that balancing moments without loss in lift or changes in lift without change in attitude or balance might be attained.

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National Advisory Committee for Aeronautics
Moffett Field, Calif.

REFERENCES

1. Rathert, George A., Jr., and Cooper, George E.: Wing-Flow Tests of a Triangular Wing of Aspect Ratio Two.- I. Effectiveness of Several Types of Trailing-Edge Flaps on Flat-Plate Models. NACA RM No. A7G18, 1947.

2. Rose, Leonard M.: Low-Speed Investigation of a Small Triangular Wing of Aspect Ratio 2.0. I - The Effect of Combination with a Body of Revolution and Height Above a Ground Plane. NACA RM No. A7K03, 1947.

3. Anderson, Adrien E.: An Investigation at Low Speed of a Large-Scale Triangular Wing of Aspect Ratio Two.- I. Characteristics of a Wing Having a Double-Wedge Airfoil Section with Maximum Thickness at 20-Percent Chord. NACA RM No. A7F06, 1947.

Figure 1.– Flat–plate model mounted in the wind tunnel.

[redacted]

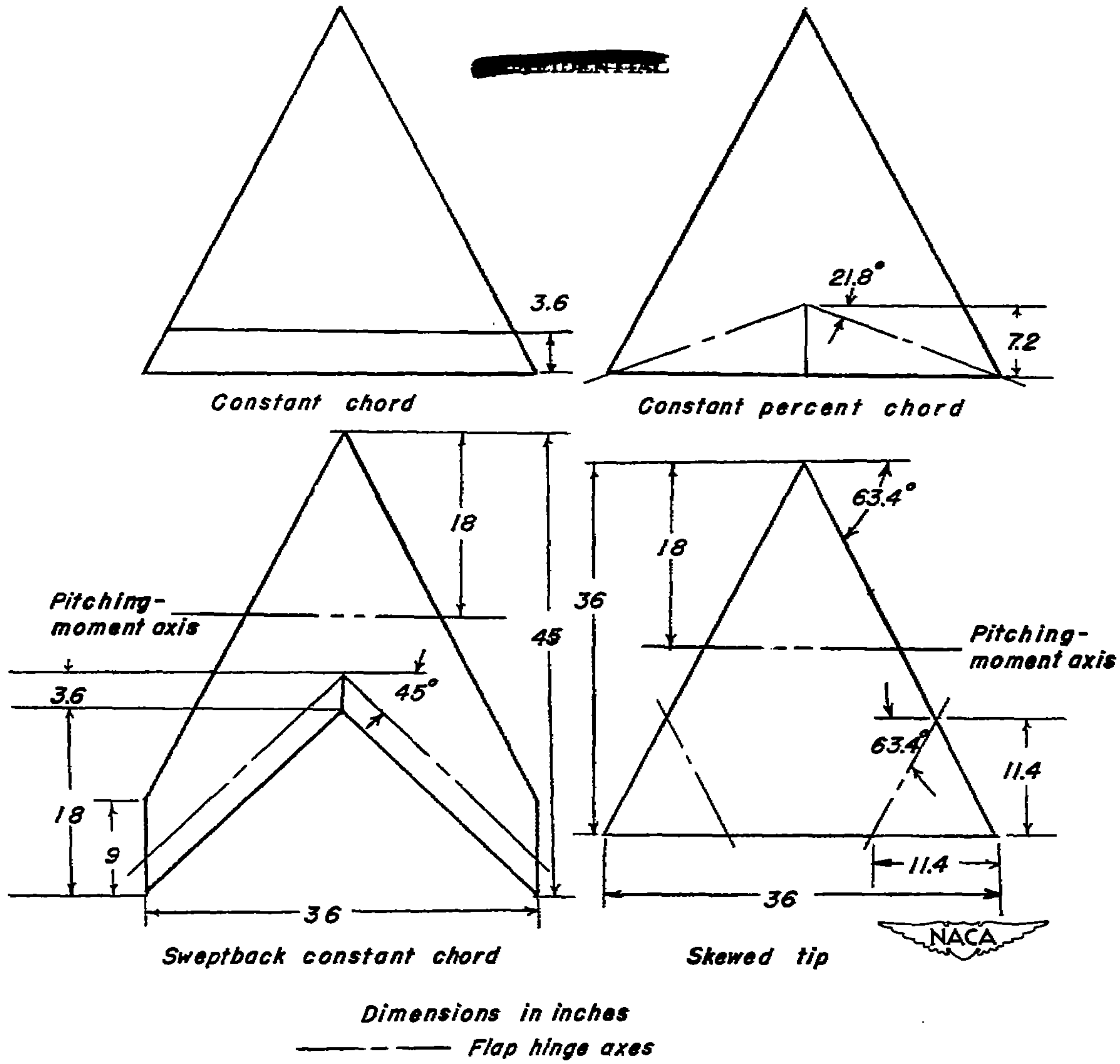

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Figure 2.– Plan forms and locations of the flaps tested on the flat-plate models.

