

NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS

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TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 330

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

PART III. EFFECTS OF CHANGES IN VARIOUS COMBINATIONS
OF STAGGER, GAP, SWEEPBACK, AND DECALAGE

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

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Memorial Aeronautical
Laboratory

Washington
December, 1929



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E R R A T A

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OF STAGGER, GAP, SWEEPBACK, AND DECALAGE.

On Figures 12, 13, 14, 16, 17, 18 and 19, after the word
"monoplane," insert "without sweepback."

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S u m m a r y

This preliminary report furnishes information on the changes in the forces on each wing of a biplane cellule for various combinations of stagger and gap, stagger and sweepback, stagger and decalage, and gap and decalage. 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 as well as 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 air loads on two wing models arranged in different biplane combinations. The effects of various combinations of stagger and gap, stagger and sweep-

back, stagger and decalage, and gap and decalage were investigated. Two previous reports, Part I and Part II (See References), covered the effects of variations of dihedral, overhang and each of the above factors taken separately. A more complete presentation of the results of the entire investigation and an analysis from the standpoints of spinning, stalled flight, and structural design of biplane wings will be published at a later date.

The tests were made in the atmospheric wind tunnel of the Langley Memorial Aeronautical Laboratory. A complete description of the models, apparatus, method of testing and procedure in working up the test data is given in Part I (Reference 1) 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 orifices.

T e s t s

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

1. Variations in stagger and gap.

(Decalage = 0, dihedral = 0, sweepback = 0, overhang = 0.)

	<u>Gap/chord</u>	<u>Stagger</u>
(a)	.75	- 0
(b)	.75	+25 per cent chord
(c)	.75	+50 per cent chord
(d)	1.25	0
(e)	1.25	+25 per cent chord
(f)	1.25	+50 per cent chord

2. Variations in stagger and sweepback.

(Gap/chord = 1, decalage = 0, dihedral = 0, overhang = 0.)

Note: Stagger is measured at midspan.

	<u>Sweepback</u>	<u>Stagger</u>
(a)	10° upper wing	+50 per cent chord
(b)	5° upper wing	+25 per cent chord
(c)	0	0
(d)	* 5° lower wing	-25 per cent chord
(e)	10° lower wing	-50 per cent chord

*Not run.

3. Variations in stagger and decalage.

(Gap/chord = 1, dihedral = 0, sweepback = 0, overhang = 0.)

	<u>Decalage</u>	<u>Stagger</u>
(a)	+3°	0
(b)	+3°	+25 per cent chord
(c)	+3°	+50 per cent chord
(d)	-3°	0
(e)	-3°	+25 per cent chord
(f)	-3°	+50 per cent chord

4. Variations in gap and decalage.

(Stagger = 0, dihedral = 0, sweepback = 0, overhang = 0.)

	<u>Decalage</u>	<u>Gap/chord</u>
(a)	+3°	.75
(b)	+3°	1.00
(c)	+3°	1.25
(d)	-3°	.75
(e)	-3°	1.00
(f)	-3°	1.25

Each test was made at angles of attack of -8° , -4° , 0° , $+4^\circ$, 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, 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.

R e s u l t s

The results are presented in four groups of comparison curves from which may be determined the magnitude and point of action of the semispan normal force on each wing for each combination of stagger and gap, stagger and sweepback, stagger and decalage, and gap and decalage tested. The angle of attack range covers most of the angles likely to be encountered in flight. Following is a list of the comparison curves, all of which are plotted against angle of attack. (The first, second,

third, and fourth figure numbers refer to the stagger-gap group, stagger-sweepback group, stagger-decalage group, and gap-decalage group, 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 of upper wing.
Figures 10, 19, 28, 37:	Lateral center of pressure of 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.

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 2 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 the scale effect will doubtless change the absolute value of the coefficients, the relative changes produced by variations of each pair of factors will probably hold for Reynolds Numbers greater than that of the tests.

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

• R e f e r e n c e s

1. 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.
2. Knight, Montgomery
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Noyes, Richard W. : Wind Tunnel Pressure Distribution Tests on a Series of Biplane Wing Models. Part II. Effects of Changes in Decalage, Dihedral, Sweepback, and Overhang. N.A.C.A. Technical Note No. 325, 1929.

