~~RESTRICTED~~

Copy No. 8

~~CLASSIFICATION CHANGED~~ ~~CONFIDENTIAL~~

RM No. A8C03

UNCLASSIFIED

~~11156~~ ~~126~~ ~~[illegible]~~ c, 2

~~To [illegible] 7 SEP 1948~~

~~naca Release form #578,~~

~~By authority of H. L. Dryden Date Aug. 27, 1951~~

~~by HYR 7-10-51~~

NACA RM No. A8C03

RESEARCH MEMORANDUM

LOW-SPEED INVESTIGATION OF A SMALL TRIANGULAR WING OF ASPECT RATIO 2.0. III - STATIC STABILITY WITH TWIN VERTICAL FINS

By Leonard M. Rose

Ames Aeronautical Laboratory
Moffett Field, Calif.

CLASSIFICATION CHANGED

To UNCLASSIFIED

By authority of H. L. Dryden Date 6-11-53
per NACA Release form #1469.
By HYR, 7-21-53.

CLASSIFIED DOCUMENT

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

WASHINGTON
August 24, 1948

~~CONFIDENTIAL~~

UNCLASSIFIED

~~RESTRICTED~~

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

LOW-SPEED INVESTIGATION OF A SMALL TRIANGULAR WING OF ASPECT RATIO 2.0. III - STATIC STABILITY WITH TWIN VERTICAL FINS

By Leonard M. Rose

SUMMARY

Low-speed wind-tunnel tests were made of a triangular wing with two arrangements of twin vertical fins. With these twin fins mounted either symmetrically or wholly above the wing chord plane, approximately constant effectiveness in proportion to the fin size was obtained throughout the angle-of-attack range. The addition of these fins, however, resulted in a decrease in maximum lift and a reduction in static longitudinal stability at lift coefficients above 0.4.

INTRODUCTION

Previous tests of a single vertical tail in combination with an approximately triangular wing (reference 1, configurations 7 and 8) have shown marked losses in directional stability at high lift coefficients. Considerations of the flow about triangular wings at high lift coefficients (as discussed in references 2 and 3) indicated that vertical fins mounted outboard of the center line of the wing would possibly provide more desirable characteristics.

In order to check the merits of outboard vertical fins, a short investigation of twin vertical fins on a triangular wing was made in the Ames 7- by 10-foot wind tunnel. The characteristics of the model with fins mounted symmetrically about the wing-chord plane and fins mounted wholly above the wing-chord plane were investigated.

SYMBOLS AND COEFFICIENTS

The results are presented in the form of standard NACA coefficients. The moments are referred to the stability axes which are illustrated in figure 1. The forces are referred to the wind axes which are mutually perpendicular and disposed perpendicular and parallel to the relative wind. Both systems of axes have their origin 18 inches aft of the apex of the wing, as shown in figure 2. The symbols and coefficients used are defined as follows:

C_L	lift coefficient $\left(\frac{\text{lift}}{qS}\right)$
C_m	pitching-moment coefficient $\left(\frac{\text{pitching moment}}{qS\bar{c}}\right)$
C_l	rolling-moment coefficient $\left(\frac{\text{rolling moment}}{qSb}\right)$
C_n	yawing-moment coefficient $\left(\frac{\text{yawing moment}}{qSb}\right)$
C_Y	side-force coefficient $\left(\frac{\text{side force}}{qS}\right)$
q	dynamic pressure $\left(\frac{1}{2}\rho V^2\right)$, pounds per square foot
ρ	mass density of air, slugs per cubic foot
V	air-stream velocity, feet per second
S	wing area, square feet
$\bar{c}$	mean aerodynamic chord of the wing, feet
b	wing span, feet
α	angle of attack, degrees
ψ	angle of yaw, degrees
C_{n_ψ}	rate of change of yawing-moment coefficient with angle of yaw $\left(\frac{\partial C_n}{\partial \psi}\right)$

C_{Y_ψ} rate of change of side-force coefficient with angle of yaw $\left(\frac{\partial C_Y}{\partial \psi}\right)$

C_{l_ψ} rate of change of rolling-moment coefficient with angle of yaw $\left(\frac{\partial C_l}{\partial \psi}\right)$

MODEL AND TEST METHODS

The model used for this investigation was triangular in plan form with an aspect ratio of 2.0. The airfoil section was a double wedge with a maximum thickness of 5 percent of the chord at 20 percent of the chord. This was the model used previously (reference 2), except that the interior of the model was modified to include a strain gage for the measurement of rolling moments.