[redacted]

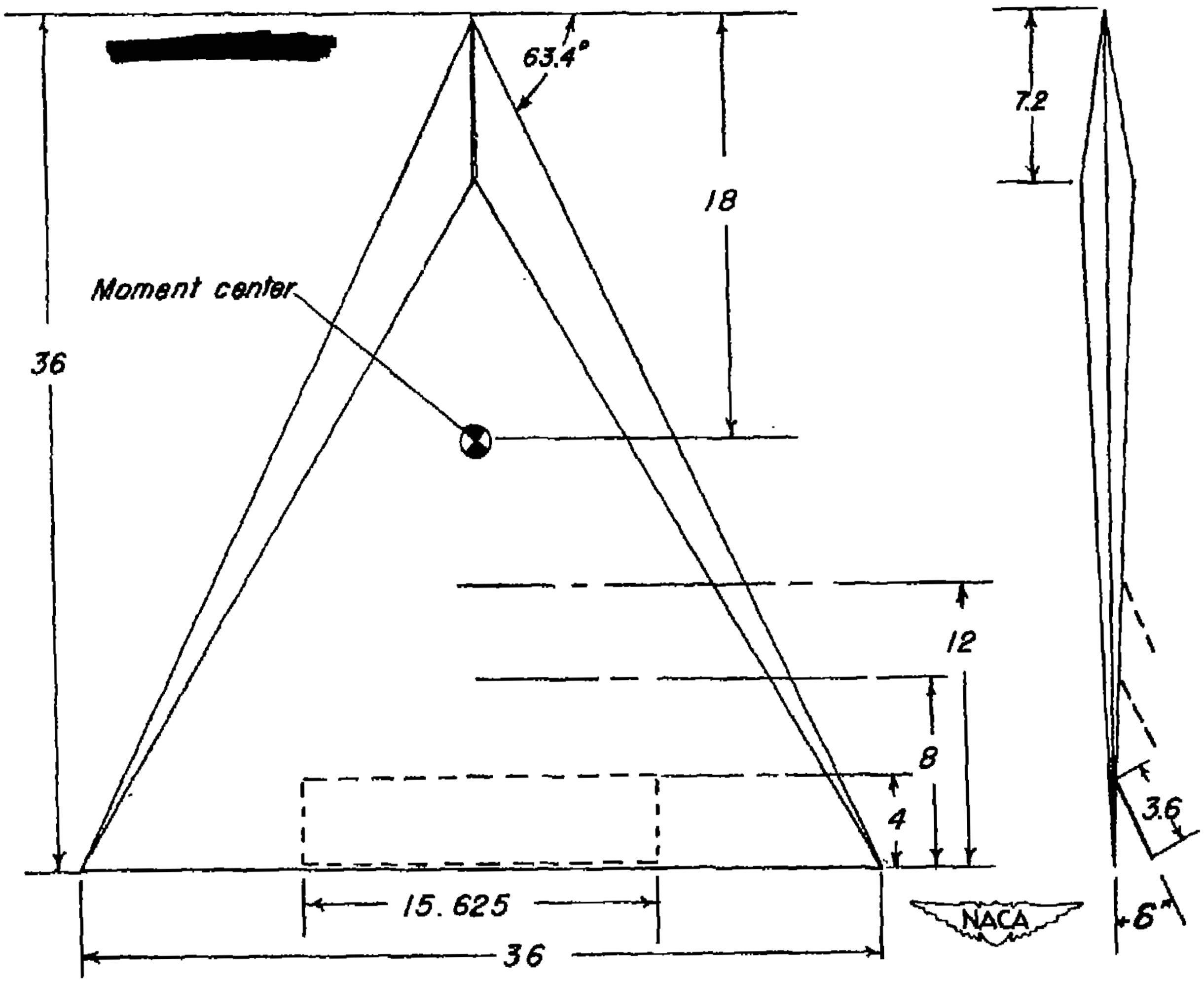

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Figure 3.- The chordwise locations of the split flap tested on the 5-percent thick wing.

