TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 325

WIND TUNNEL PRESSURE DISTRIBUTION TESTS ON A SERIES OF BIPLANE WING MODELS

PART II. EFFECTS OF CHANGES IN DECALAGE, DIHEDRAL, SWEEPBACK AND OVERHANG

By Montgomery Knight and Richard W. Noyes
Langley Memorial Aeronautical Laboratory

Washington
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Summary

This preliminary report furnishes information on the changes in the forces on each wing of a biplane cellule when the decalage, dihedral, sweepback and overhang are separately varied. The data were obtained from pressure distribution tests made in the Atmospheric Wind Tunnel of the Langley Memorial Aeronautical Laboratory. Since each test was carried up to 90° angle of attack, the results may be used in the study of stalled flight and of spinning and in the structural design of biplane wings

This preliminary report presents the results of wind tunnel pressure distribution tests which were made in order to determine the magnitude and disposition of the normal or "beam" air loads on two wing models arranged in different biplane combinations. The effects of changes in decalage, dihedral, sweepback, and overhang were investigated separately. A previous report, Part I (see Reference), has covered the results of similar tests in which the stagger and gap were varied. A subsequent report, Part III, will cover the results of additional tests in which the above factors were varied in pairs, such as various amounts of stagger for various amounts of gap, etc. A more complete presentation of the results of the entire investigation and an analysis from the standpoints of spinning, stalled flight, and the structural design of biplane wings will be published at a later date.

The tests were made in the Five-Foot Atmospheric Wind Tunnel of the Langley Memorial Aeronautical Laboratory. A complete description of the models, apparatus, method of testing, and the procedure in working up the test data is given in Part I (See Reference) and will not be repeated here. The Clark Y profile was used on each wing. Figure 1 shows the wing plan form and location of the pressure orifice.

Tests

The biplane arrangements tested were divided into four groups as follows:

1. Variation in decalage (stagger = 0, gap/chord = 1, dihedral = 0, sweepback = 0, overhang = 0).

   See Figure 2.

   (a) −6°

   (b) −3°

   (c) 0°

   (d) +3°

   (e) +6°

2. <u>Variation in dihedral</u> (stagger = 0, gap/chord = 1
decalage = 0, sweepback = 0,
overhang = 0).

See Figure 11.

(a) 3° upper wing, 0° lower wing.

(b) 0° both wings.

(c) 0° upper wing, 3° lower wing.

3. <u>Variation in sweepback</u> (stagger = 0, gap/chord = 1,
decalage = 0, dihedral = 0,
overhang = 0).

See Figure 20.

(a) 10° upper wing, 0° lower wing.

(b) 5° upper wing, 0° lower wing.

(c) 0° both wings.

(d) 0° upper wing, 5° lower wing.

(e) 0° upper wing, 10° lower wing.

4. <u>Variation in overhang</u> (stagger = 0, gap/chord = 1.
decalage = 0, dihedral = 0,
sweepback = 0).

See Figure 29.

(a) $\frac{\text{Lower wing span}}{\text{Upper wing span}} = 1.25.$

(b) $\frac{\text{Lower wing span}}{\text{Upper wing span}} = 1.00.$

(c) $\frac{\text{Lower wing span}}{\text{Upper wing span}} = 0.80.$

(d) $\frac{\text{Lower wing span}}{\text{Upper wing span}} = 0.60.$

Each test was made at angles of attack of −8°, −4°, 0°, +4°, 8°, 12°, 14°, 16°, 18°, 20°, 22°, 25°, 30°, 35°, 40°, 50°, 60°, 70°, 80°, and 90°. The dynamic pressure q, indicated by the "service" Pitot-static tube as explained in Part I, was maintained at 4.09 lb. per sq.ft., corresponding to an average velocity of very nearly 40 m.p.h., and to a Reynolds Number of about 150,000.

Results

The results are presented in the form of comparison curves and are divided into four groups. In the first group is shown the way in which the loadings on the wings are affected by changing the decalage, in the second the dihedral, in the third the sweepback, and in the fourth the overhang. From these curves may be determined the magnitude and point of action of the semi-span normal force on each wing for any reasonable decalage, dihedral, sweepback, and overhang and for most of the angles of attack apt to be encountered in flight. Following is a list of comparison curves, all of which are plotted against angle of attack: (The first, second, third, and fourth figure numbers refer to decalage, dihedral, sweepback, and overhang, respectively.)

Figures 3, 12, 21, 30. Normal force coefficient for cellule.

Figures 4, 13, 22, 31. Normal force coefficient for upper wing.

Figures 5, 14, 23, 32. Normal force coefficient for lower wing.

Figures 6, 15, 24, 33. Ratio of load on each wing to load on cellule.

Figures 7, 16, 25, 34. Longitudinal center of pressure for upper wing.

Figures 8, 17, 26, 35. Longitudinal center of pressure for lower wing.

Figures 9, 18, 27, 36. Lateral center of pressure for upper wing.

Figures 10, 19, 28, 37. Lateral center of pressure for lower wing.

In order to show the general nature of the interference effects on two biplane wings, each figure, with the obvious exception of Figures 6, 15, 24 and 33, has superimposed upon it the corresponding monoplane curve for the maximum span wing without dihedral or sweepback.

~~ures 3, 12, 21, and 30, is the mean of the monoplane curves for each wing.~~

The accuracy of the results may be inferred from the fact that the average deviation of the curve points on the figures from a mean value was within plus or minus two per cent. This was determined from check tests, fairings, and integrations.

In interpreting the results of this wind tunnel investigation, the low Reynolds Number of the tests (150,000) and the fact that the results have not been corrected for tunnel wall effects should be kept in mind. While scale effect will doubtless change the absolute value of the coefficients, the relative changes produced by decalage, dihedral, sweepback, and overhang variations will probably hold for Reynolds Numbers greater than that of the tests.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., August 8, 1929.

Reference

Knight, Montgomery and Noyes, Richard W.: Wind Tunnel Pressure Distribution Tests on a Series of Biplane Wing Models. Part I. Effects of Changes in Stagger and Gap. N.A.C.A. Technical Note No. 310, 1929.

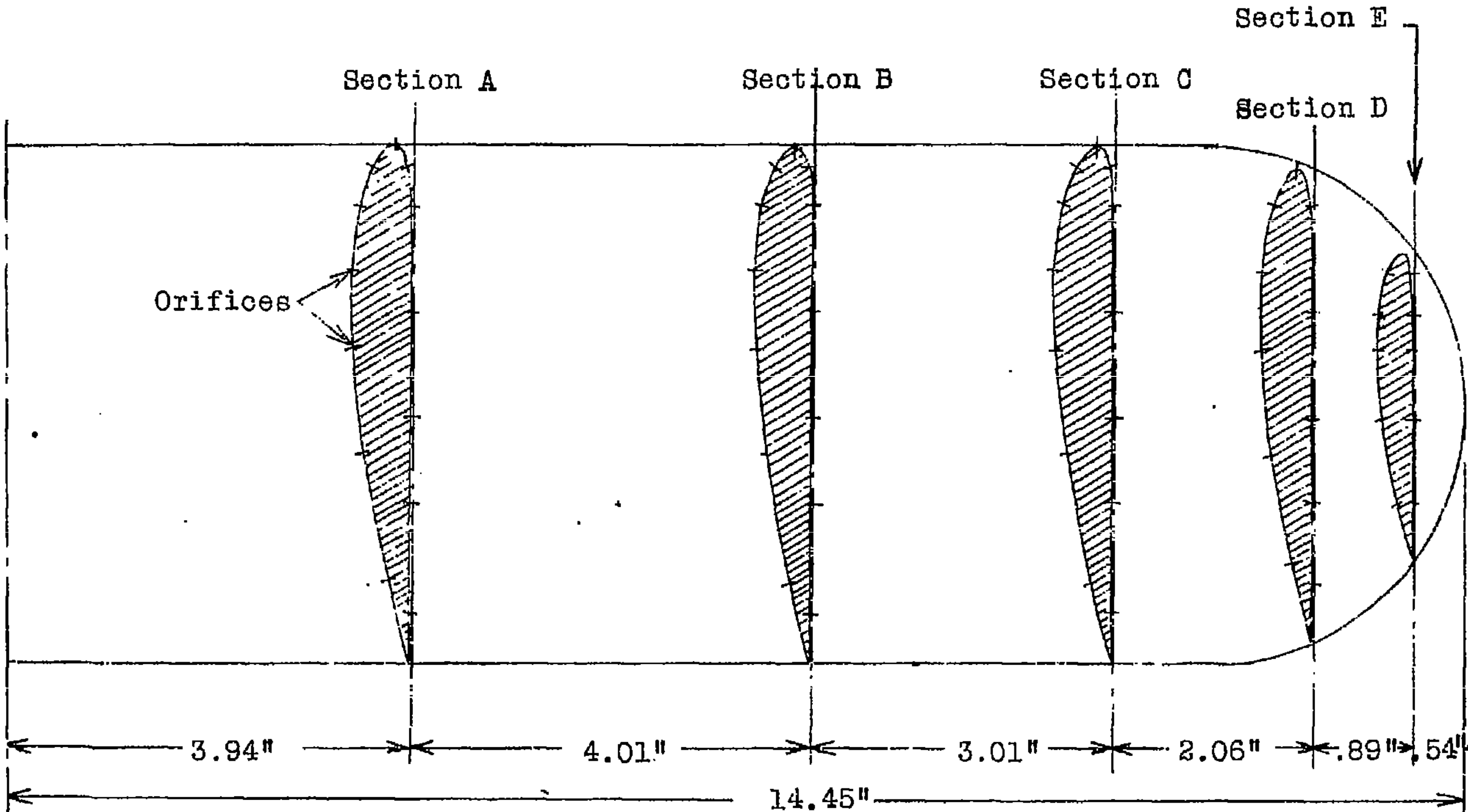


Fig.1 Wing showing orifice locations

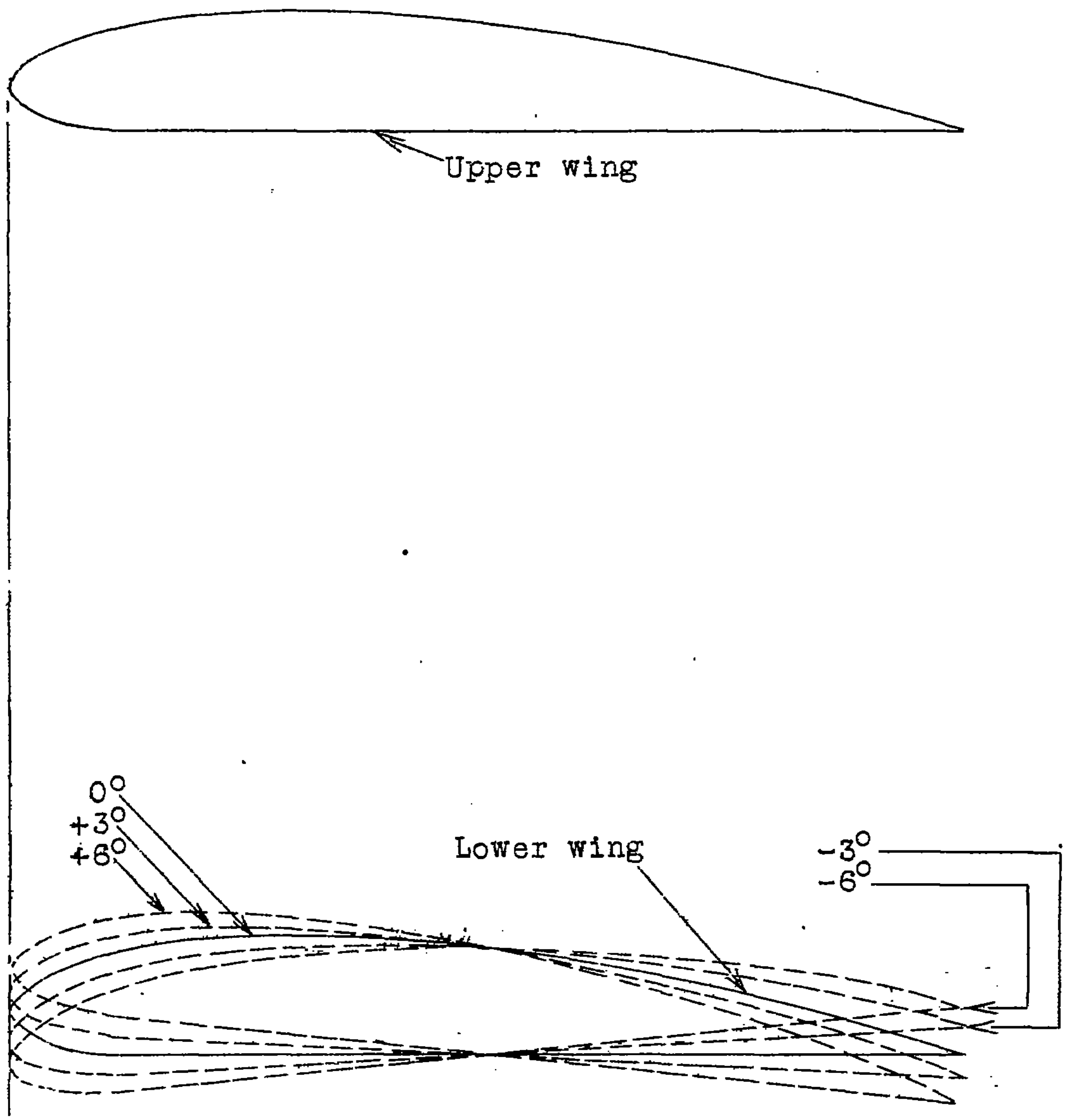


Fig.2 Wing model arrangements used in tests on the effect of variation in decalage

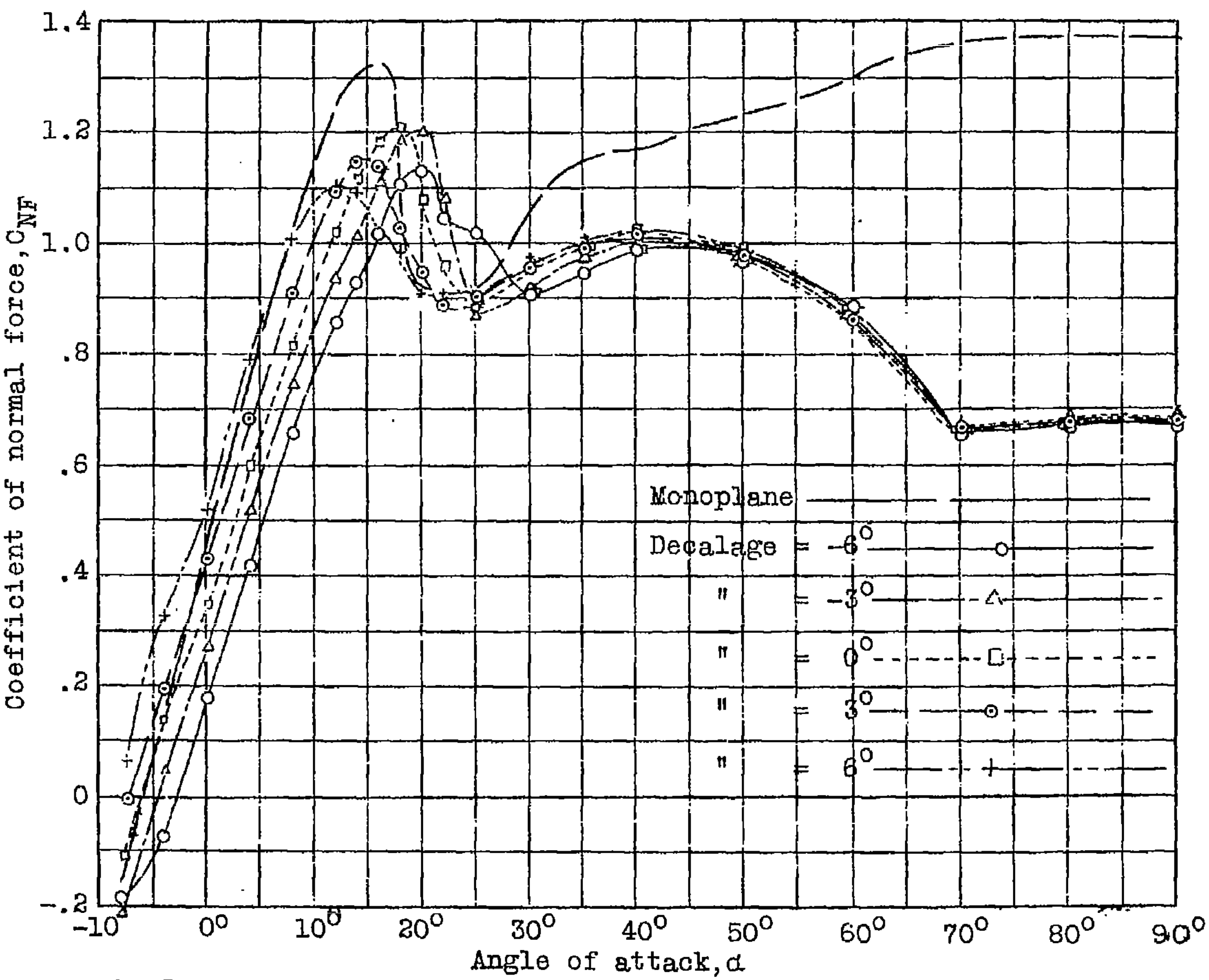


Fig. 3 Effect of decalage on cellule coefficient of normal force.