Two arrangements of twin vertical fins were tested. The fins of one set were geometrically similar to the wing in plan form and were mounted symmetrically about the wing-chord plane as shown in figure 2. The lower halves of these fins were eliminated to form the other tail arrangement. Both sets of fins were located 72.8 percent of the semispan outboard of the wing center line. The fins were made of 1/16-inch-thick aluminum sheet.

The tests were made at a Reynolds number of 1.8×10^6 based on the mean aerodynamic chord of the wing. Since the alterations made in the model did not change the mounting arrangement externally, the previously determined strut tares and wind-tunnel-wall corrections (reference 2) were applied to the results presented herein.

RESULTS AND DISCUSSION

The basic test results are presented in figures 3 and 4. The static lateral stability parameters C_{l_ψ}, C_{n_ψ}, and C_{Y_ψ}, are plotted as functions of angle of attack in figure 5. Examination of these test results indicates that both vertical-fin arrangements contributed directional stability approximately in proportion to their size. Although the results show a reduction in directional stability at angles of attack greater than 20°, the effectiveness of the fins was nearly constant throughout the angle-of-attack range. It was expected that the large vertical fins would maintain some effectiveness throughout the angle-of-attack range, since half of their area was below the wing. To determine whether the fin area below the wing was more effective than that above, the small fins (which consisted of the upper halves of the large fins) were tested. It is evident from figure 5 that the effectiveness of the large and small fins was roughly proportional to the fin size and relatively unaffected by the change in area distribution.

Although the twin vertical fins appeared to be satisfactory for producing directional stability at all angles of attack up to the stall, these surfaces had adverse effects on the lift and pitching-moment characteristics of the wing at high angles of attack. As shown in figure 3, the maximum lift was reduced approximately 0.2 by the addition of the large fins. Also shown is a reduction in static longitudinal stability at lift coefficients above 0.4. The results presented in reference 1 indicate no losses in lift or longitudinal stability attributable to the redesigned single vertical tail.

CONCLUDING REMARKS

Wind-tunnel tests of twin vertical fins mounted on a triangular wing indicated that static directional stability was maintained throughout the angle-of-attack range with these vertical surfaces mounted either wholly above or symmetrically about the wing chord plane. Although the results indicated no marked losses in vertical-fin effectiveness at high lift coefficients, a loss in both maximum lift and static longitudinal stability resulted from the twin-fin installation.

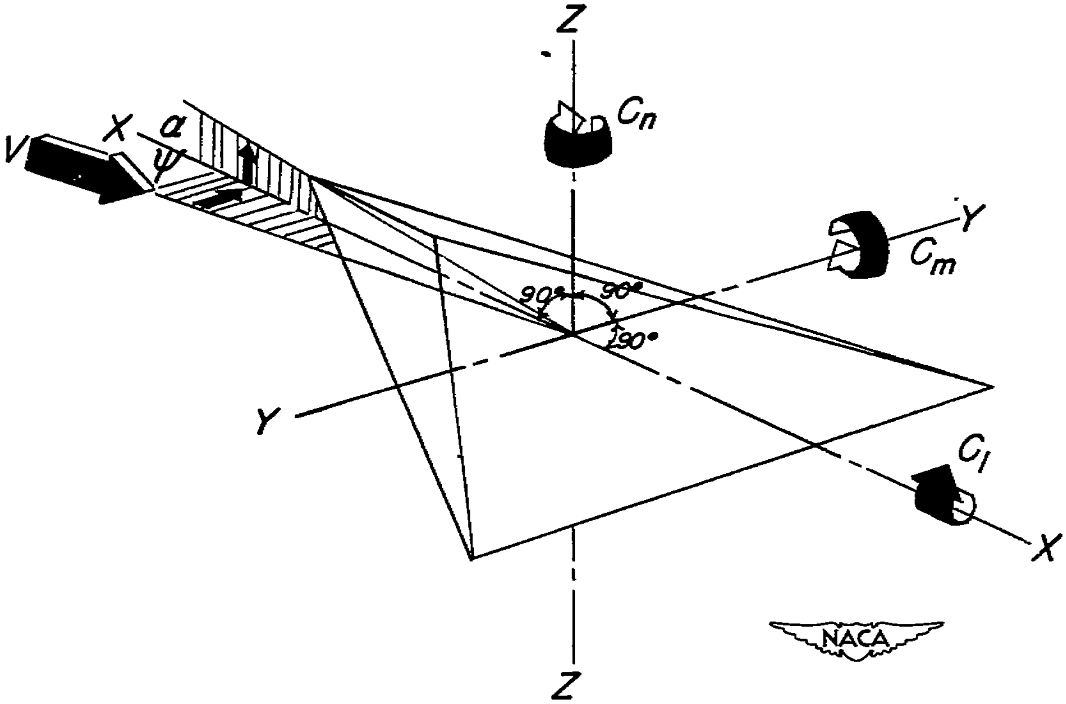
Ames Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Moffett Field, Calif.