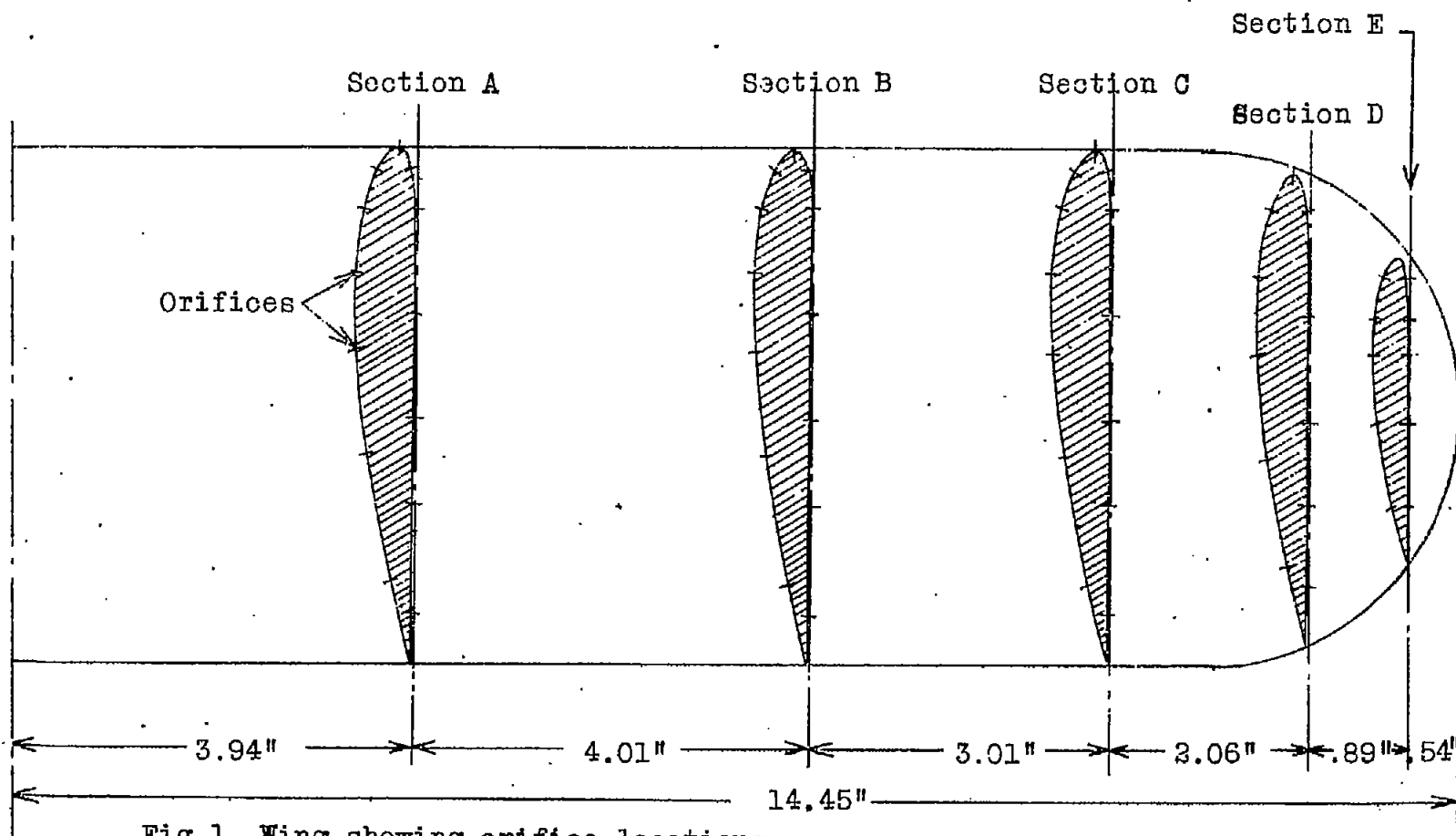


Fig.1 Wing showing orifice locations

Fig.1

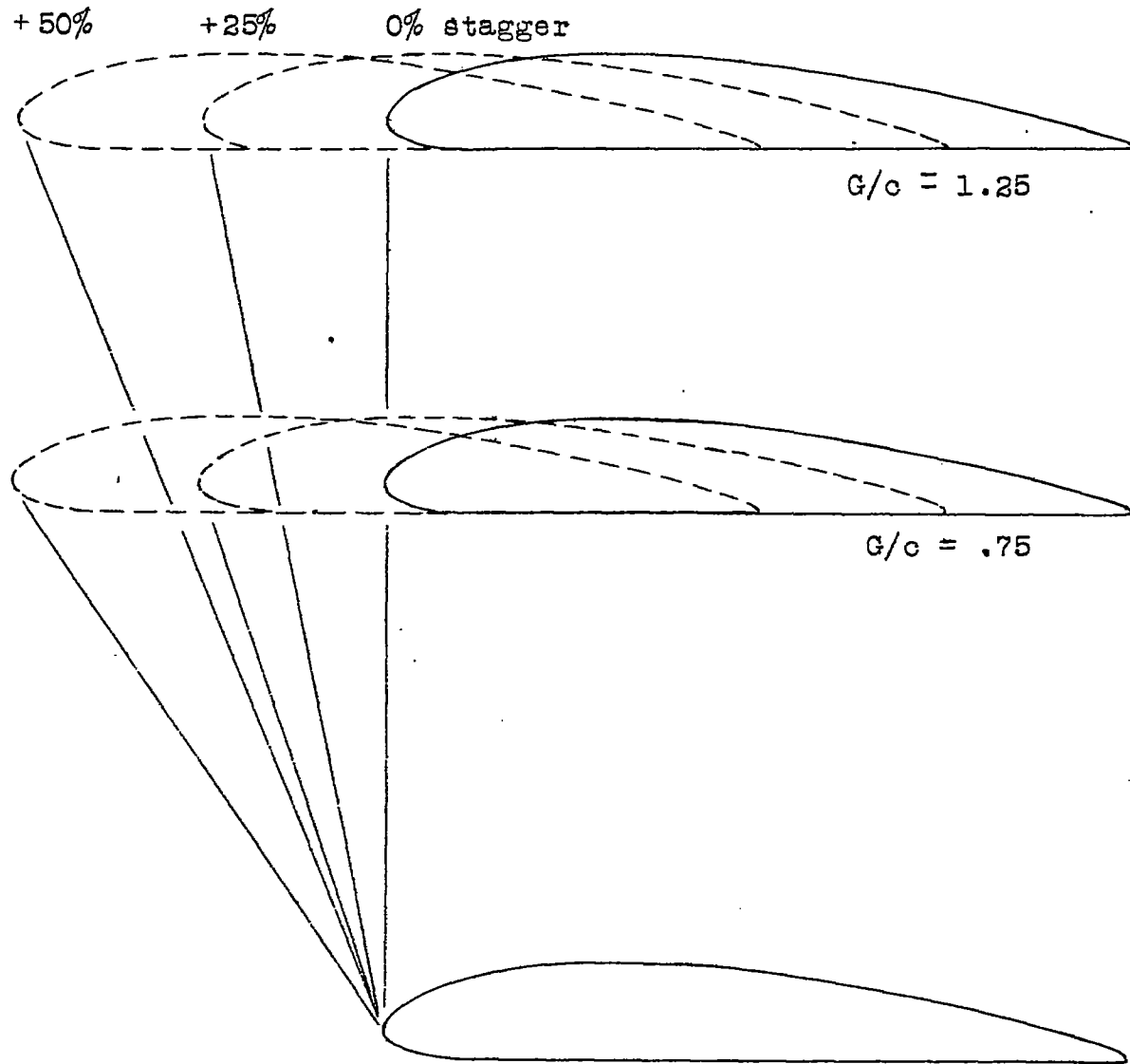


Fig.2 Wing model arrangements