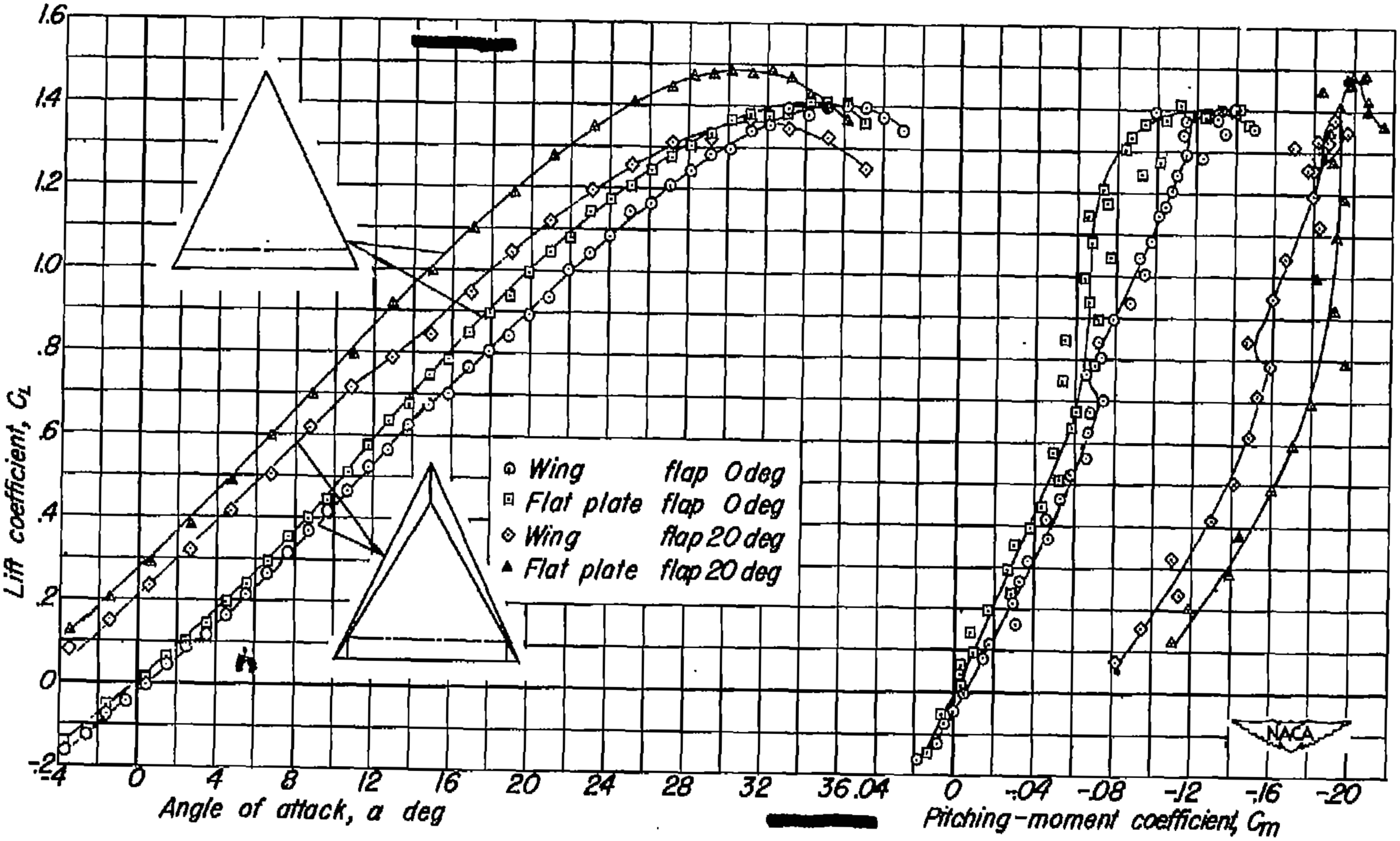

Figure 4.– The lift and pitching-moment characteristics of the flat-plate model and the 5-percent thick double wedge wing with split flaps.