REFERENCES

1. Lovell, J. Calvin, and Wilson, Herbert A., Jr.: Langley Full-scale-Tunnel Investigation of Maximum Lift and Stability Characteristics of an Airplane Having Approximately Triangular Plan Form (DM-1 Glider). NACA RM No. L7F16, 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. – II. The Effect of Airfoil Section Modifications and the Determination of the Wake Downwash. NACA RM No. A7H28, 1947.



Note: Positive direction indicated by arrows.

Figure 1.– The stability axes of the model.

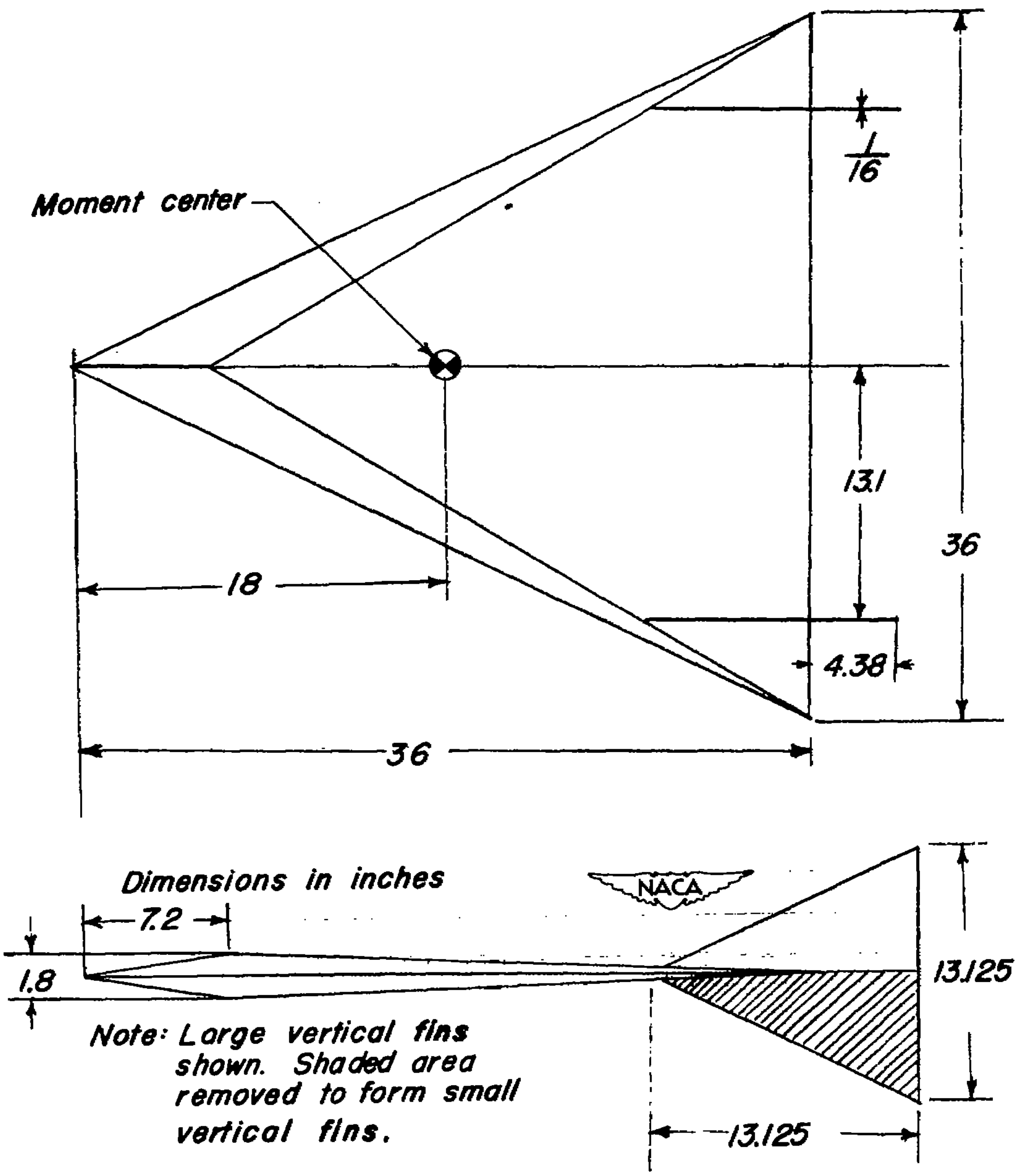


Figure 2.– The wing and twin vertical-fin arrangements investigated.