used in tests on the effect of stagger and gap.

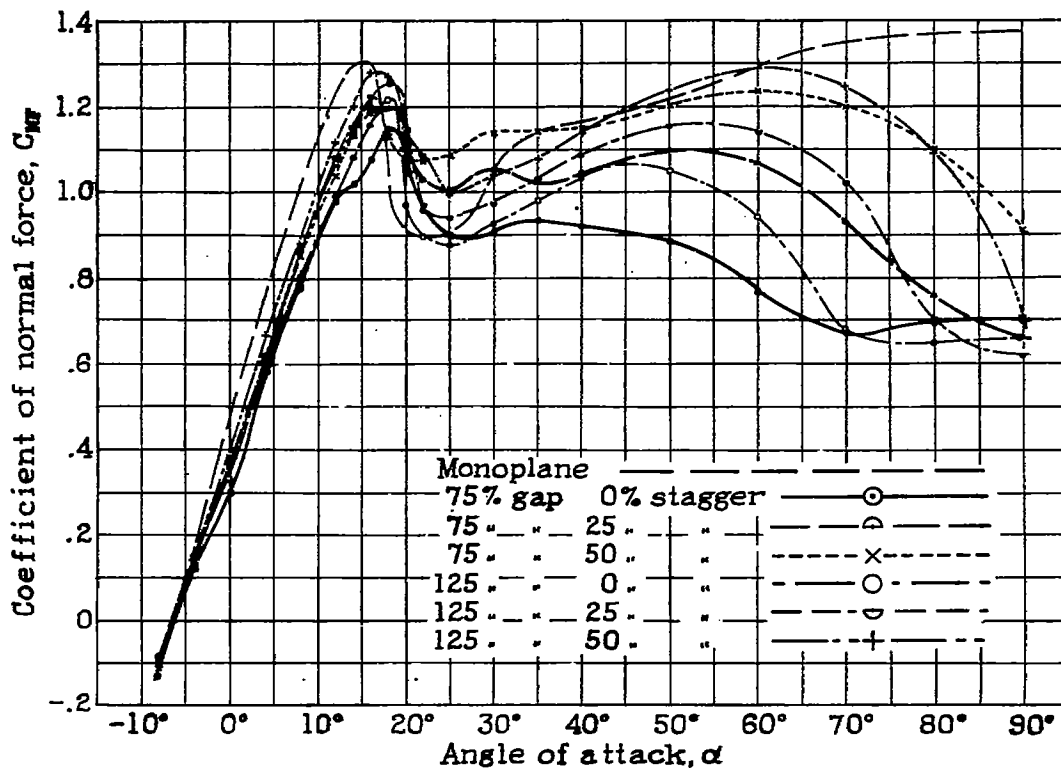


Fig.3 Effect of stagger and gap on cellule coefficient of normal force.