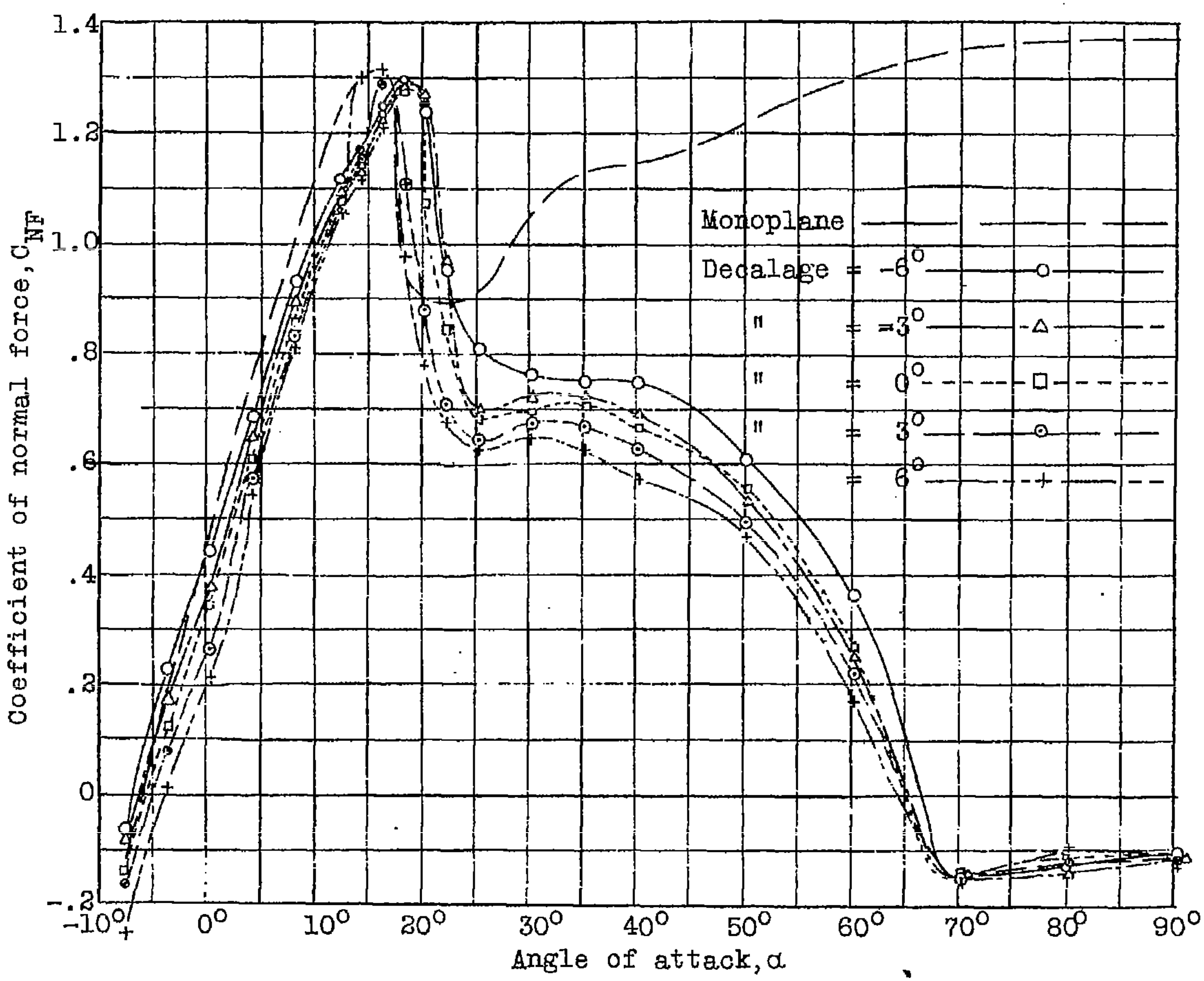


Fig.4 Effect of decalage on upper wing coefficient of normal force.

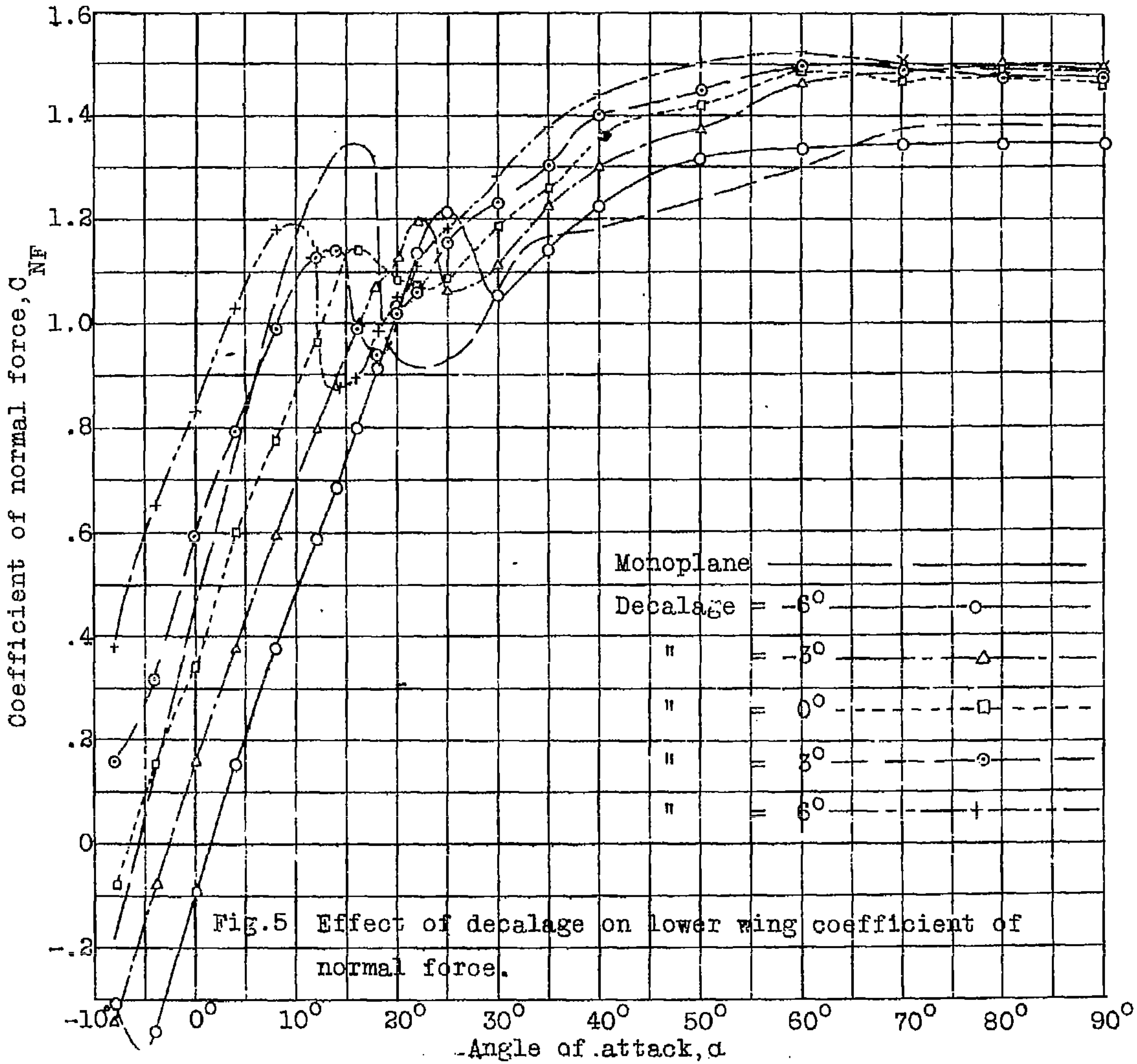


Fig. 5 Effect of decalage on lower wing coefficient of normal force.

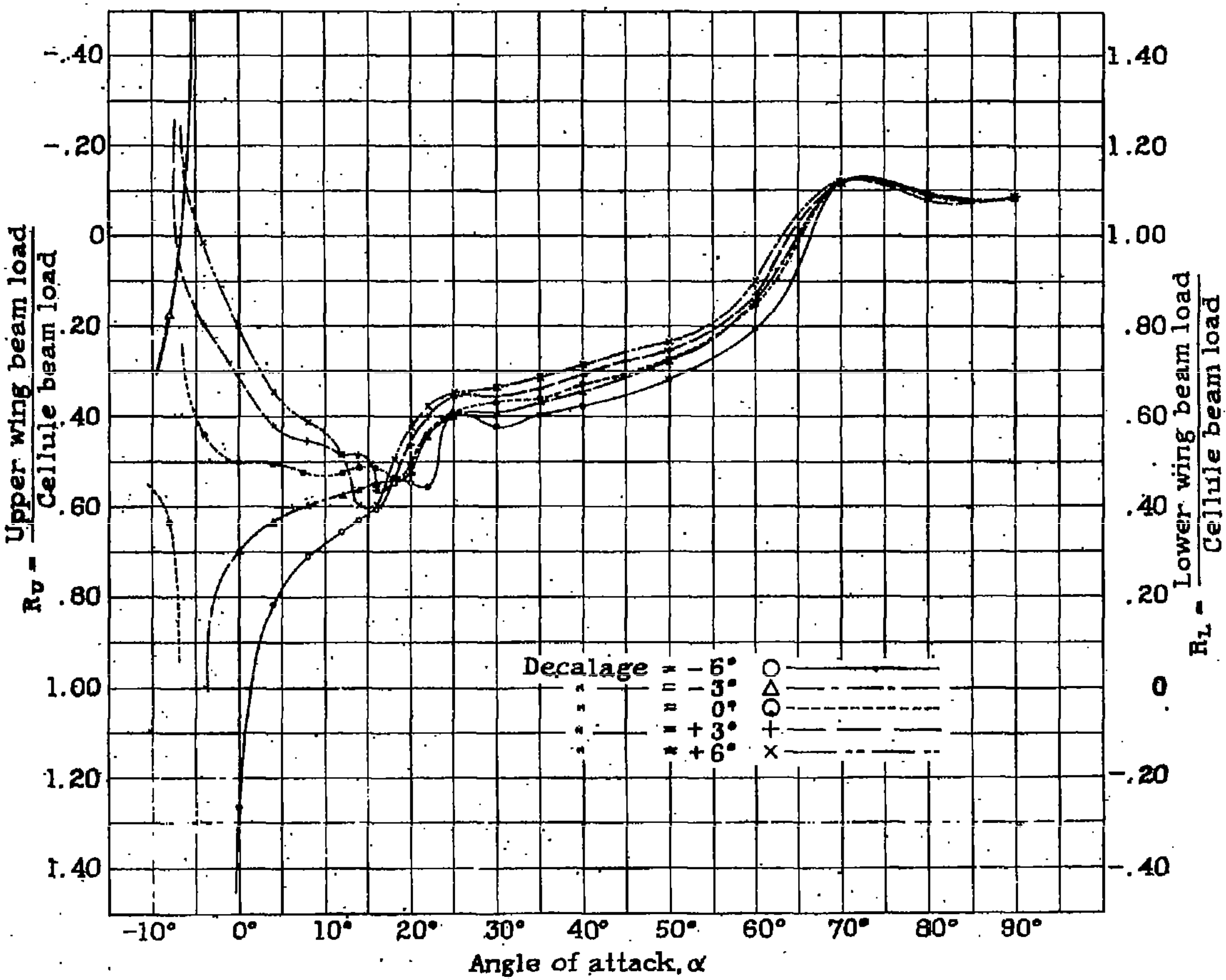


Fig. 6 Effect of decalage on wing load ratio.

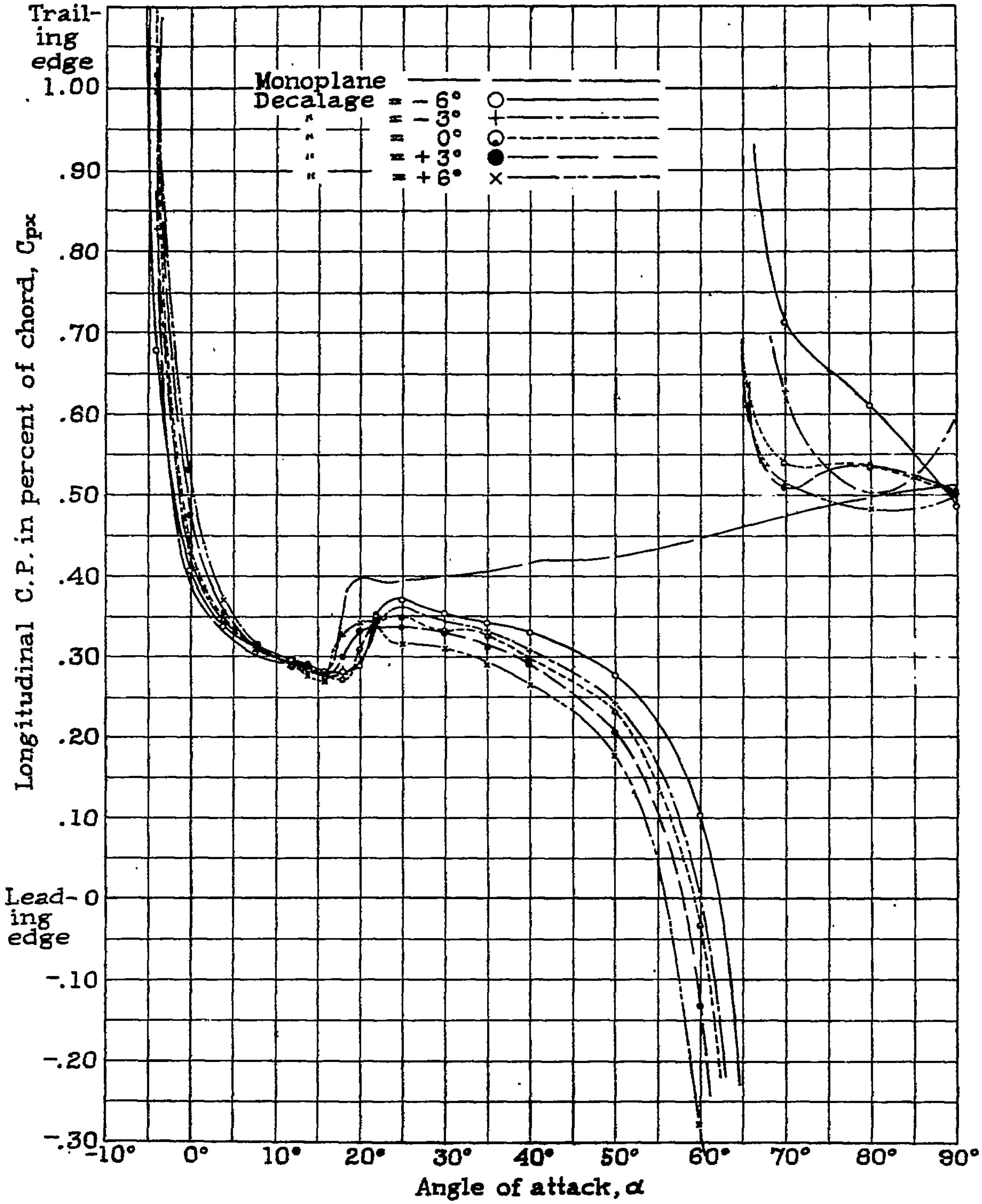


Fig. 7 Effect of decalage on upper wing longitudinal center of pressure.