CONFIDENTIAL

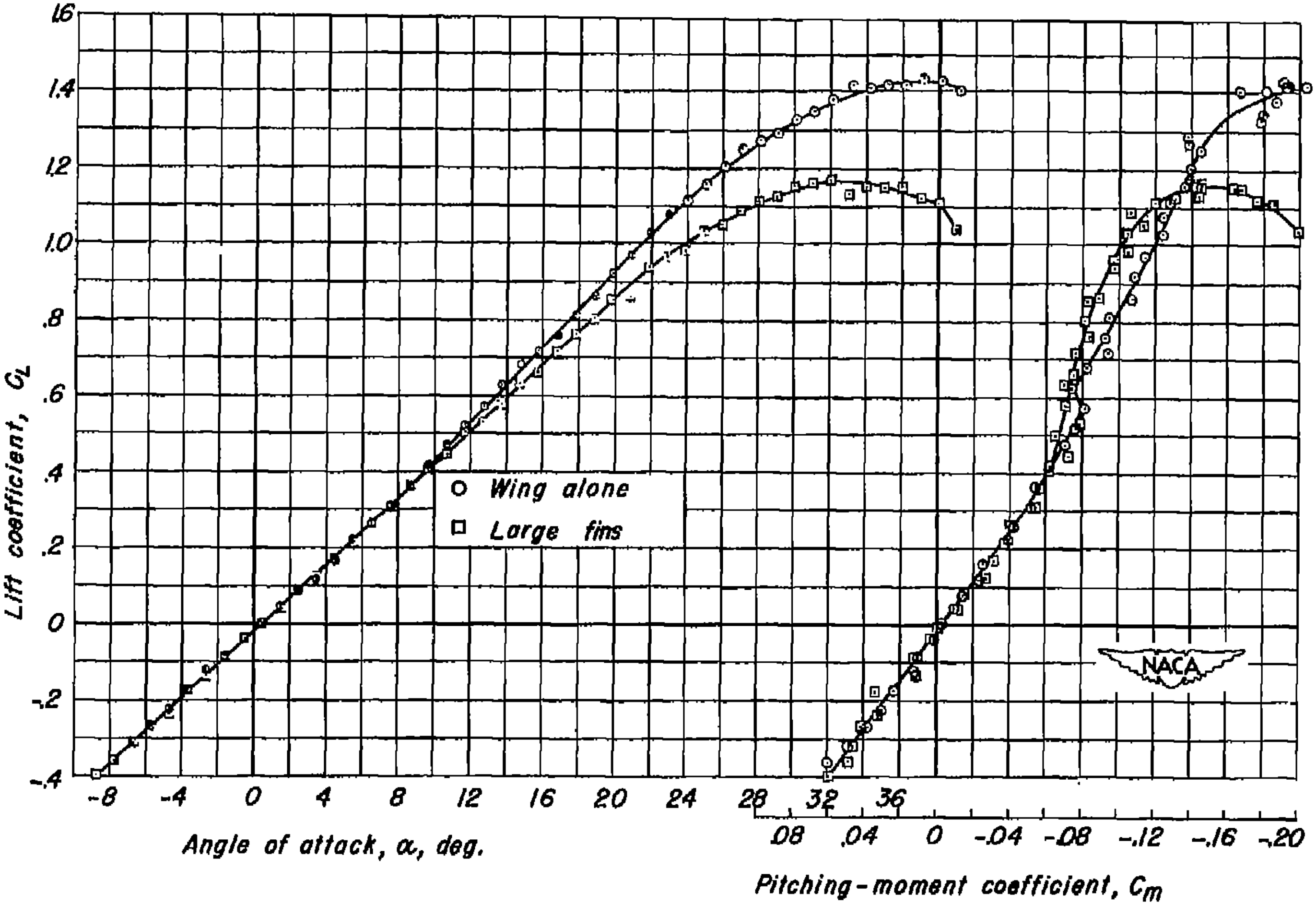
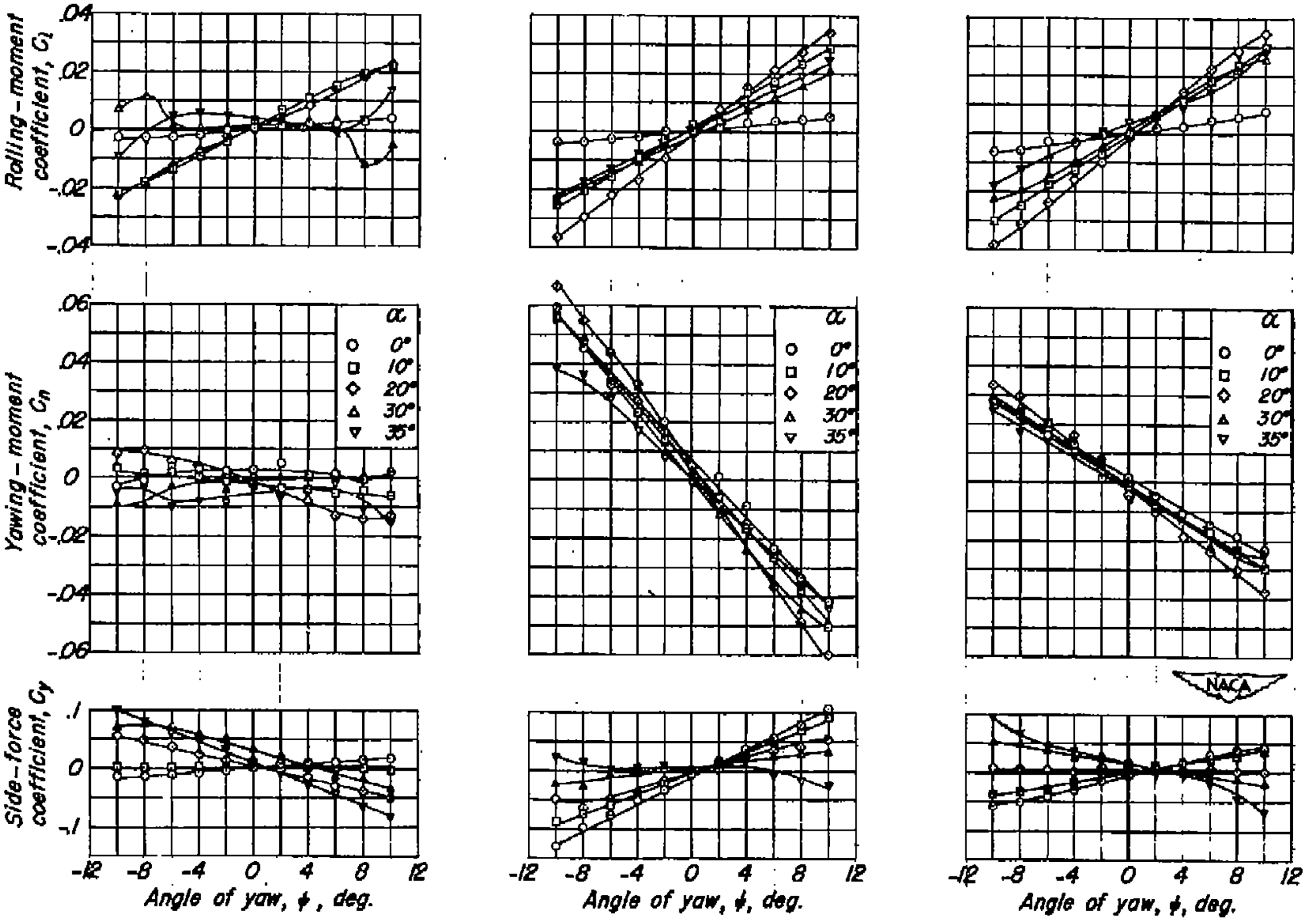


Figure 3.– The variation of lift coefficient and pitching-moment coefficient with angle of attack for the wing alone and in combination with the large vertical fins.