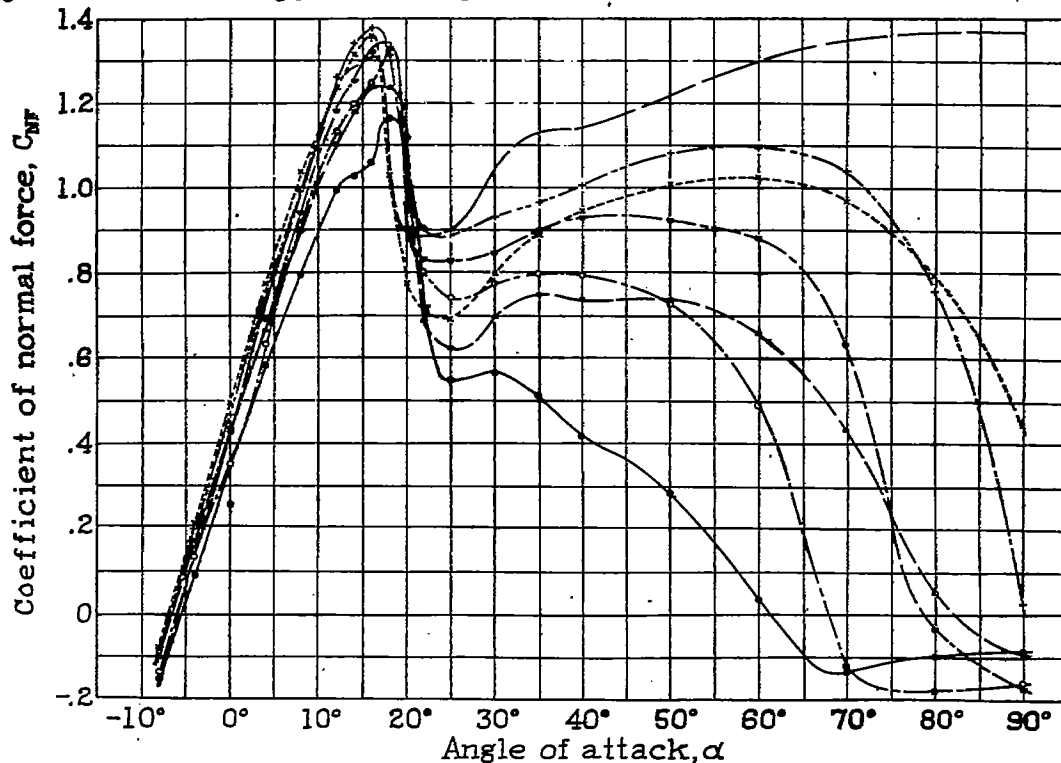


Fig.4 Effect of stagger and gap on upper wing coefficient of normal force.

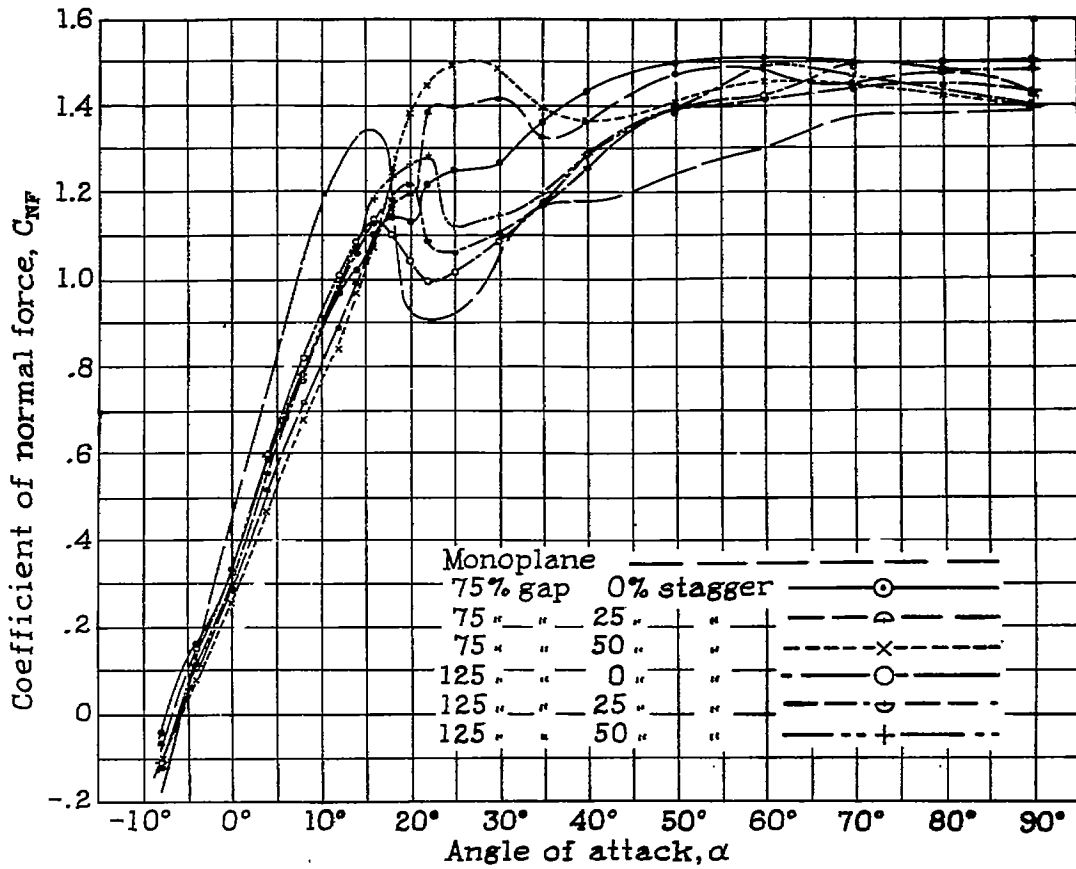


Fig. 5 Effect of stagger and gap on lower wing coefficient of normal force.