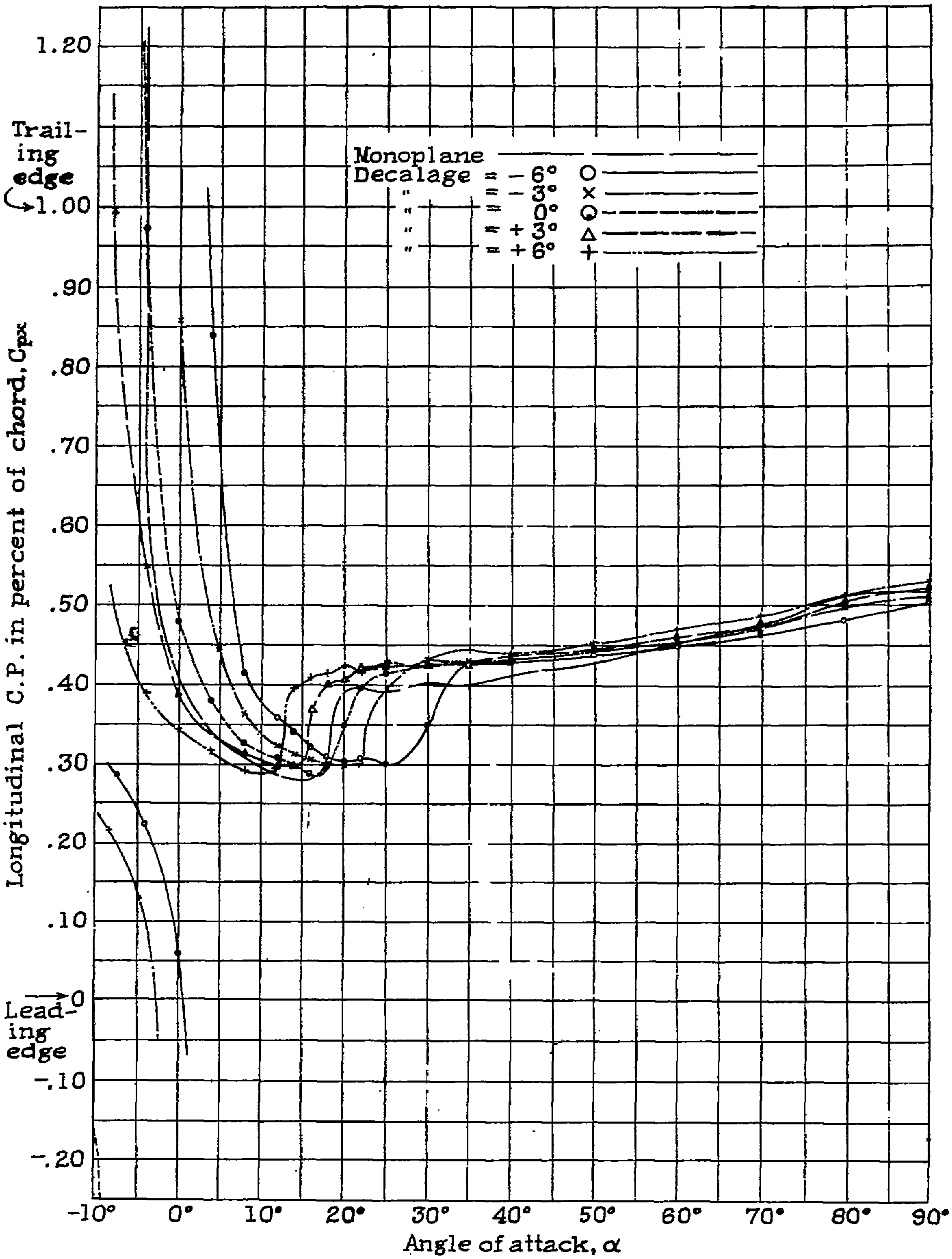


Fig. 8 Effect of decalage on lower wing longitudinal center of pressure.

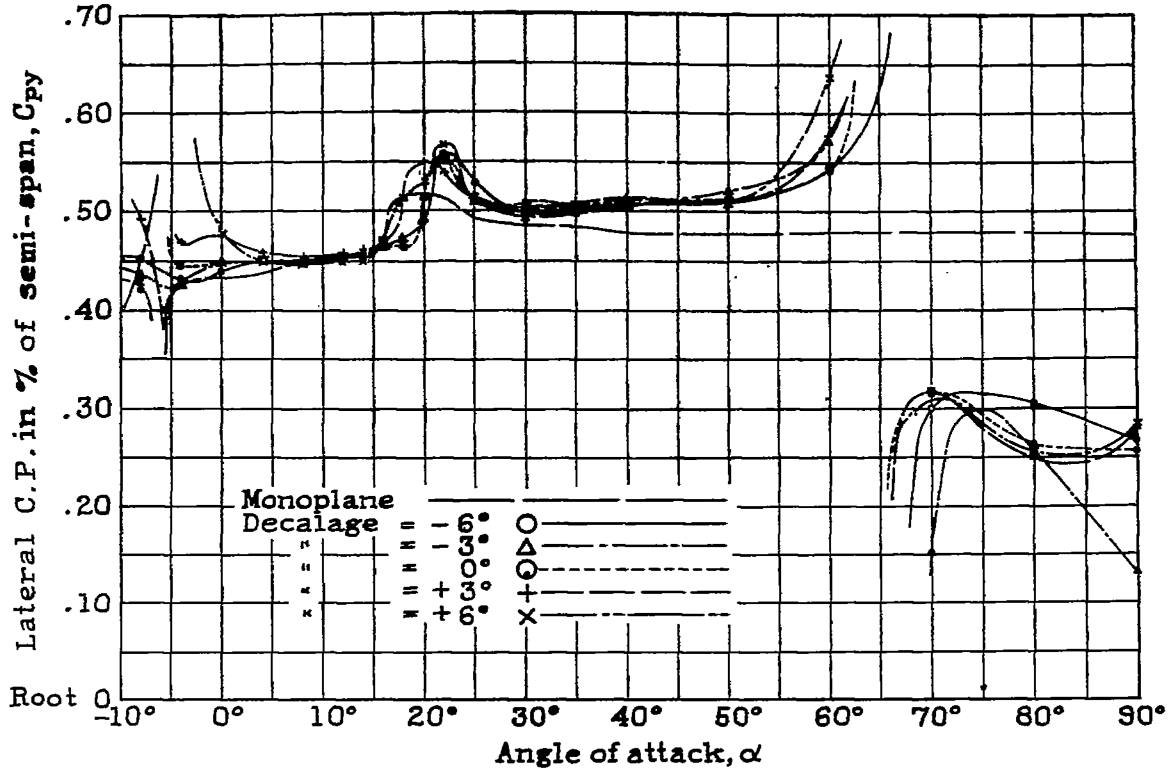


Fig. 9 Effect of decalage on upper wing lateral center of pressure.

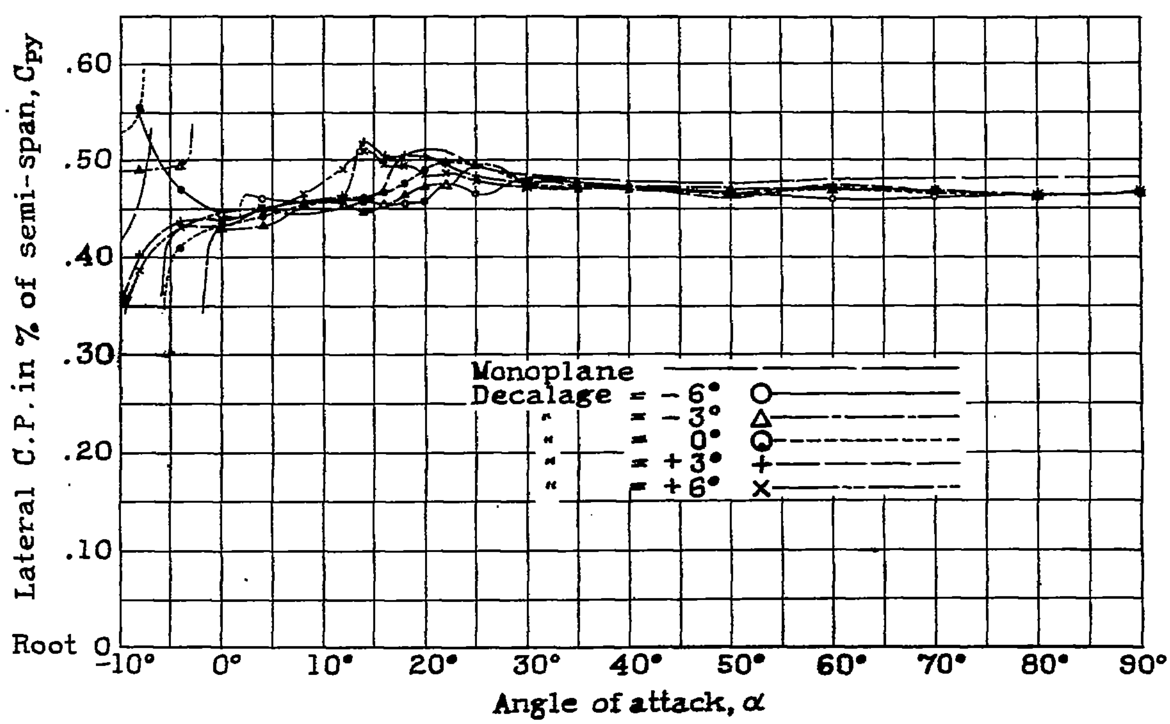
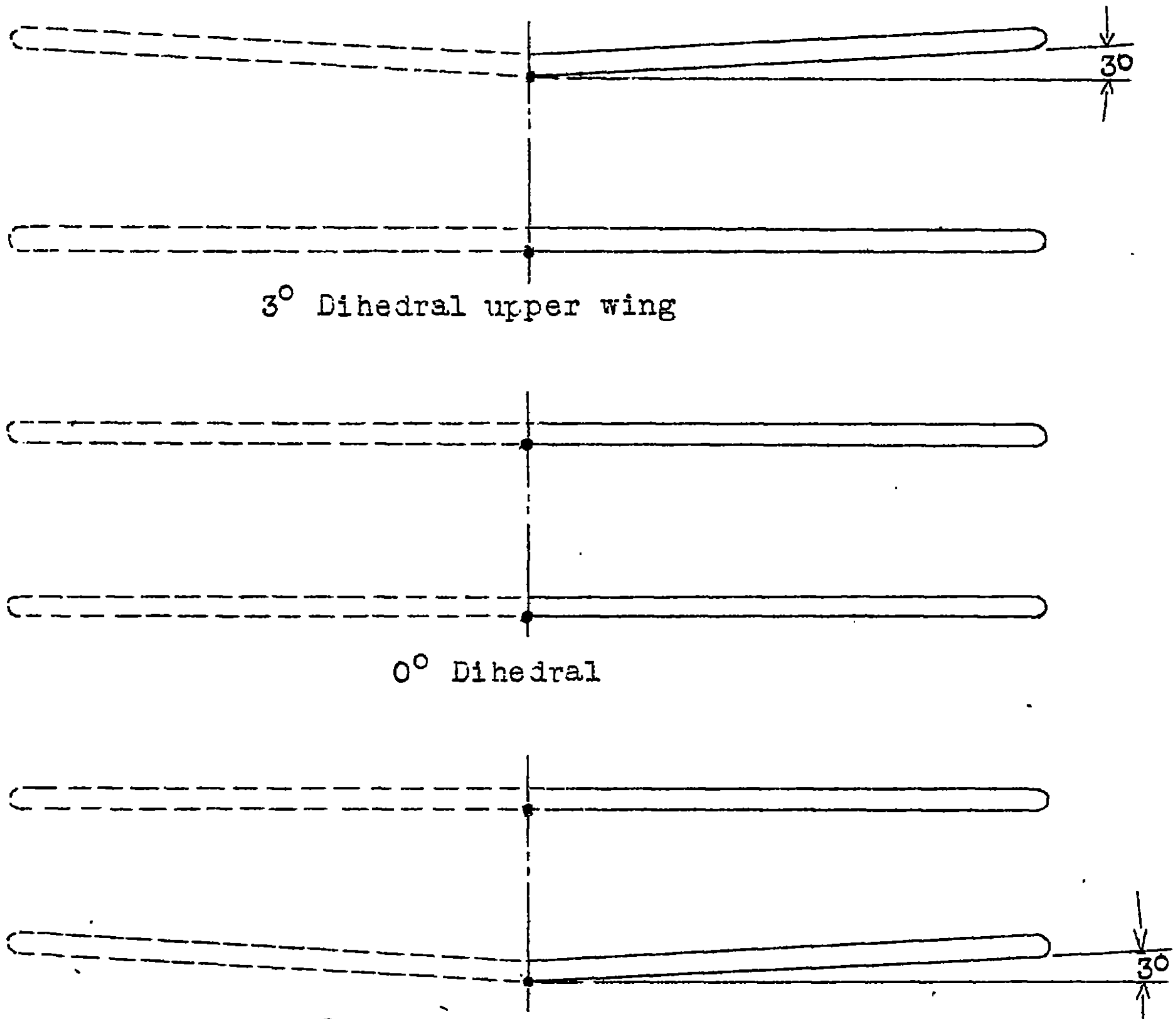


Fig. 10 Effect of decalage on lower wing lateral center of pressure.



3° Dihedral upper wing

0° Dihedral

3° Dihedral lower wing

Fig.11 Wing model arrangements used in tests on the effect of variation in dihedral.

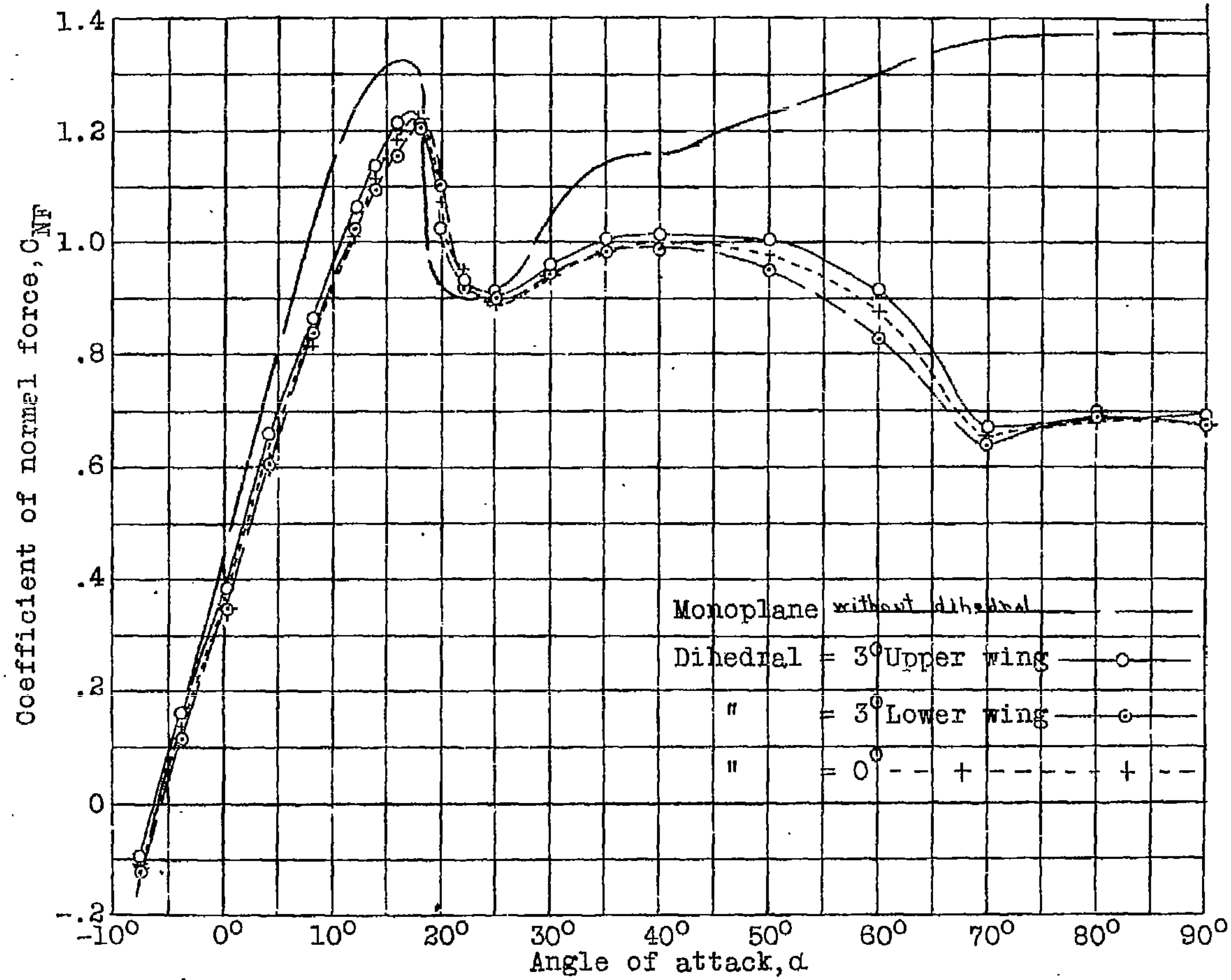


Fig.12 Effect of dihedral on cellule coefficient of normal force.