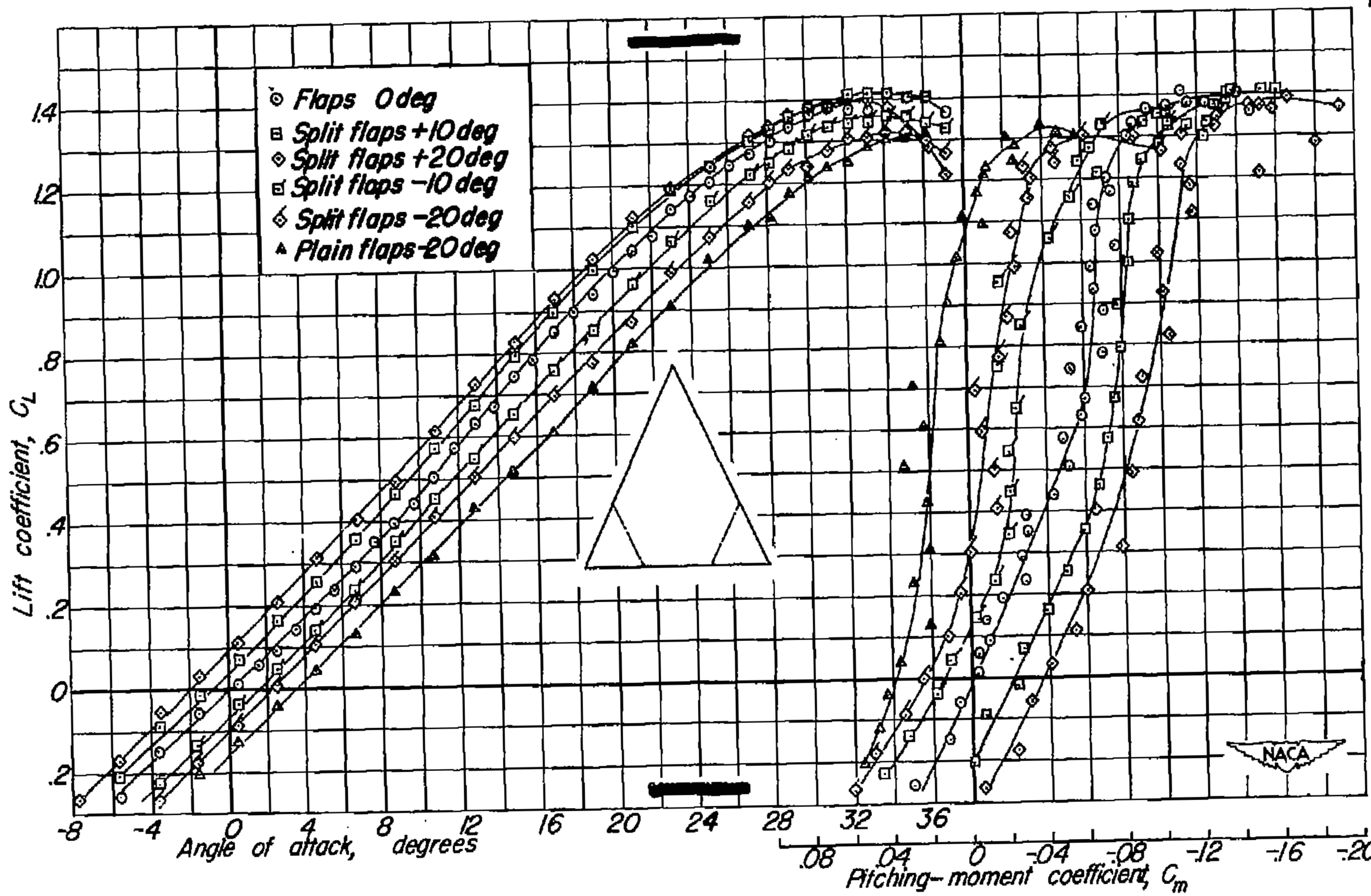

Figure 5.–The lift and pitching-moment characteristics of the flat-plate wing with a skewed tip flap.