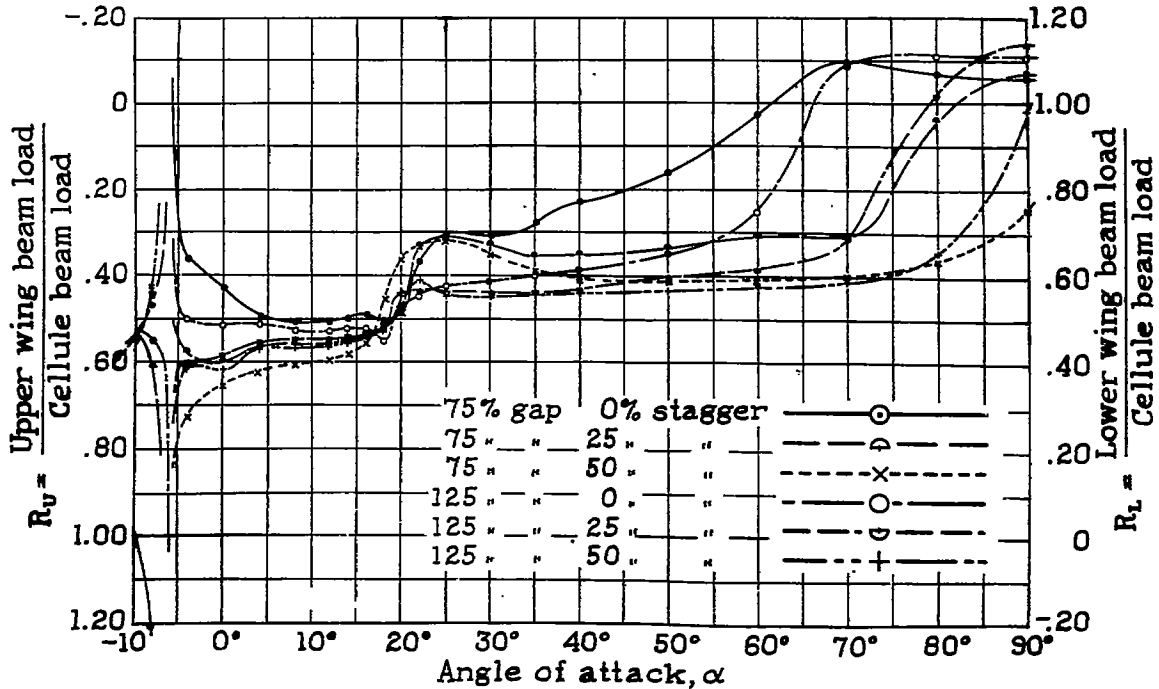


Fig. 6 Effect of stagger and gap on wing load ratio.