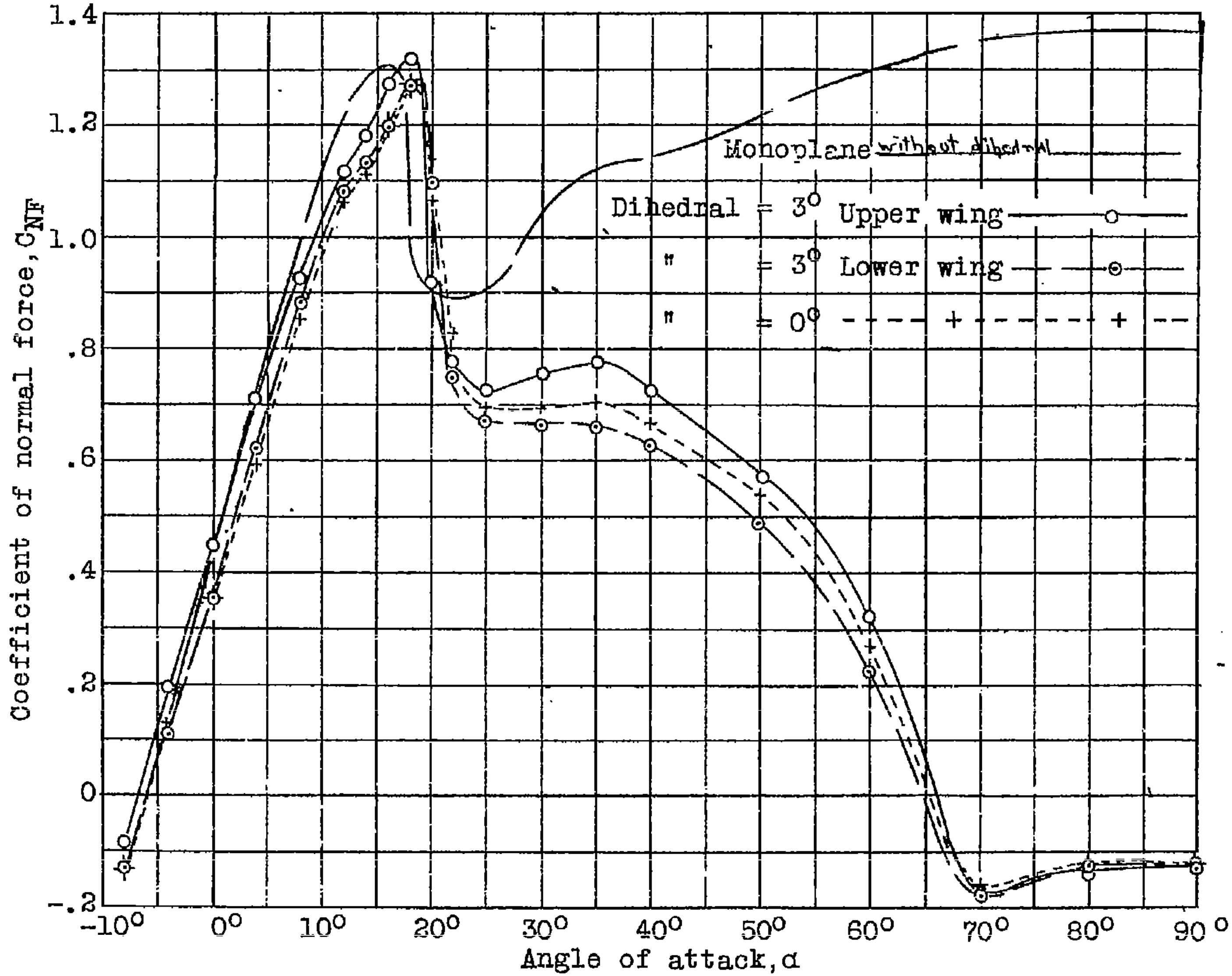


Fig.13 Effect of dihedral on upper wing coefficient of normal force.

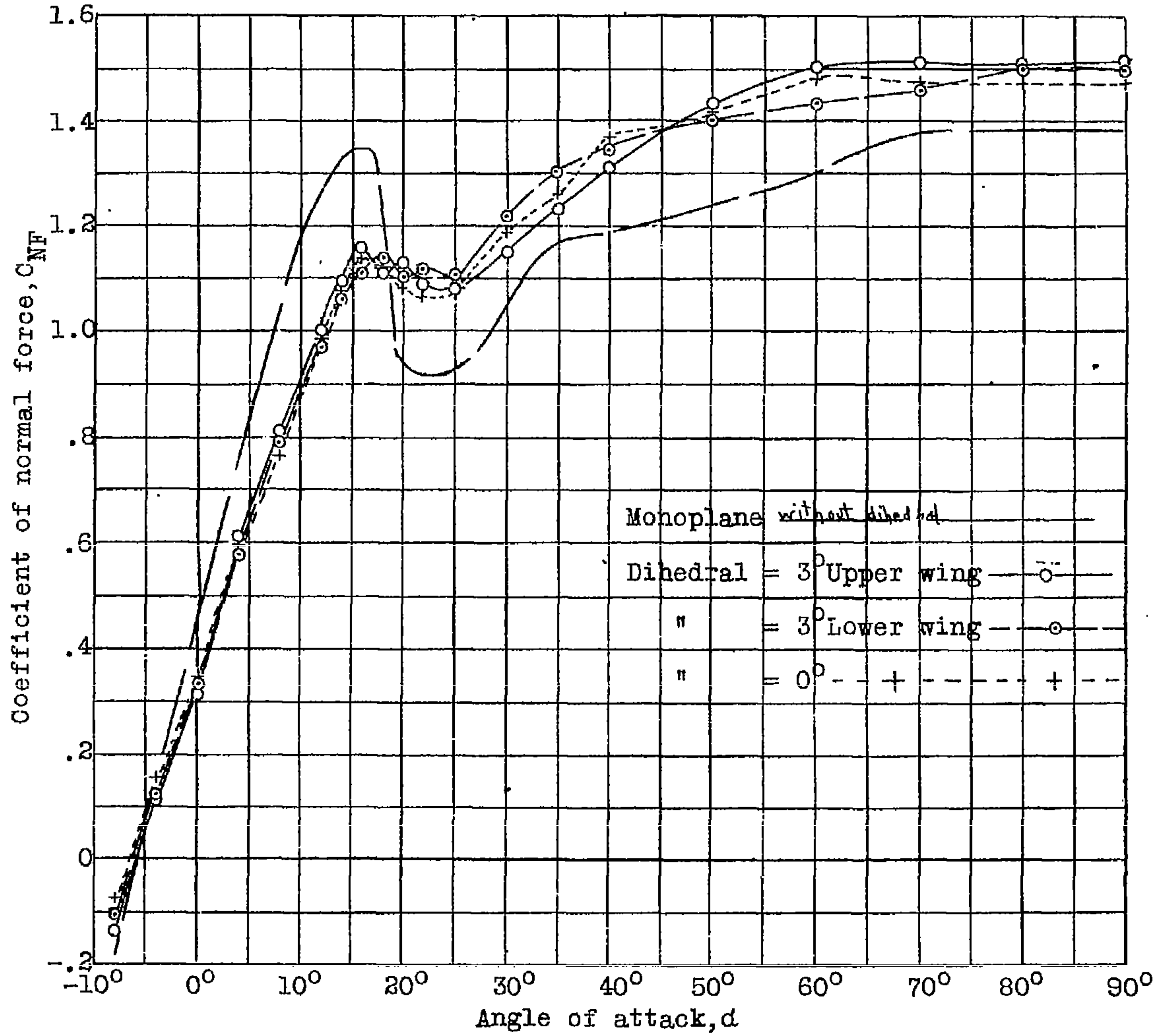


Fig.14 Effect of dihedral on lower wing coefficient of normal force,

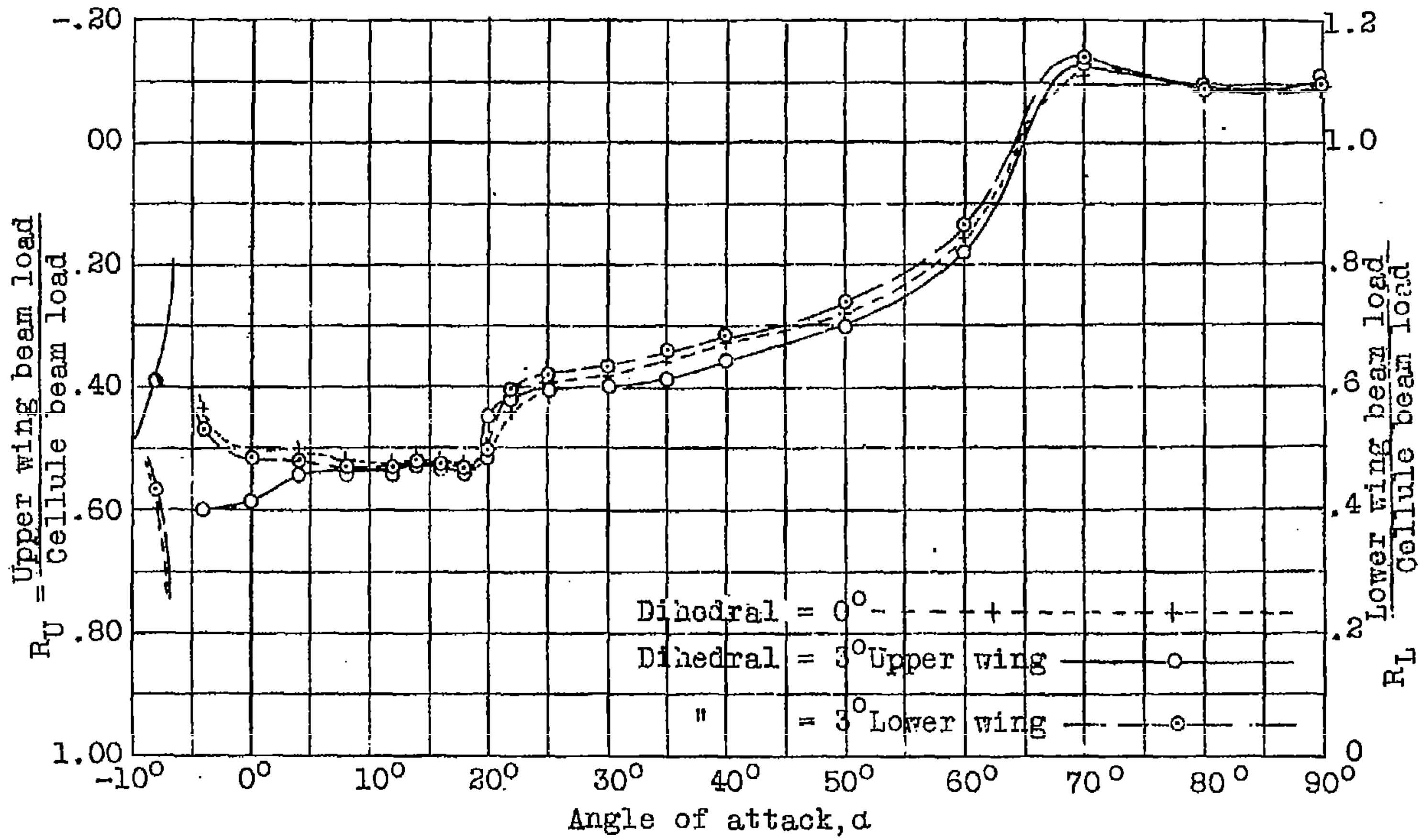


Fig.15 Effect of dihedral on wing load ratio.

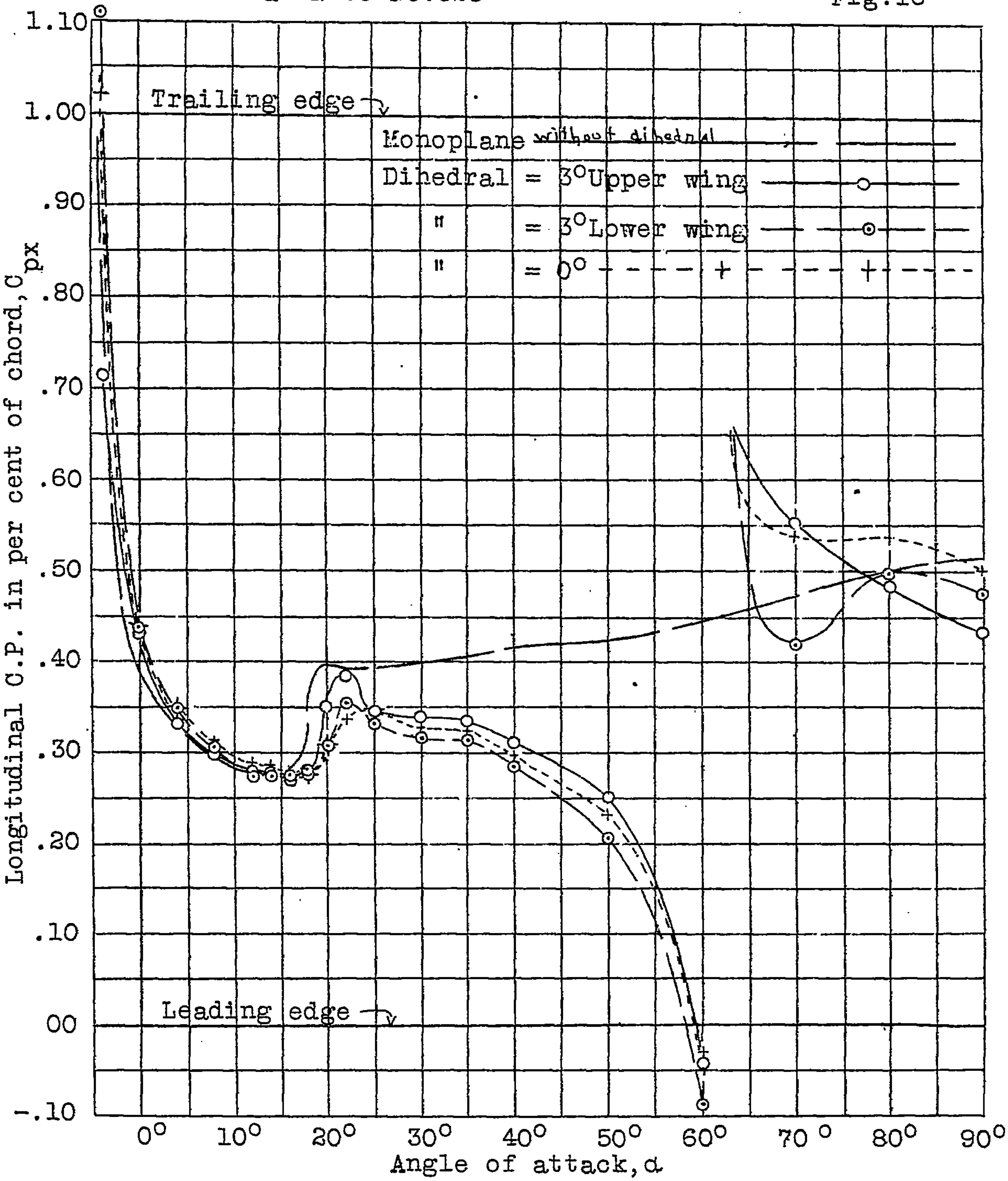


Fig.16 Effect of dihedral on upper wing longitudinal center of pressure.

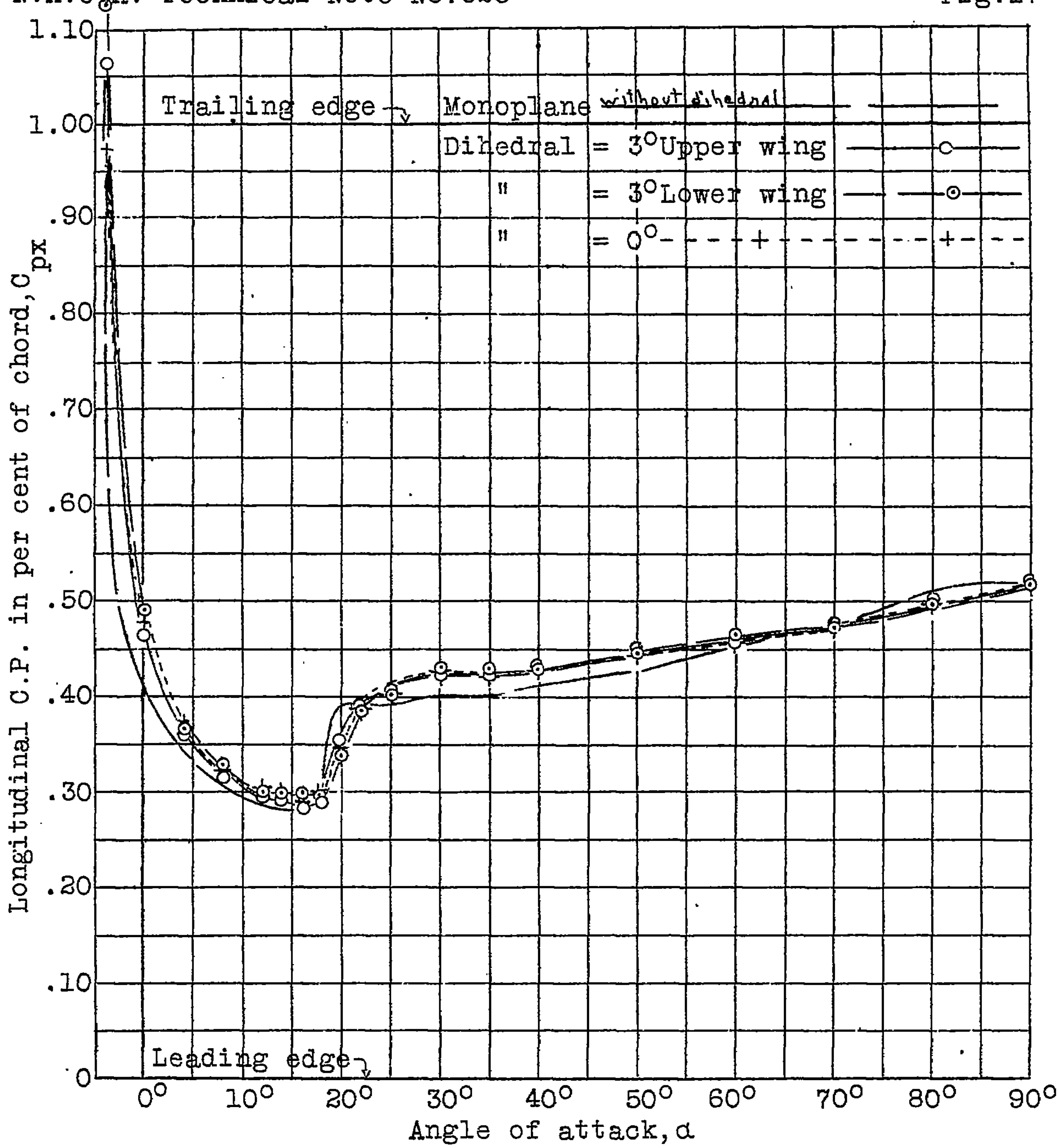


Fig.17 Effect of dihedral on lower wing longitudinal center of pressure.