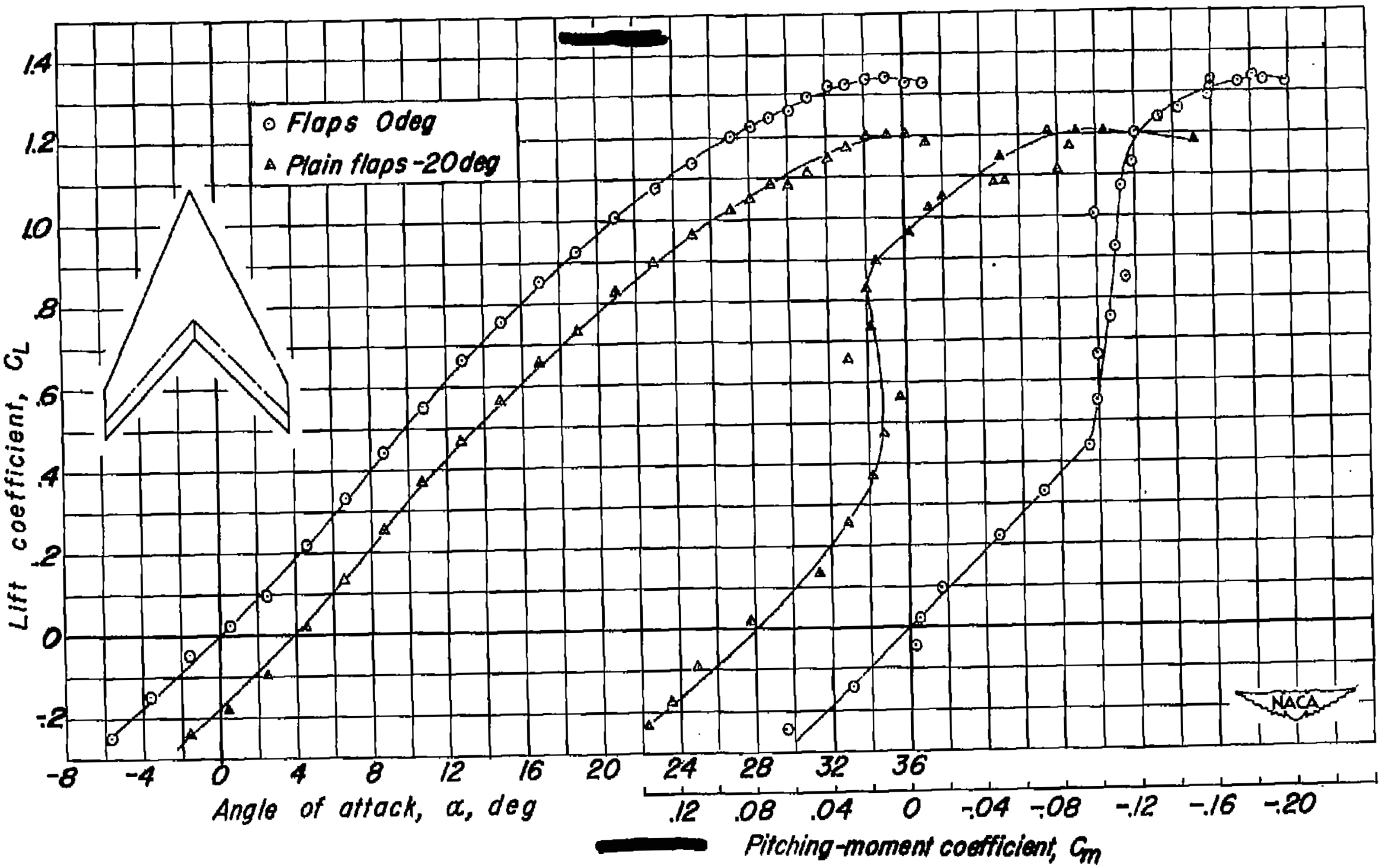

Figure 6.- The lift and pitching-moment characteristics of the flat-plate wing with a swept-back constant-chord flap.