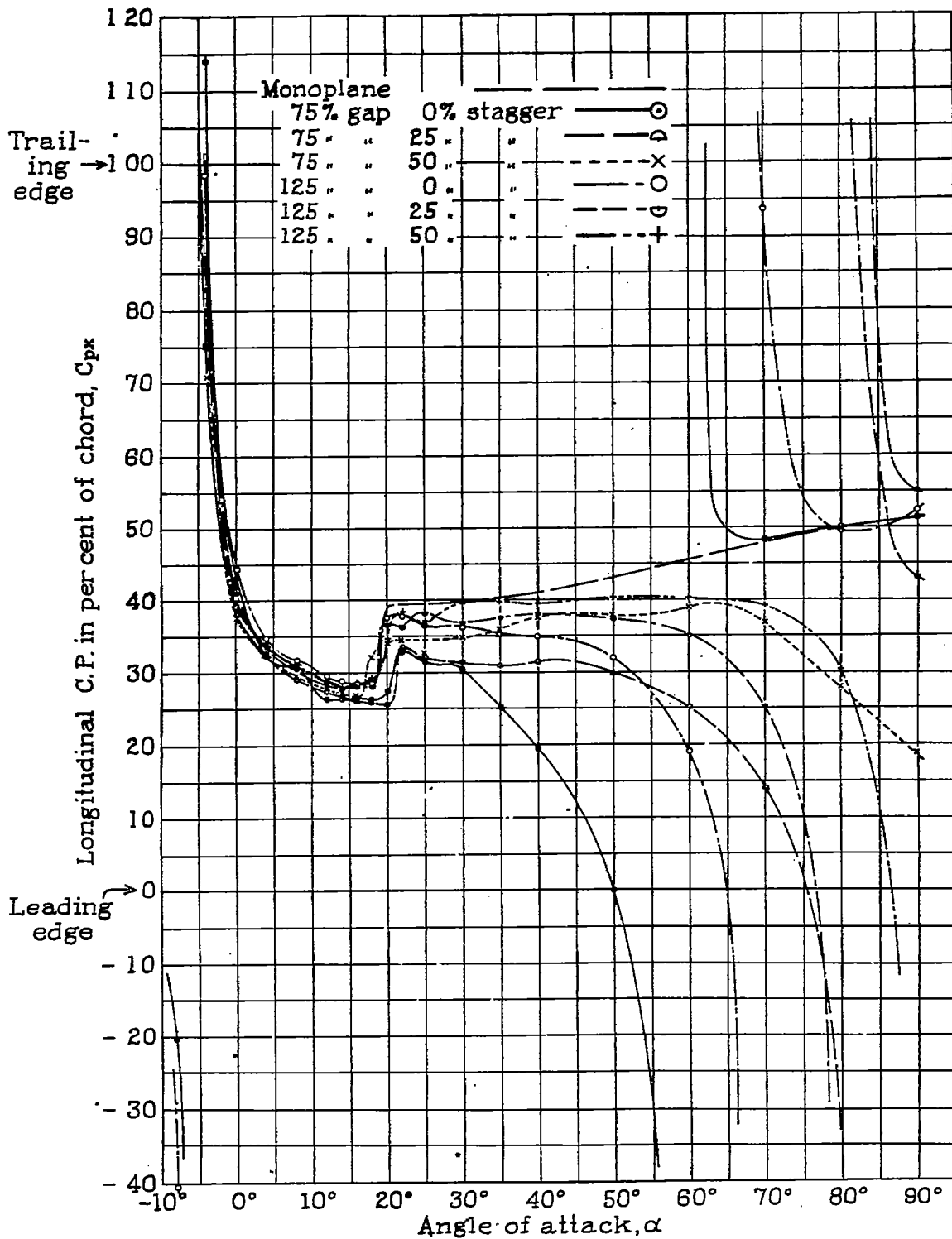


Fig. 7 Effect of stagger and gap on upper wing longitudinal center of pressure.

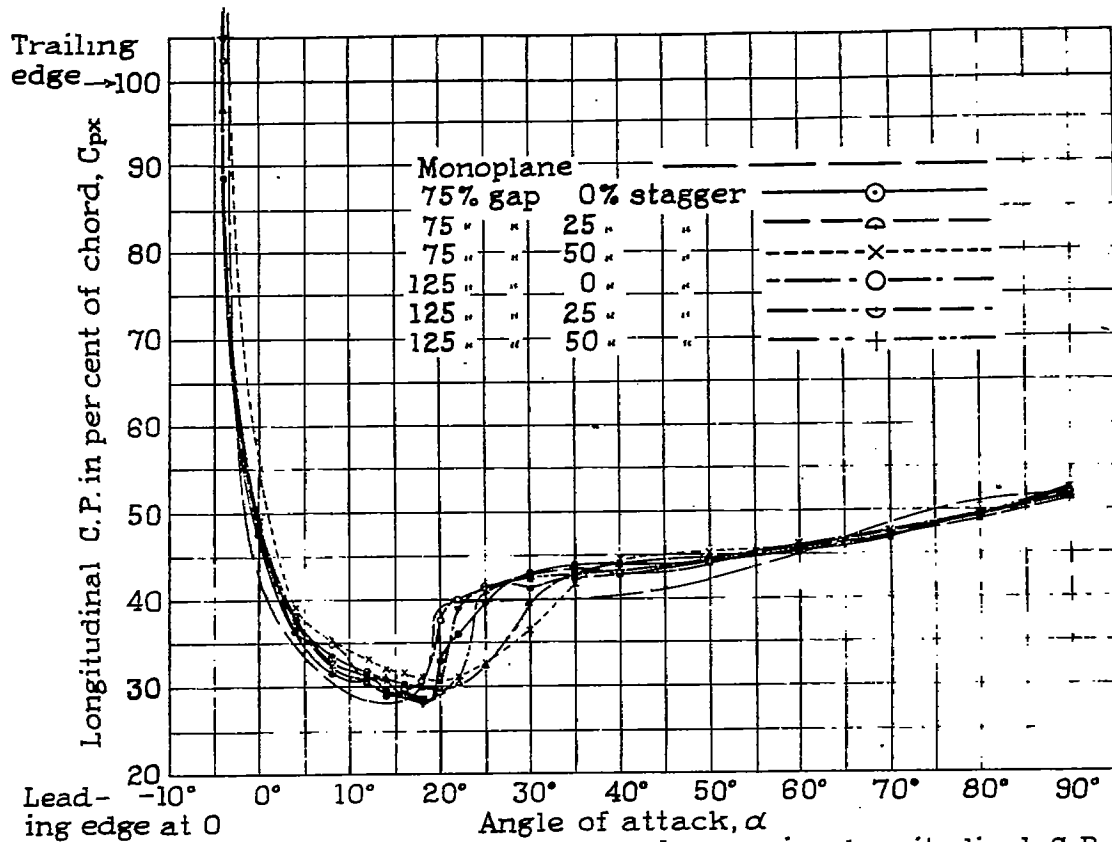


Fig. 8 Effect of stagger and gap on lower wing longitudinal C.P.