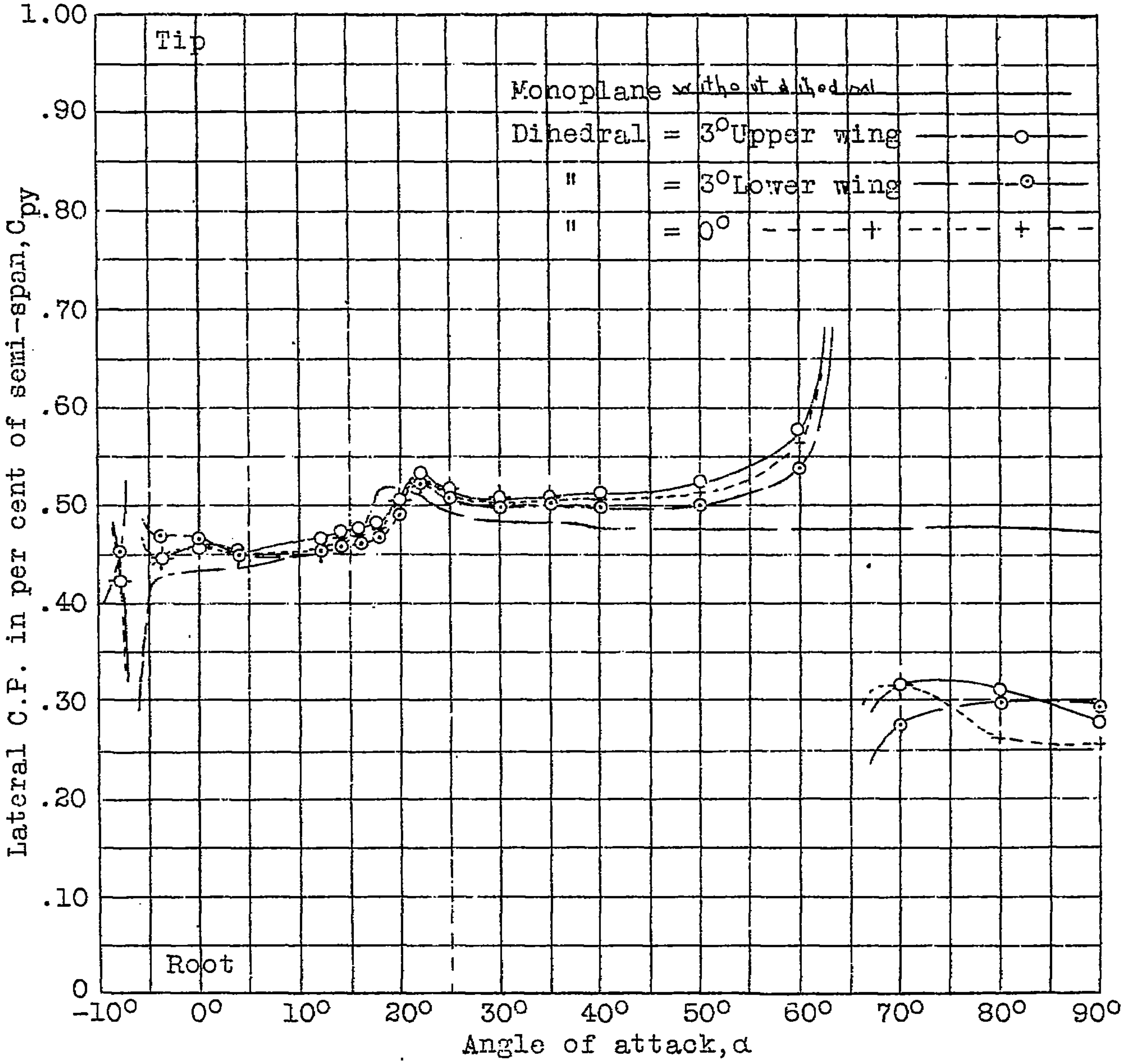


Fig.18 Effect of dihedral on upper wing lateral center of pressure.

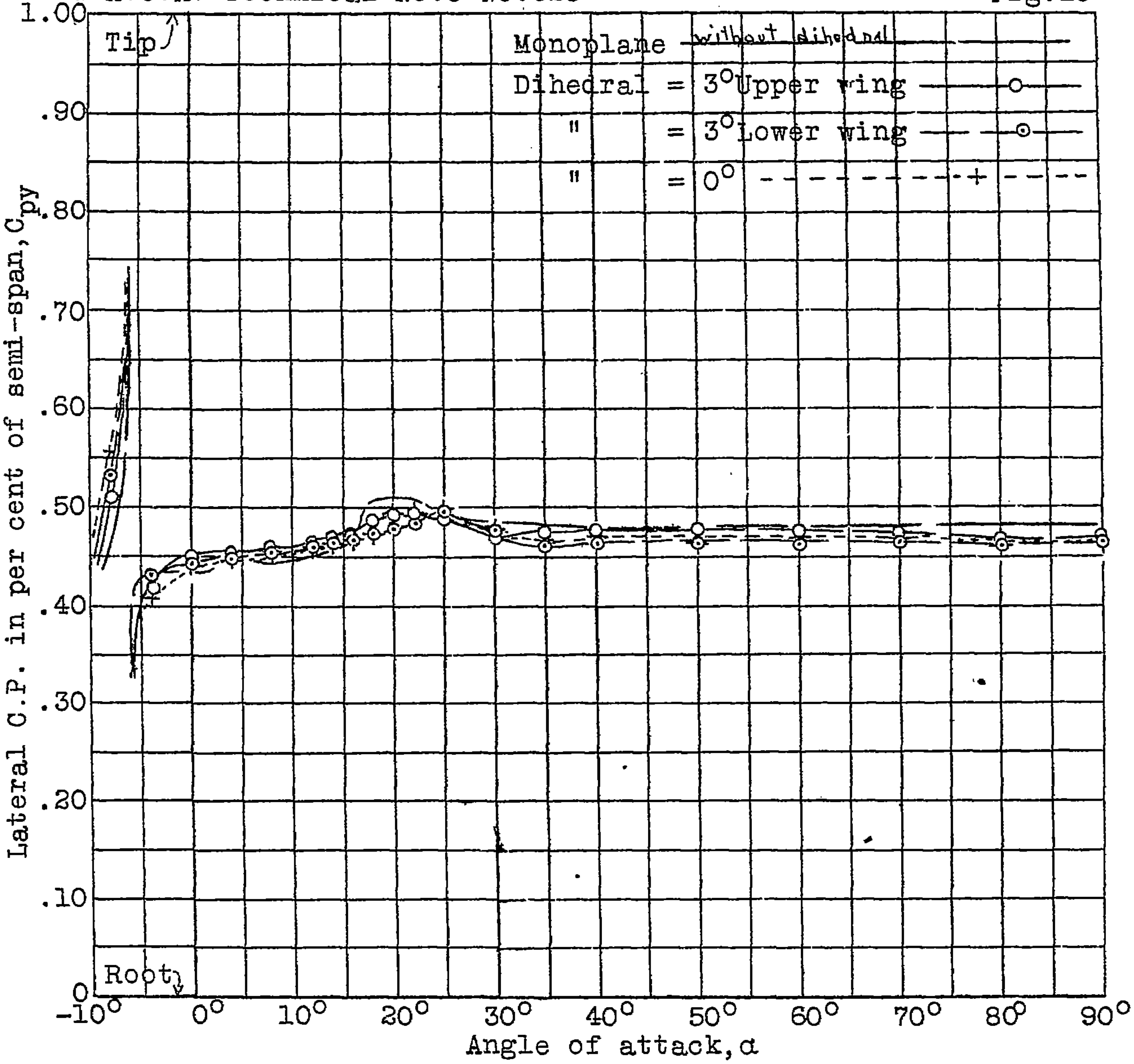


Fig.19 Effect of dihedral on lower wing lateral center of pressure.

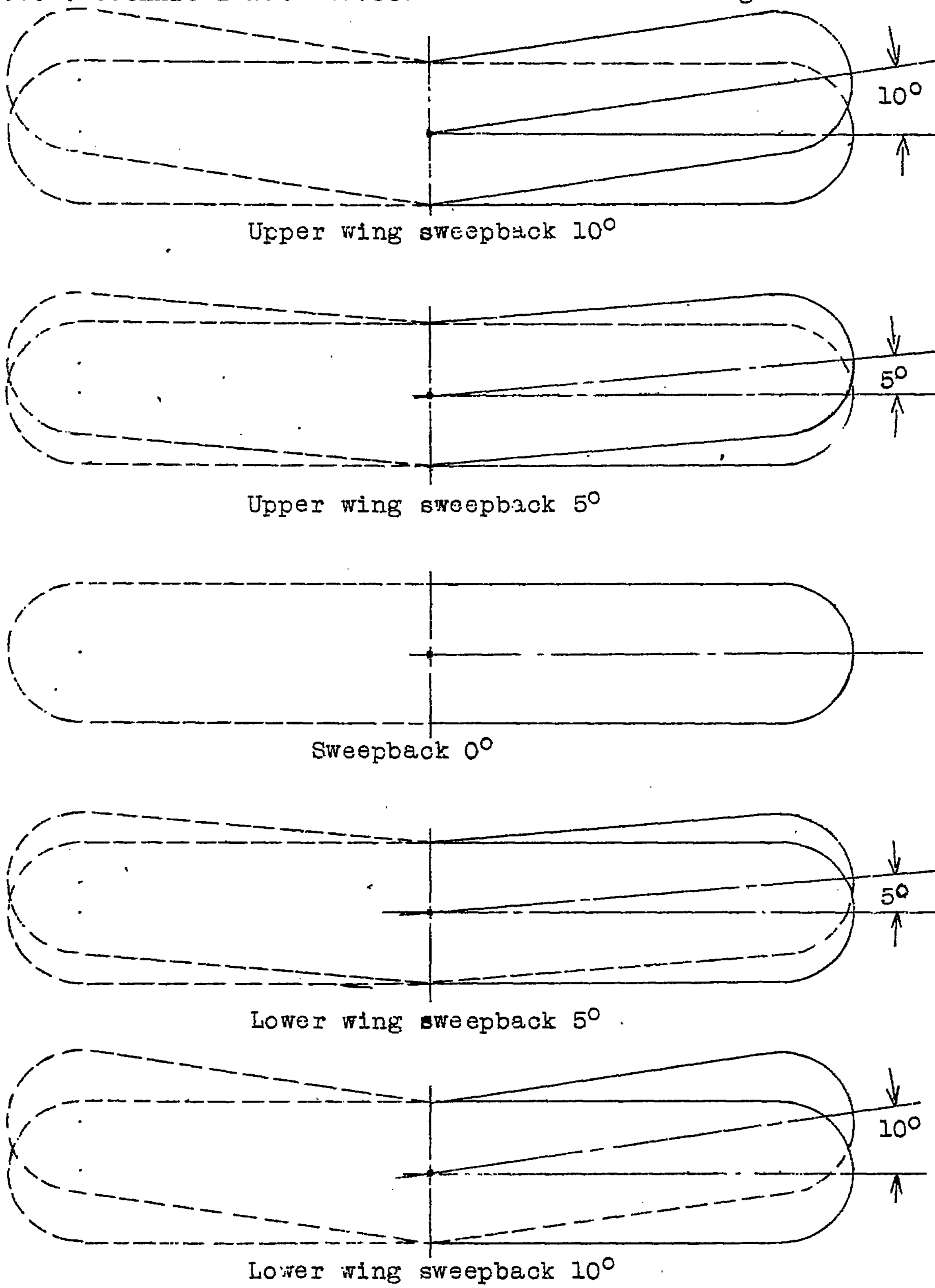


Fig.20 Wing model arrangements used in tests on effect of variations in sweepback.

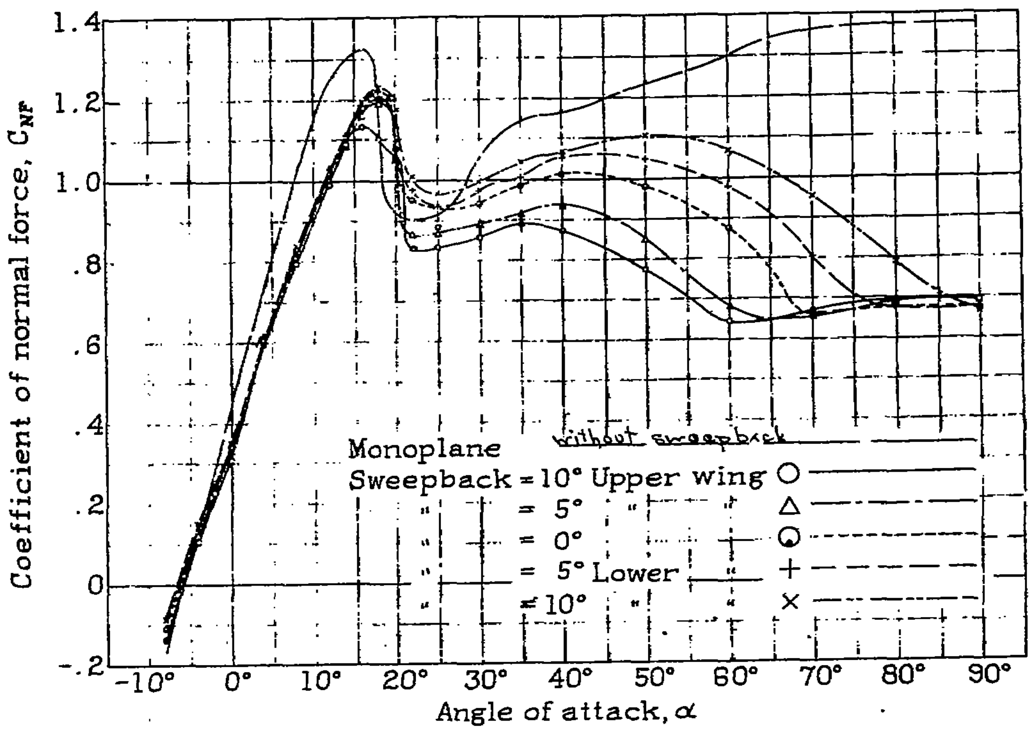


Fig. 21 Effect of sweepback on cellule coefficient of normal force.

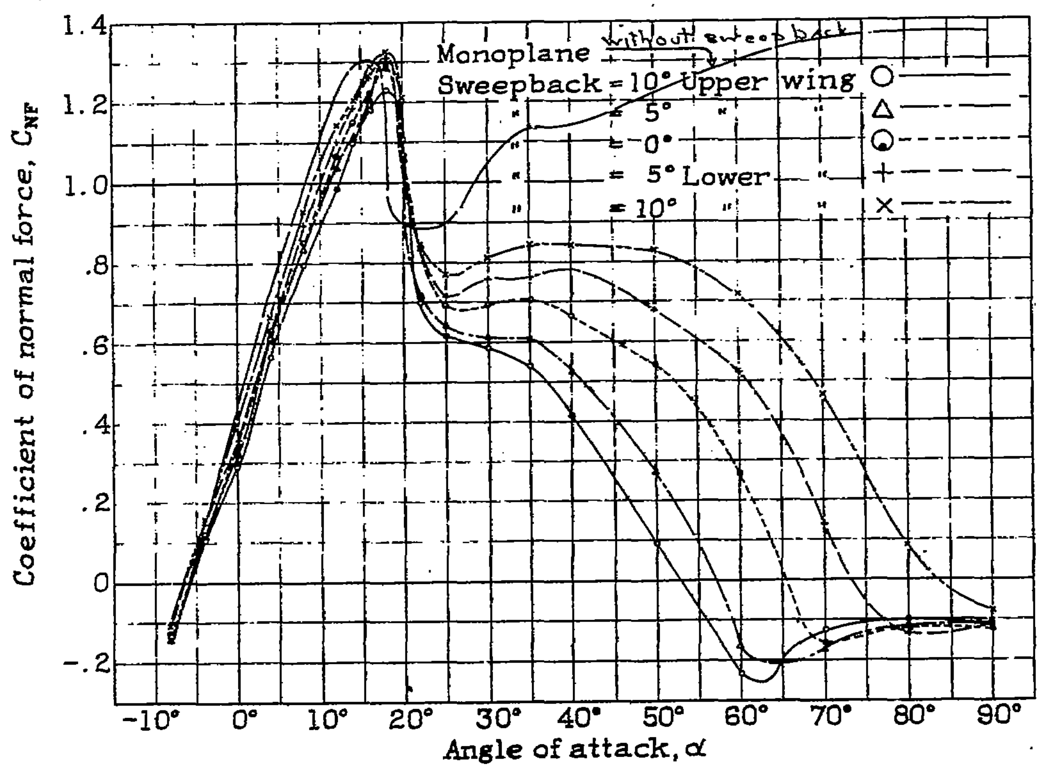


Fig. 22 Effect of sweepback on upper wing coefficient of normal force.