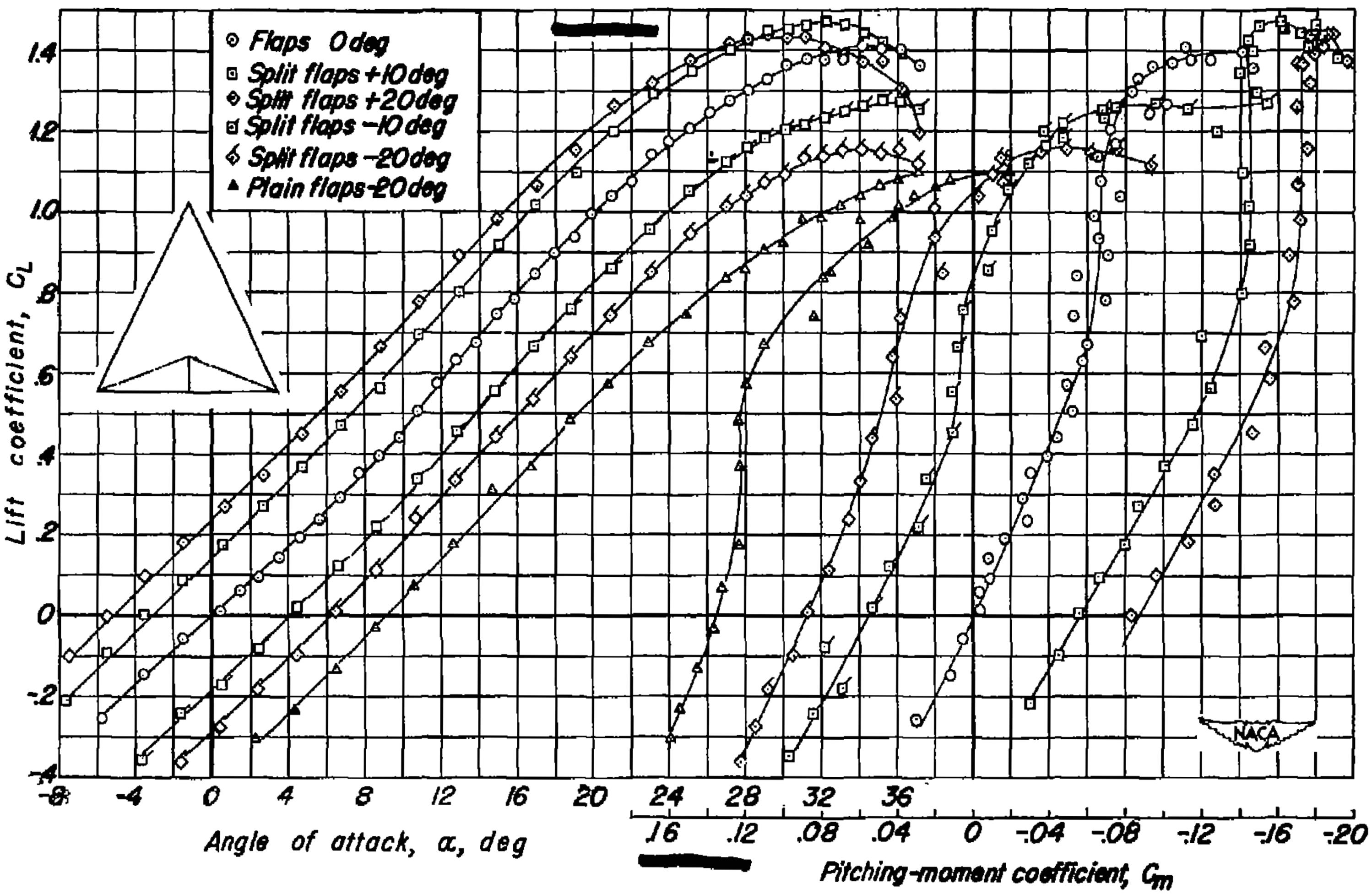

Figure 7.–The lift and pitching-moment characteristics of the flat-plate wing with a constant-percent chord flap.