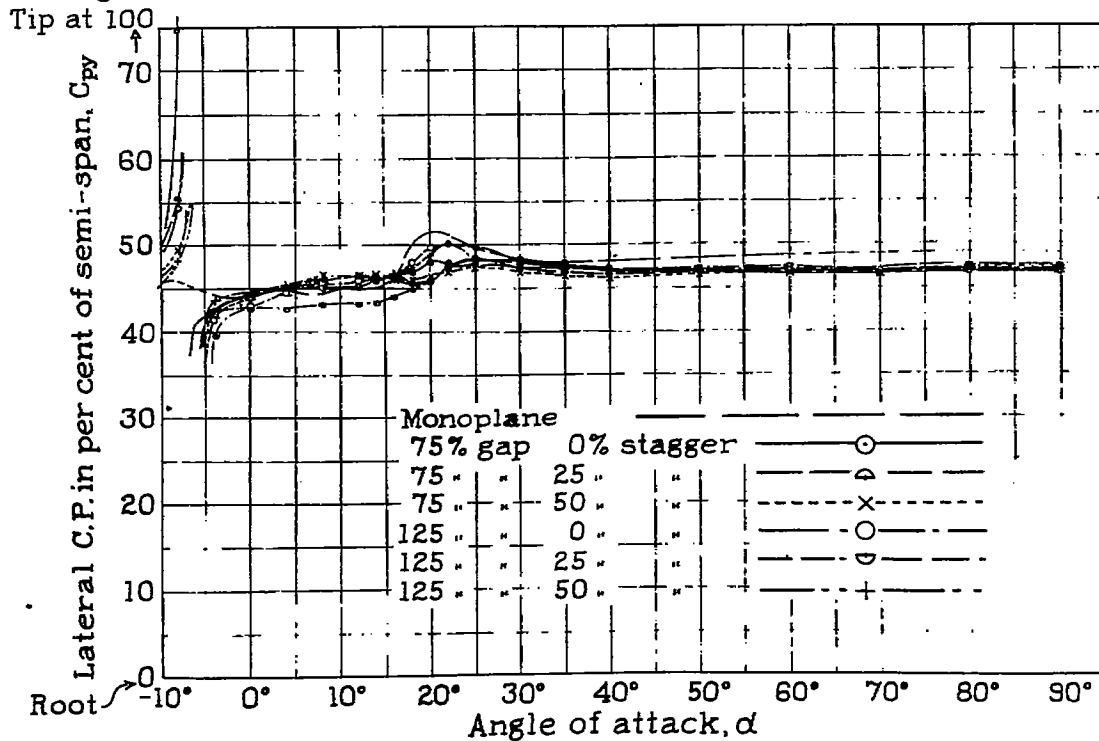


Fig. 10 Effect of stagger and gap on lower wing lateral C.P.