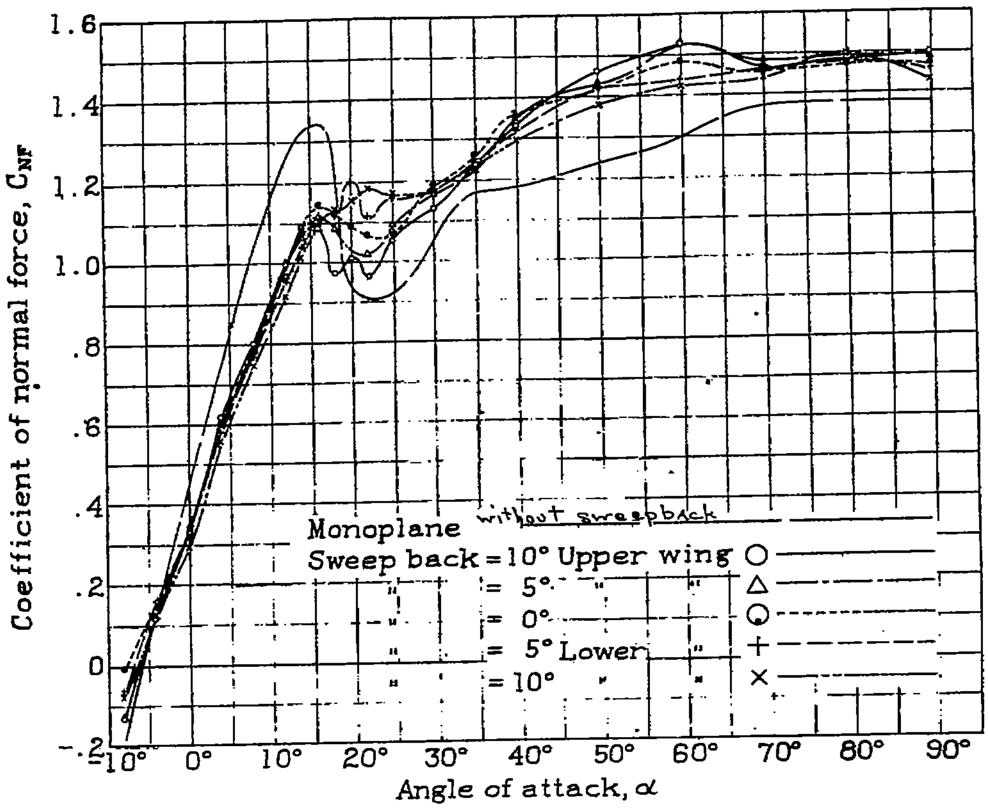


Fig.23 Effect of sweepback on lower wing coefficient of normal force.

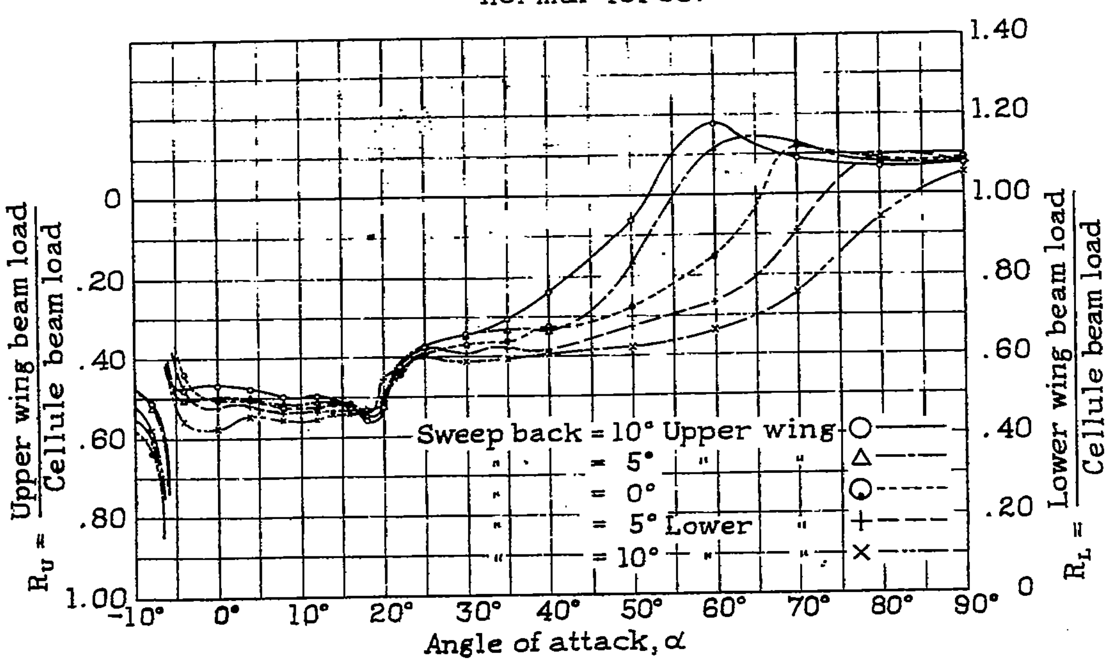


Fig. 24 Effect of sweepback on wing load ratio.

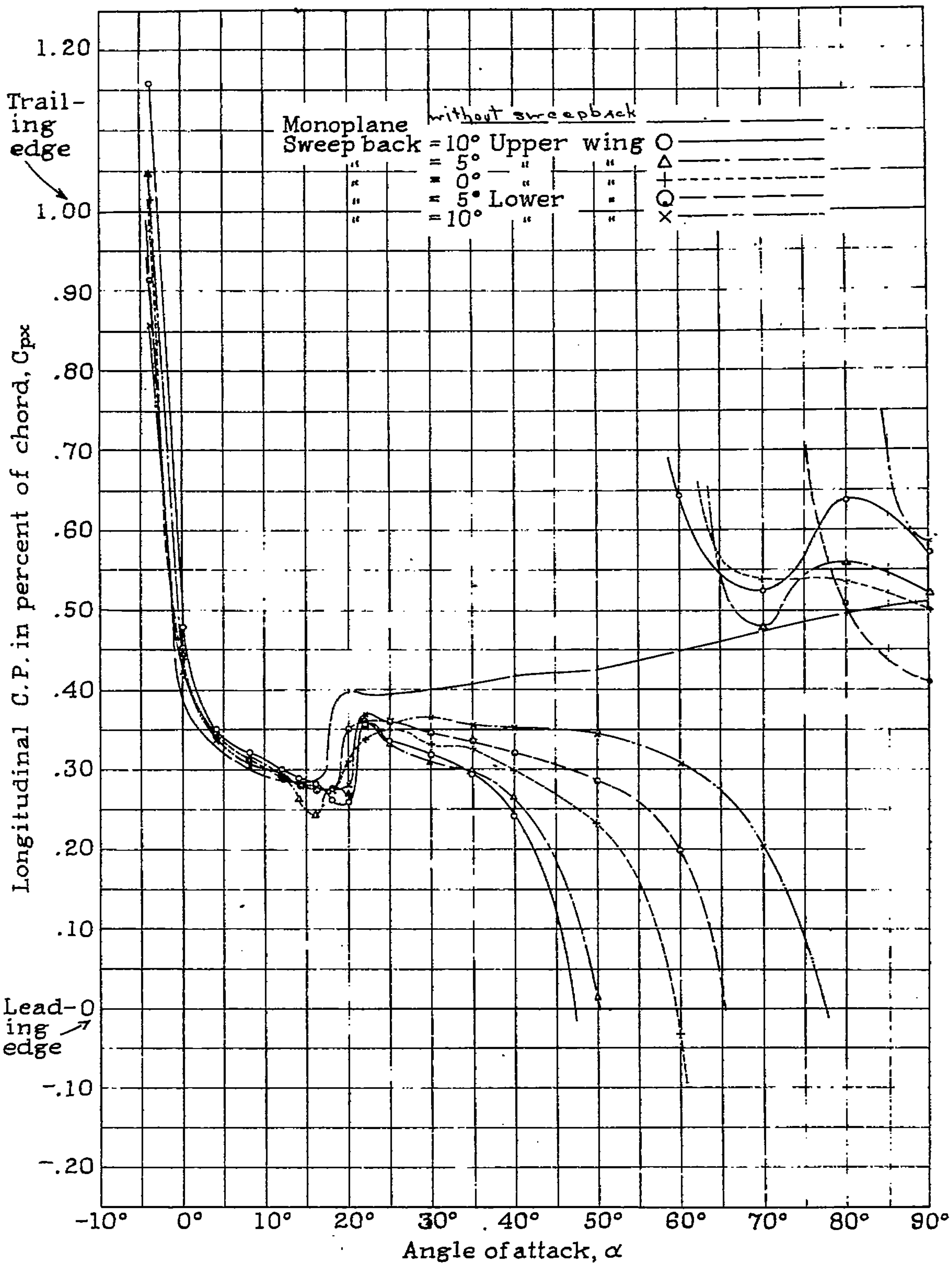


Fig. 25 Effect of sweep back on upper wing longitudinal center of pressure.

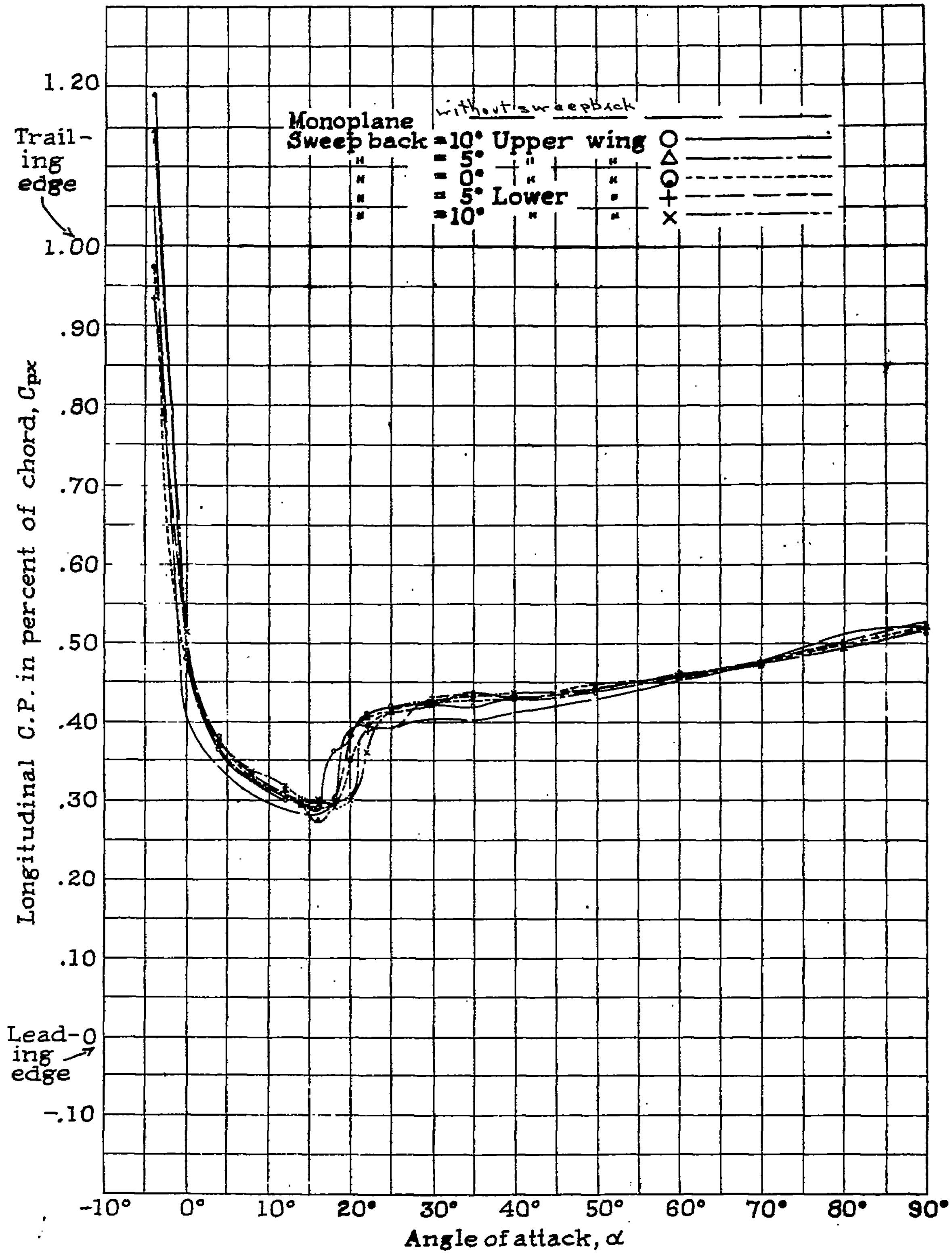


Fig. 26 Effect of sweepback on lower wing longitudinal center of pressure.

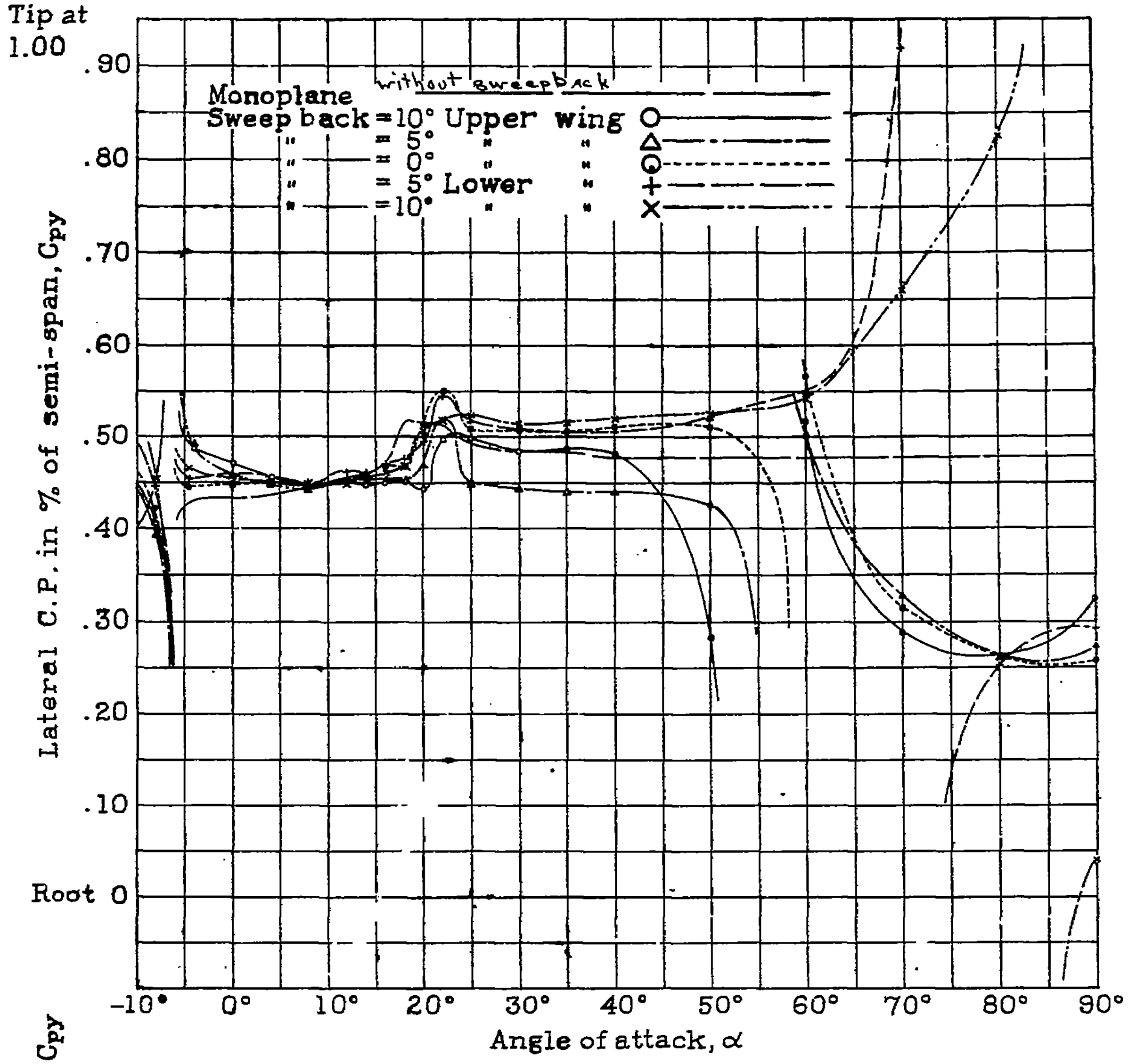


Fig. 27 Effect of sweep back on upper wing lateral center of pressure.