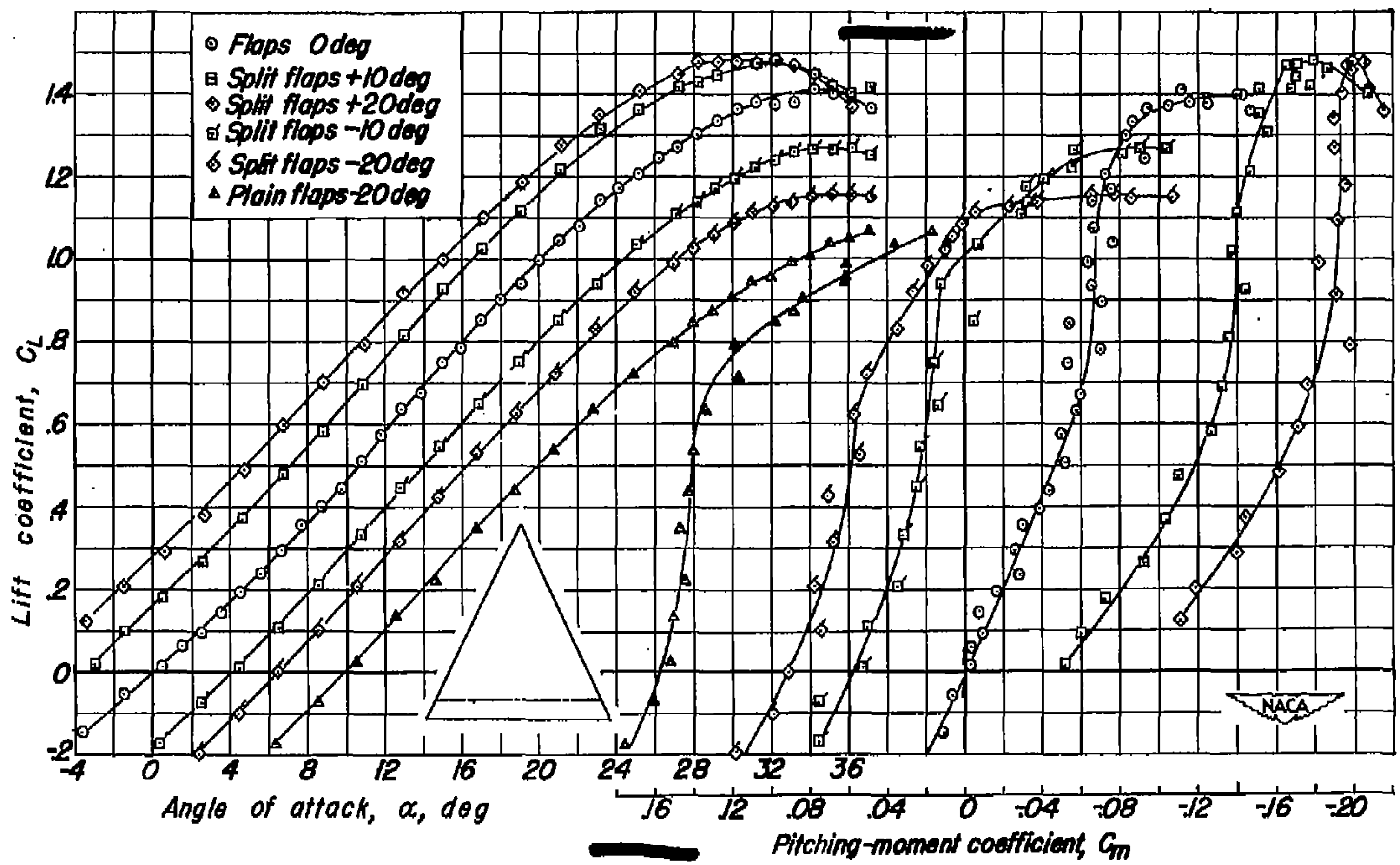

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Figure 8.–The lift and pitching-moment characteristics of the flat-plate wing with a constant-chord flap.