[redacted]

[redacted]



(a) Wing alone

(b) Large fins

(c) Small fins

Figure 4.— The characteristics in yaw of the wing alone and in combination with the two vertical-fin arrangements.

[redacted]

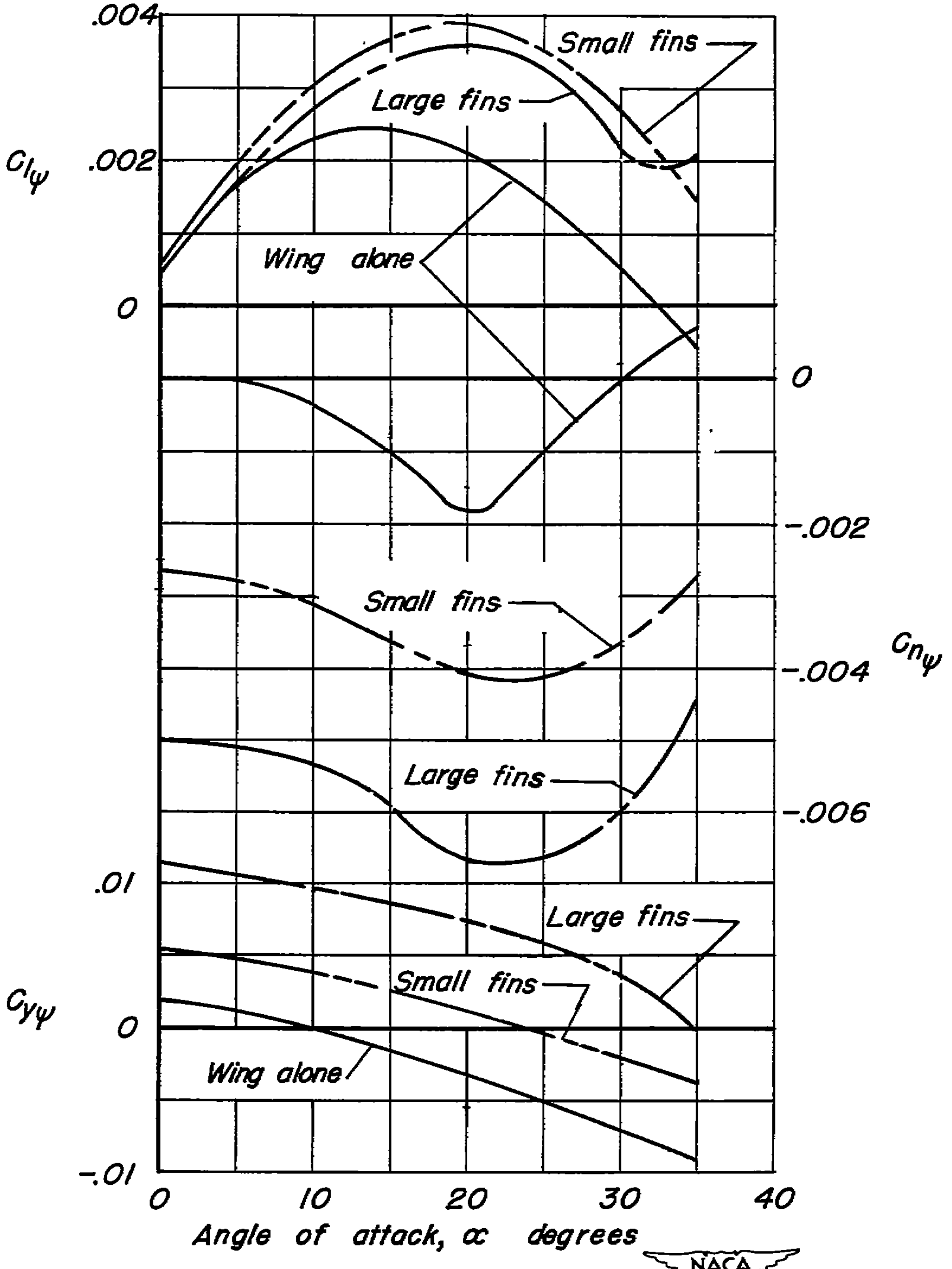


Figure 5.– The variation of the static lateral stability parameters with angle of attack.