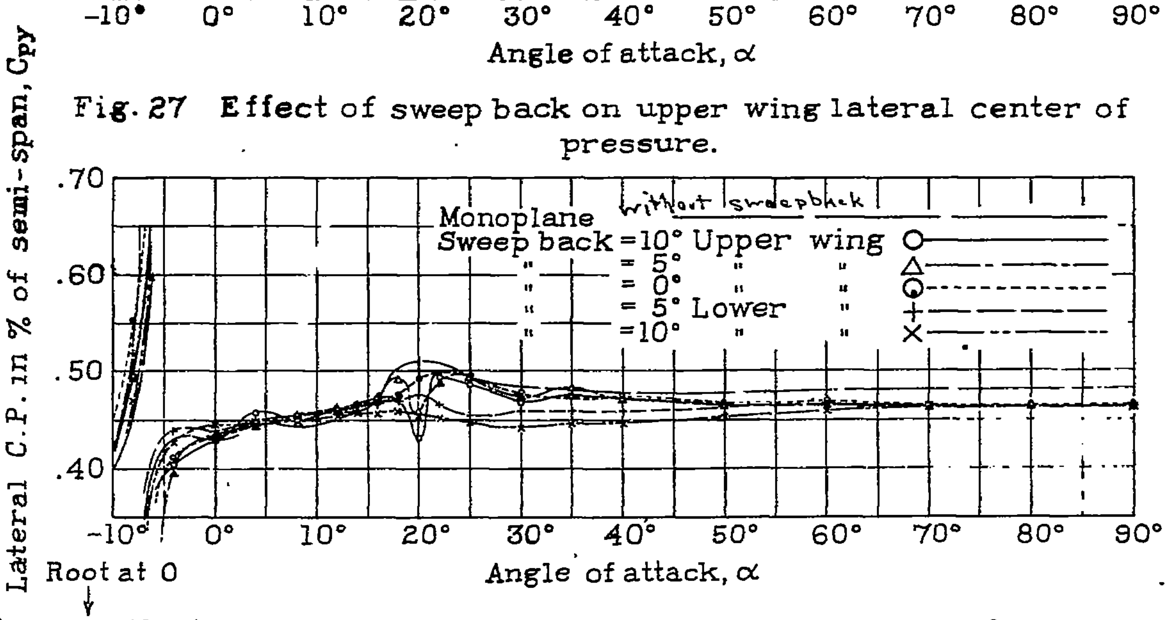


Fig. 28 Effect of sweep back on lower wing lateral center of pressure.

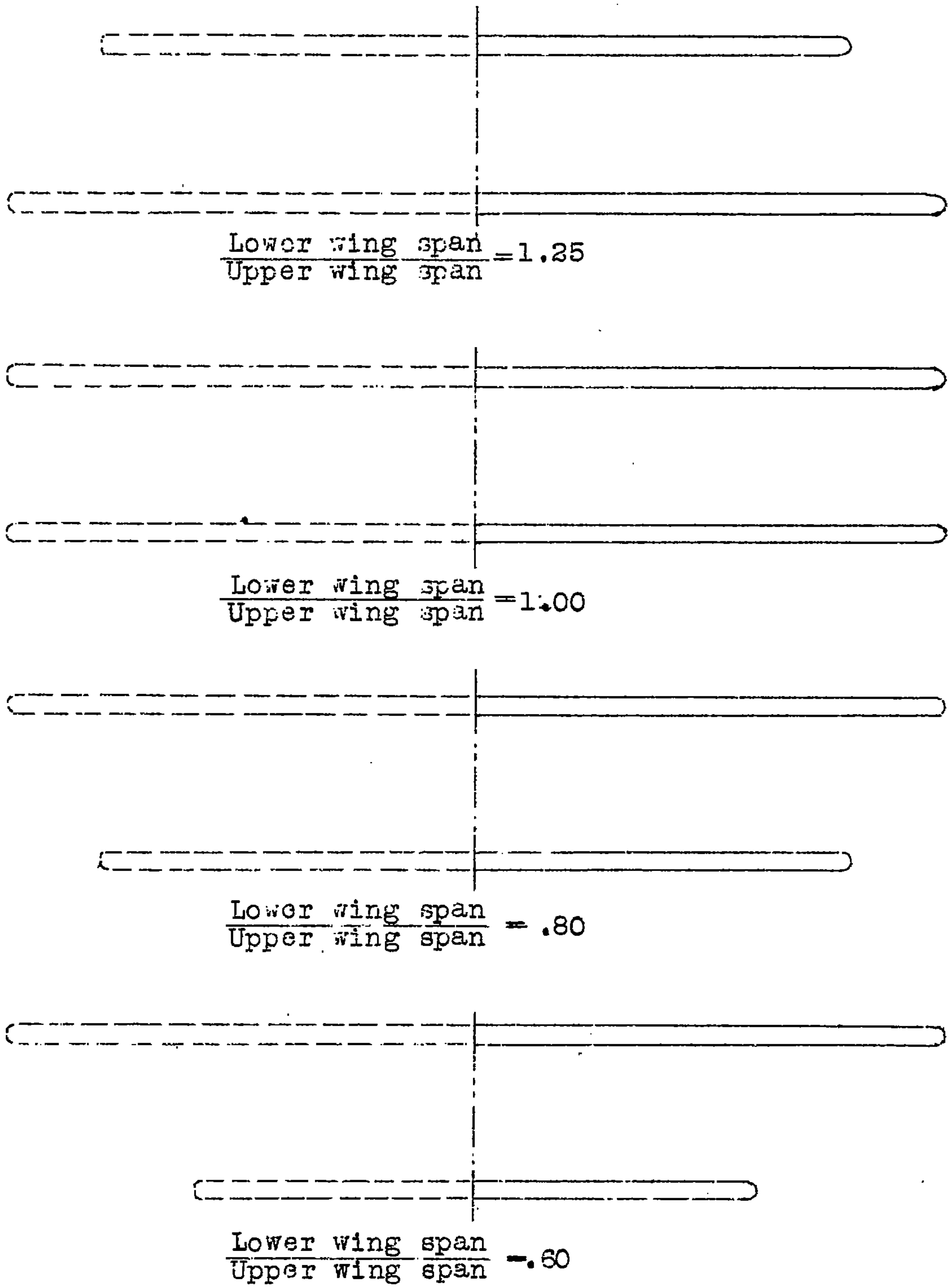


Fig.29 Wing model arrangements used in tests on the effect of variation in overhang.

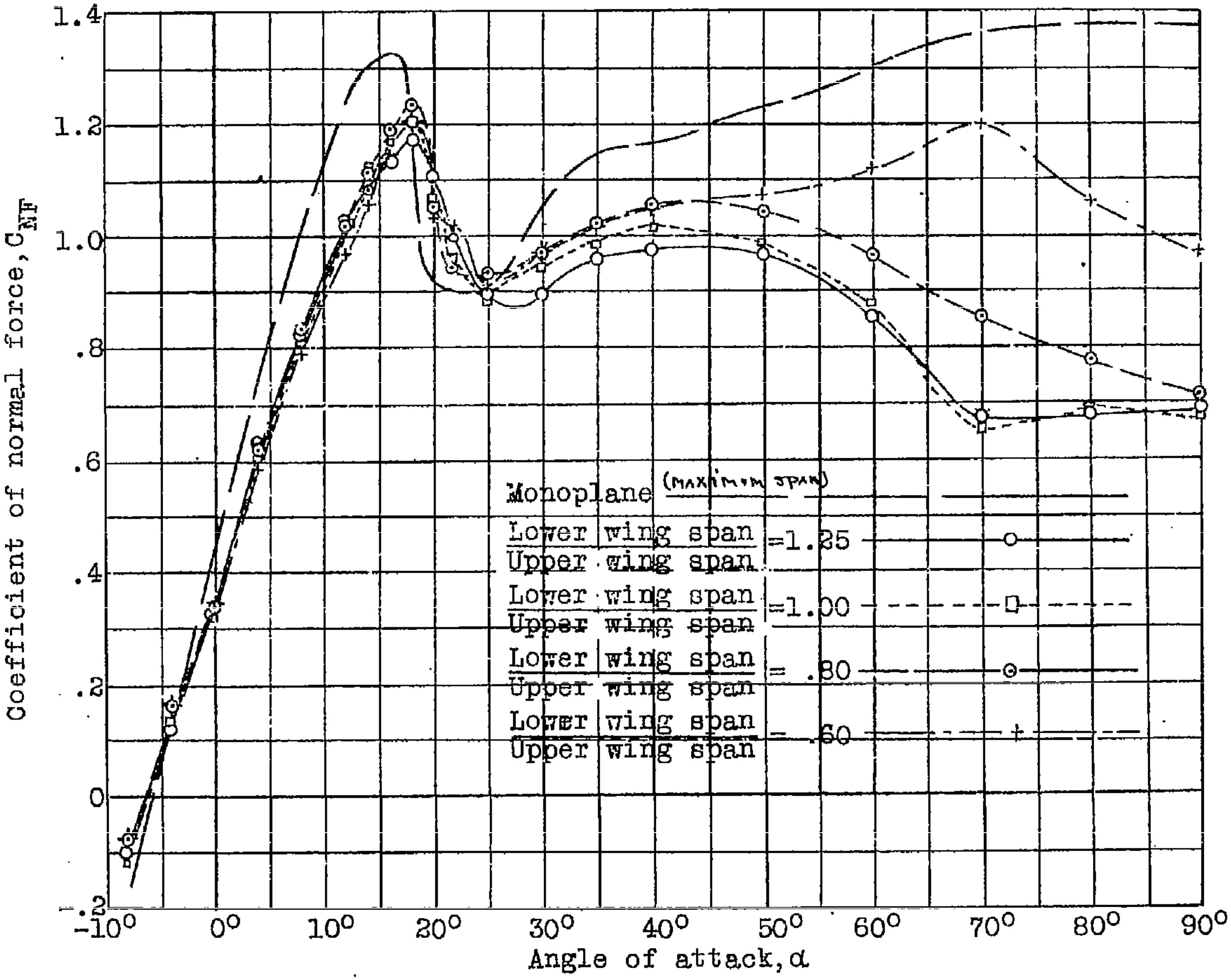


Fig.30 Effect of overhang on cellule coefficient of normal force.

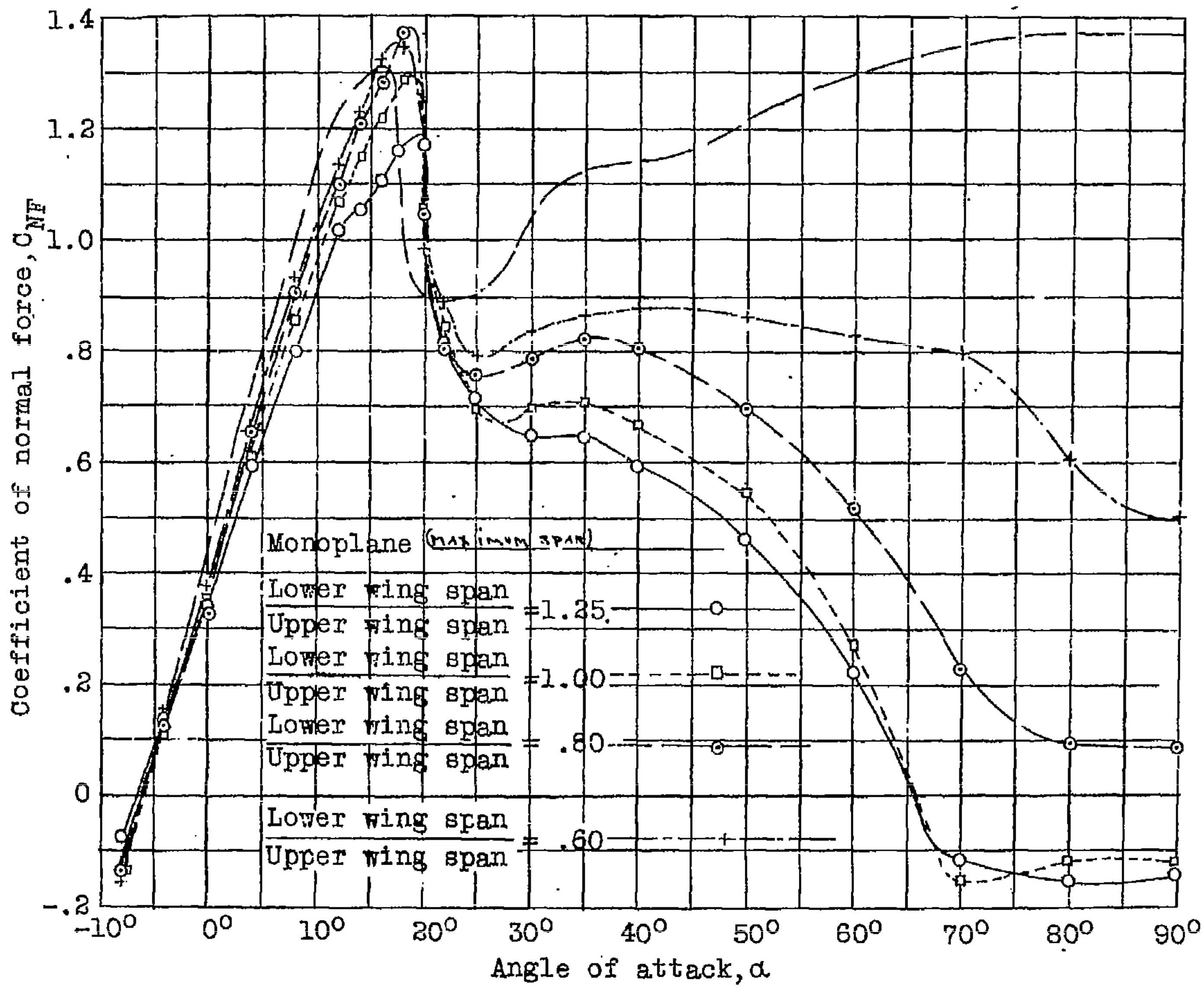


Fig.31 Effect of overhang on upper wing coefficient of normal force.

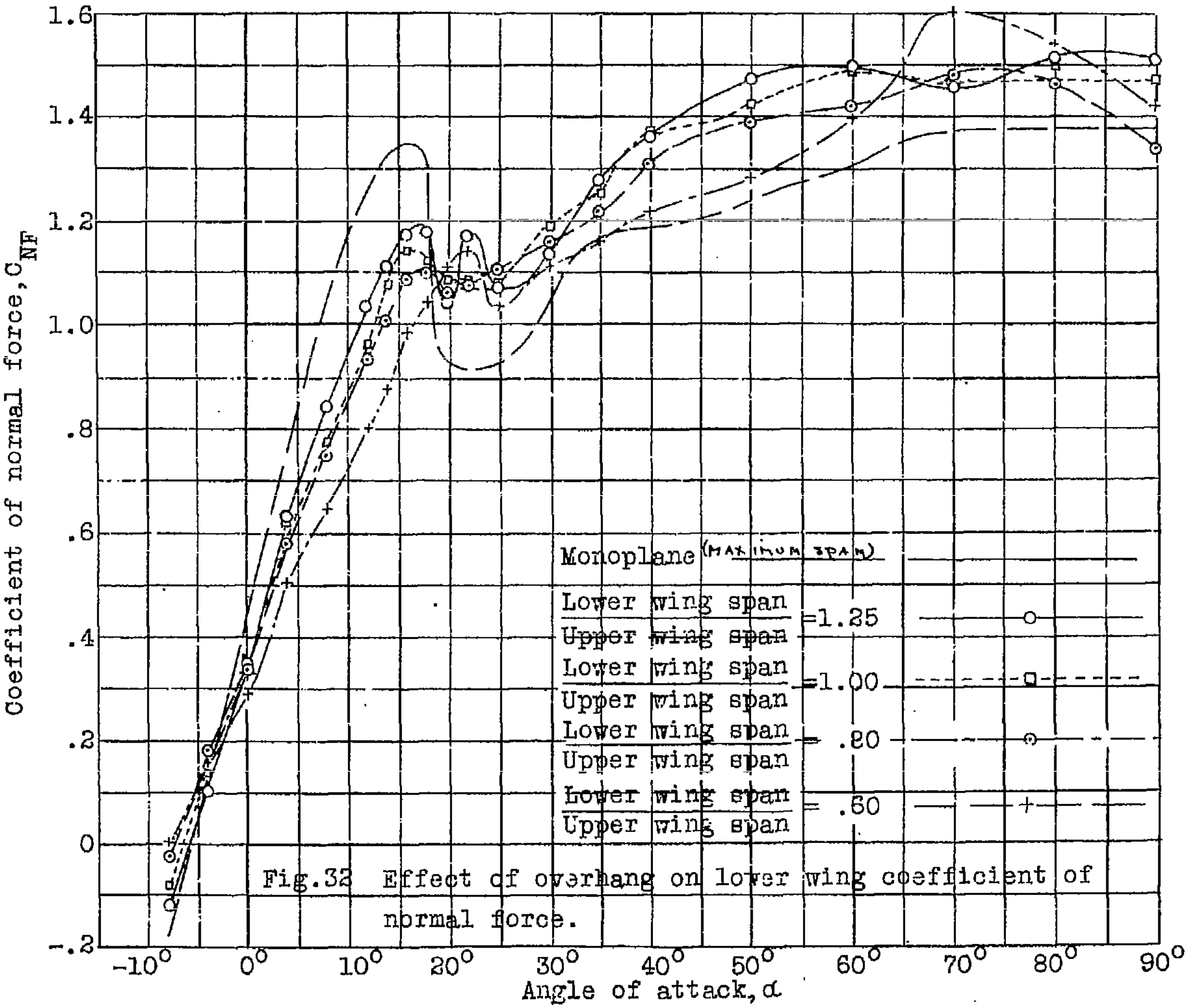
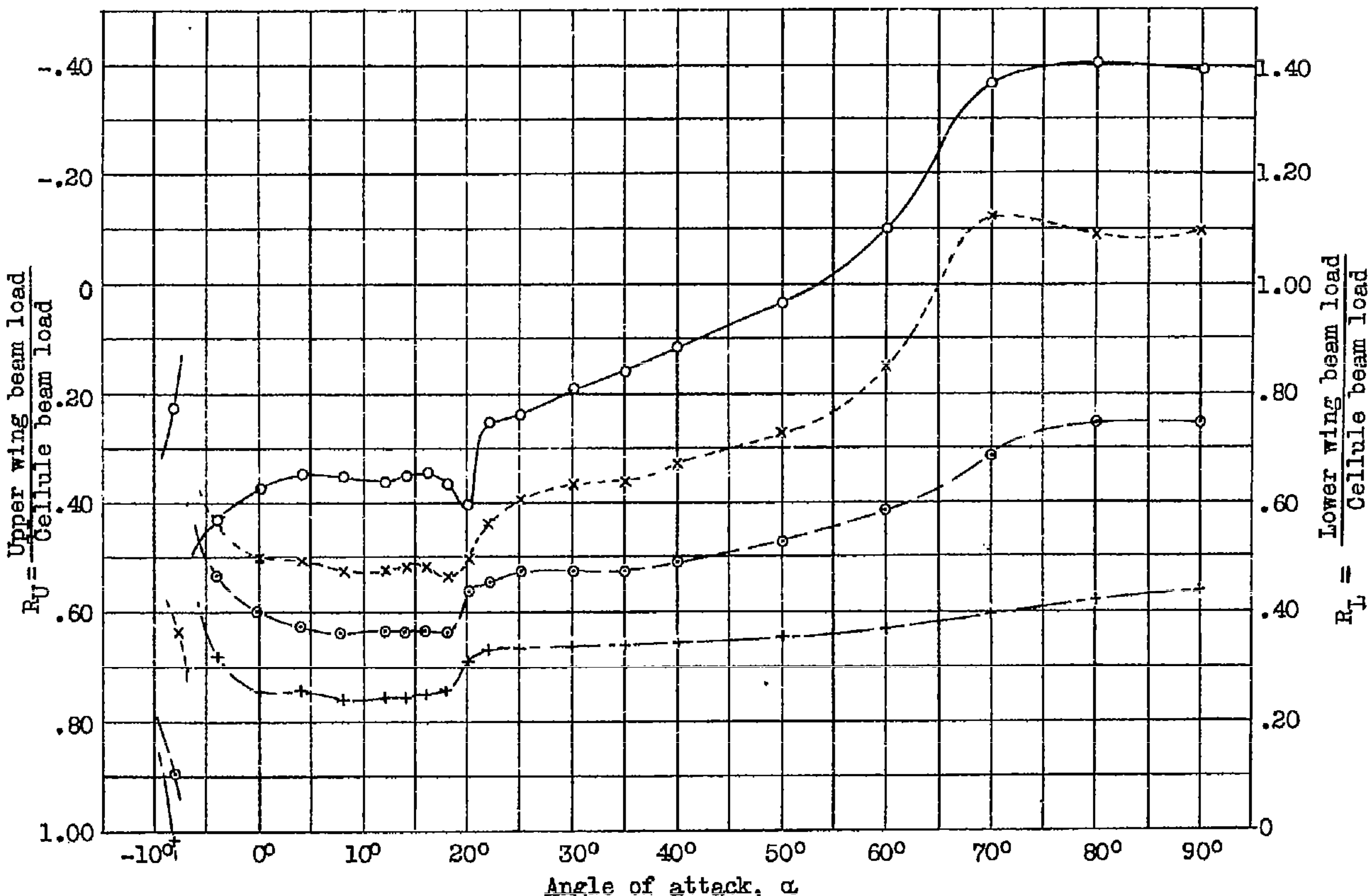