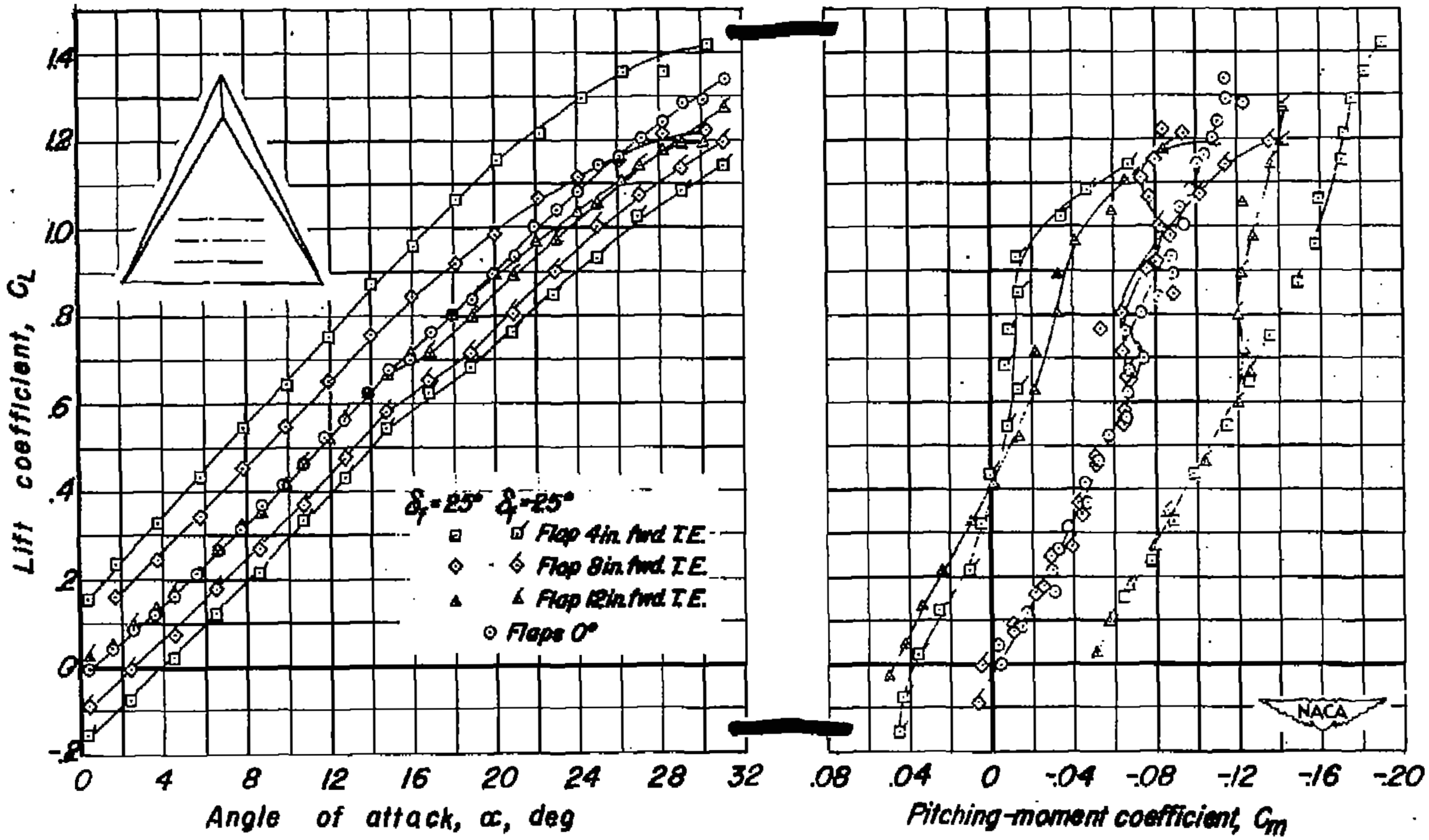

Figure 9.–The lift and pitching-moment characteristics of the 5-percent thick wing with a 43.4-percent-span constant-chord split flap at various chordwise locations.

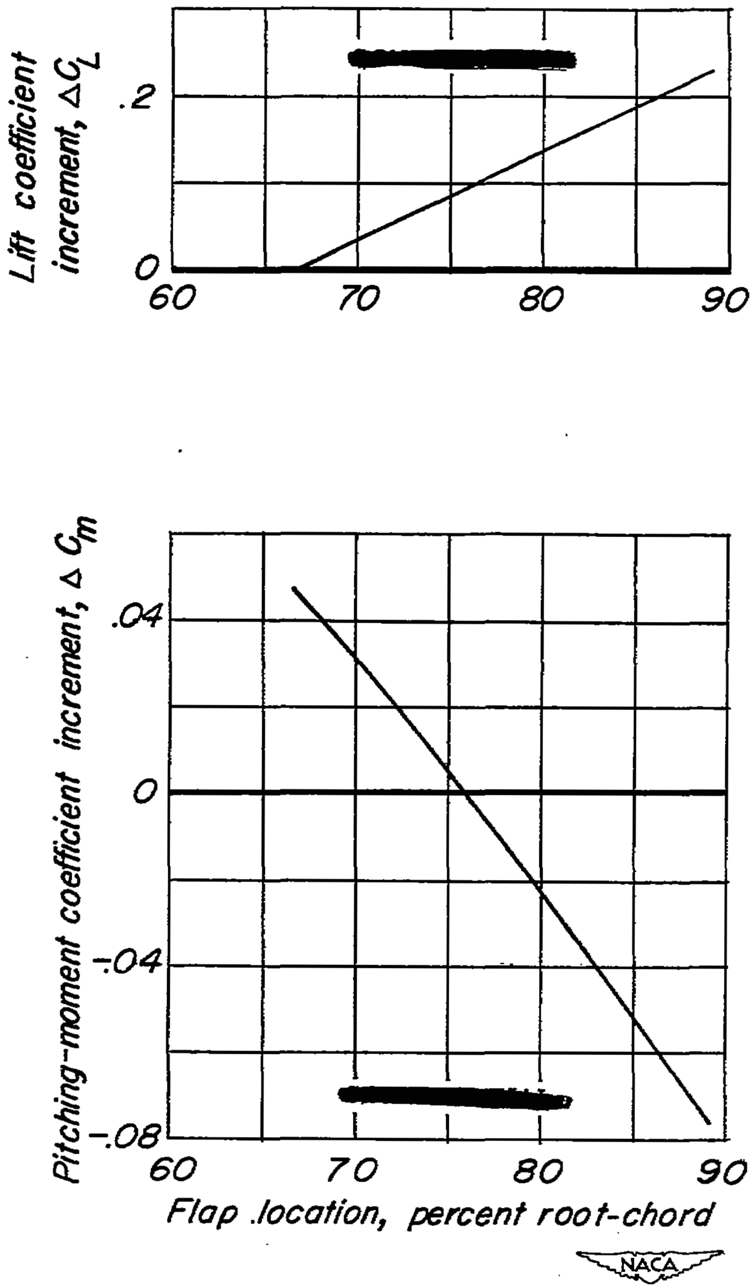

Figure 10.- The incremental lift and pitching-moment coefficients resulting from 25° deflection of a 43.4-percent-span constant-chord split flap as a function of chordwise flap location on the 5-percent thick wing. $\alpha = 10°$.