Fig.32 Effect of overhang on lower wing coefficient of normal force.



Lower wing span / Upper wing span = 1.25 ○ ———	Lower wing span / Upper wing span = .80 ⊙ — — —
Lower wing span / Upper wing span = 1.00 × - - - - -	Lower wing span / Upper wing span = .60 + —- —- —

Fig.33 Effect of overhang on wing load ratio.

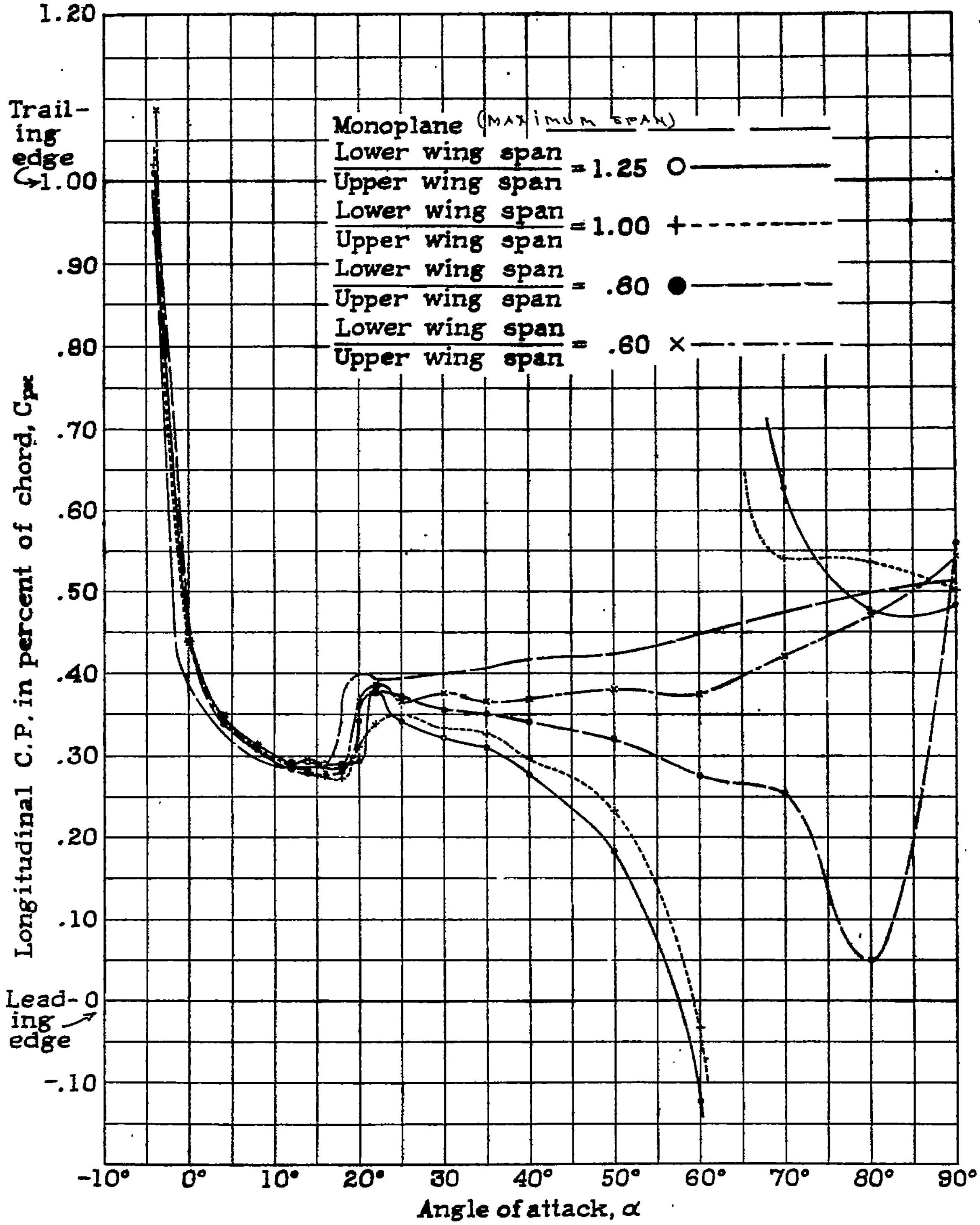


Fig.34 Effect of overhang on upper wing longitudinal center of pressure.

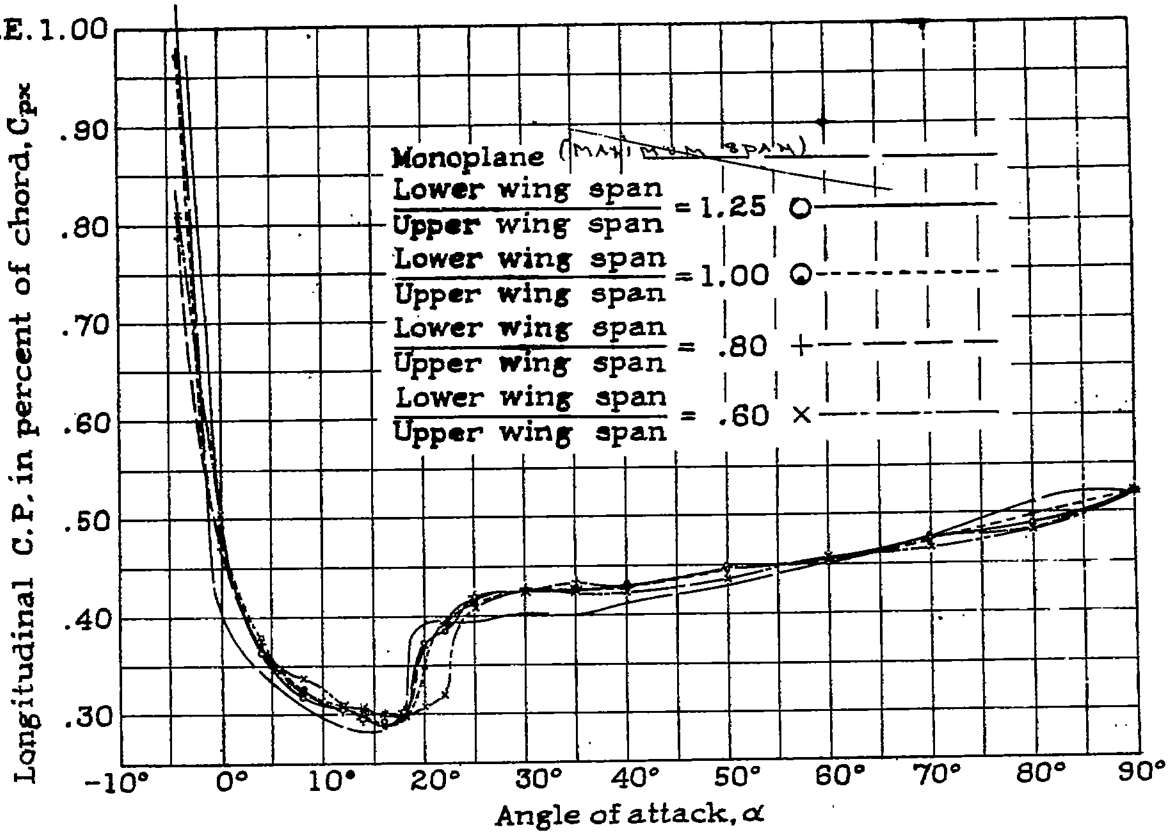


Fig. 35 Effect of overhang on lower wing longitudinal center of pressure.

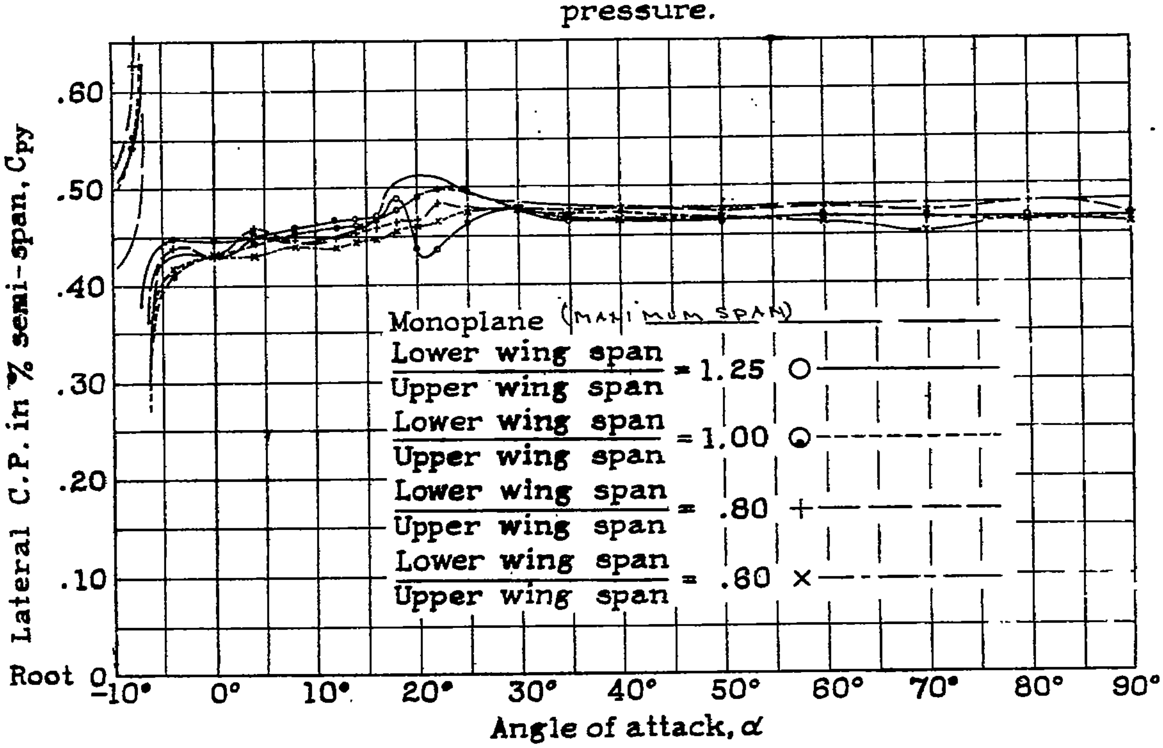


Fig. 37 Effect of overhang on lower wing lateral center of pressure.

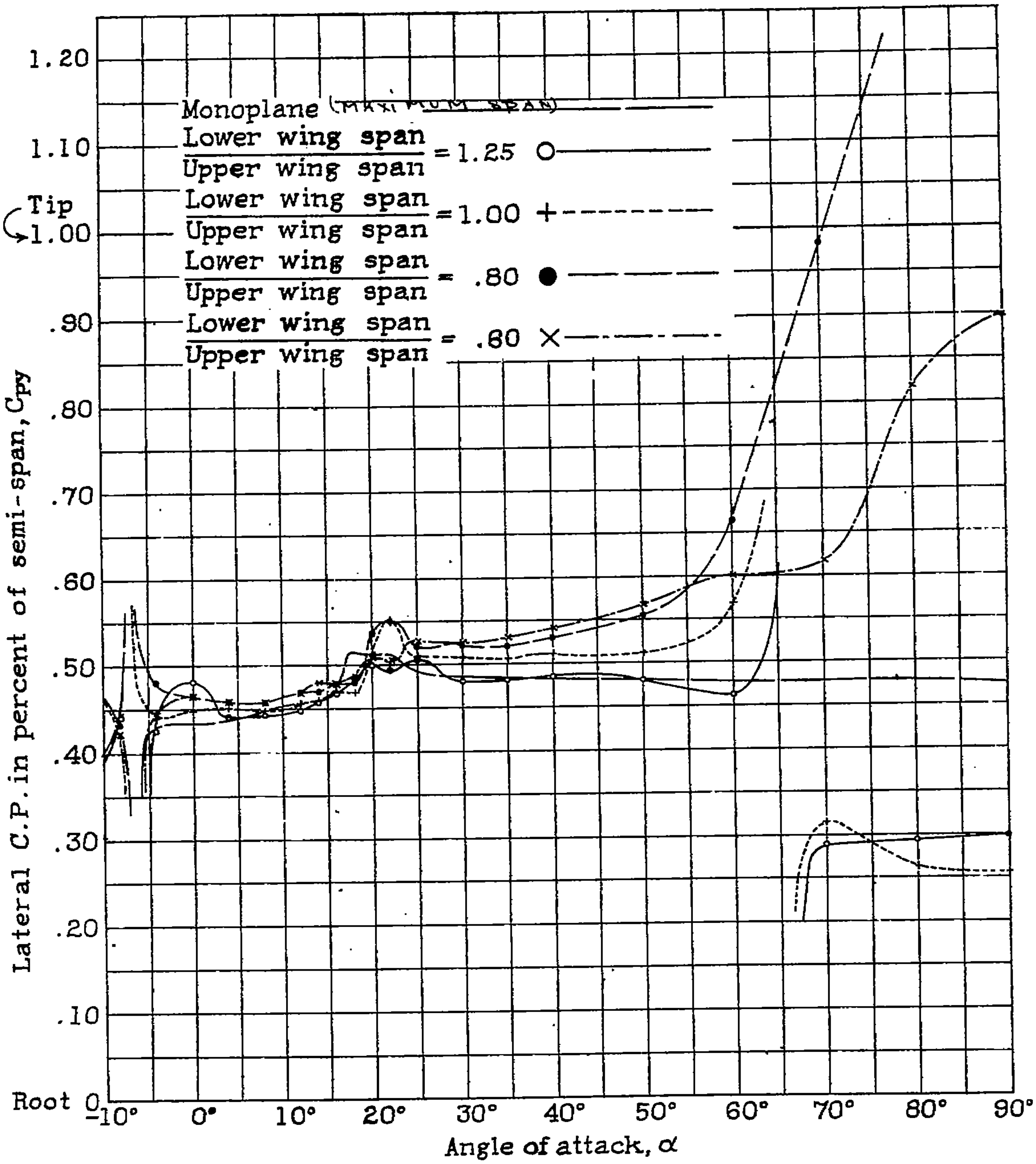


Fig.36 Effect of overhang on upper wing lateral center of pressure.