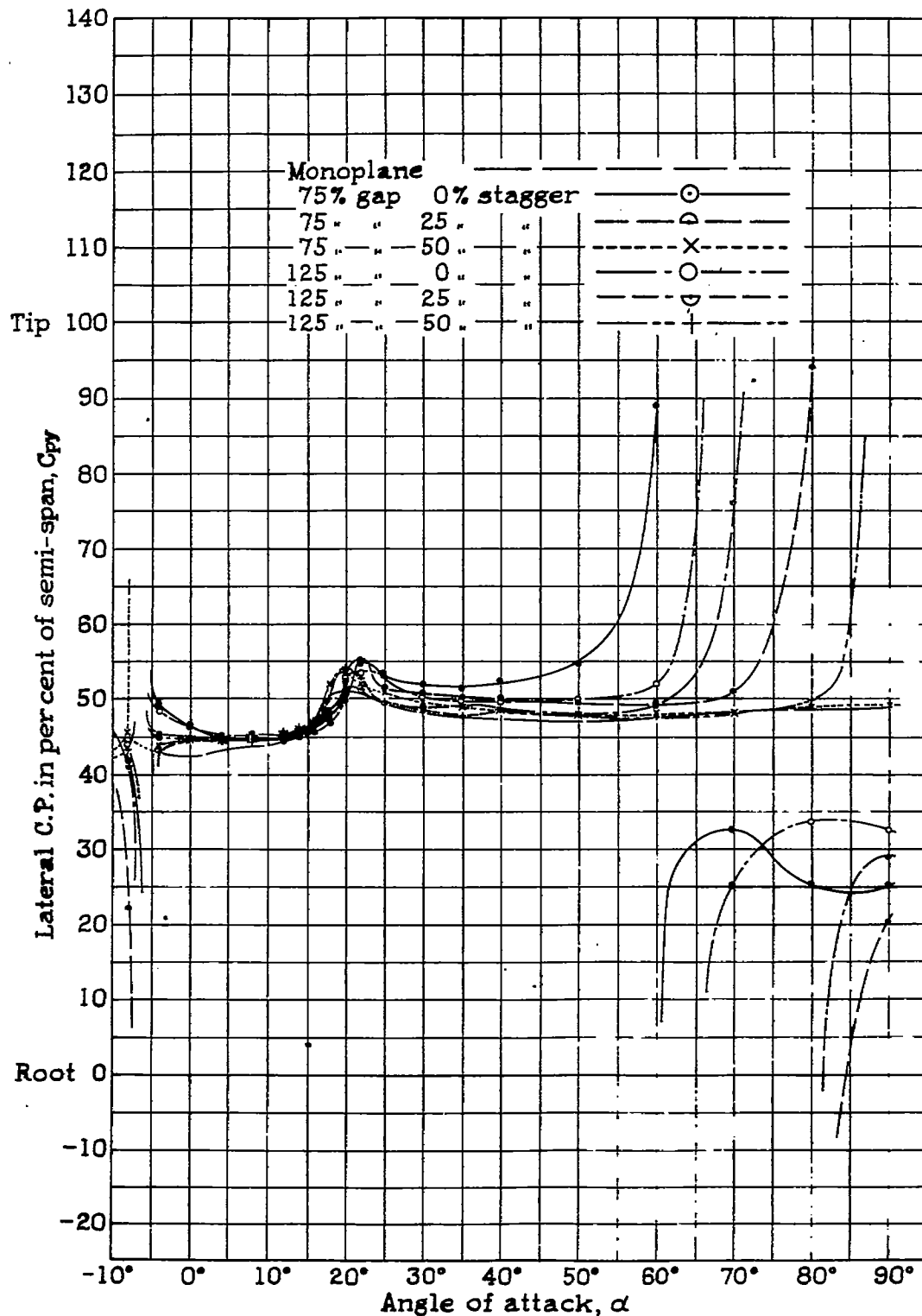


Fig. 9 Effect of stagger and gap on upper wing lateral center of pressure.

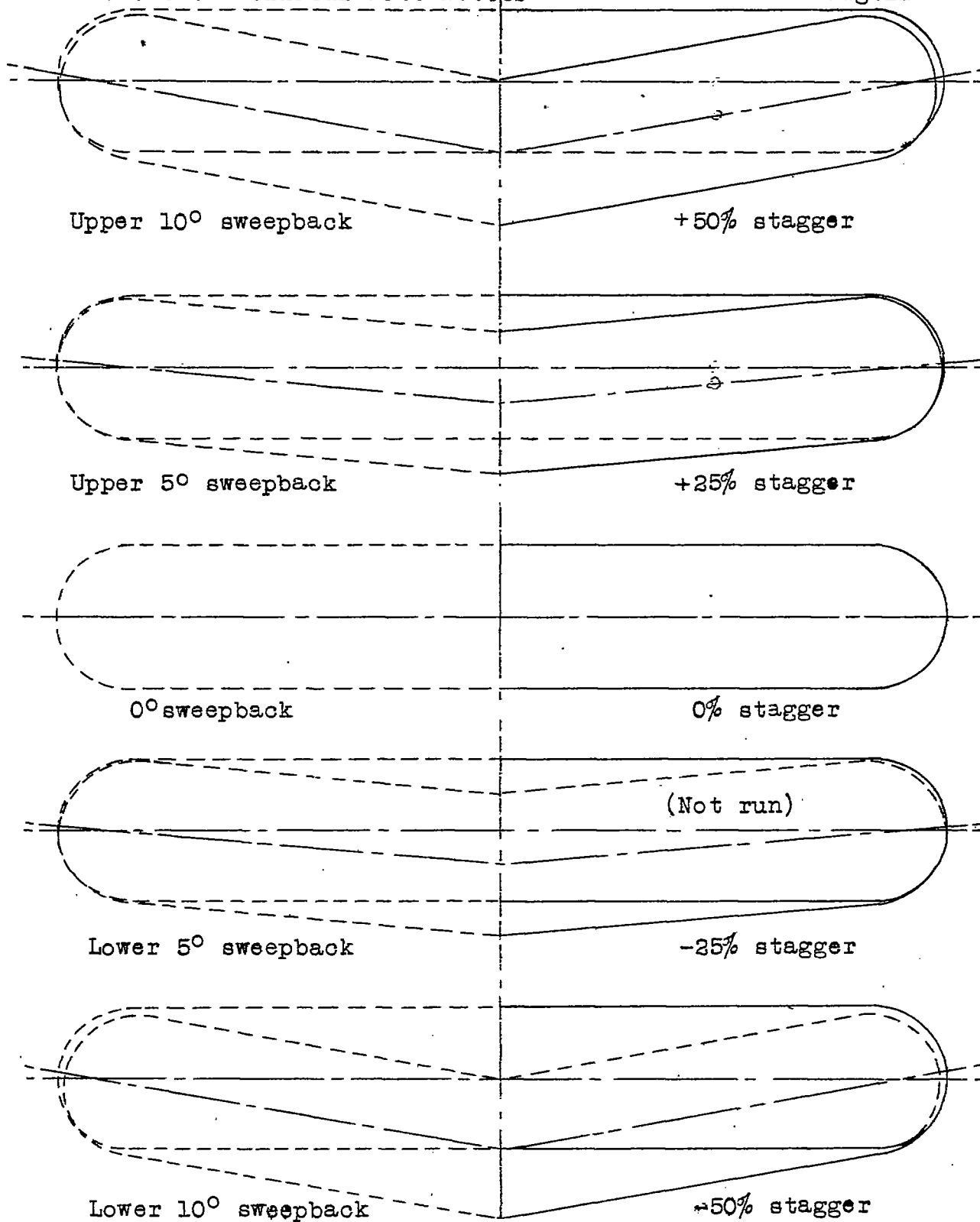


Fig. 11 Wing model arrangements used in tests on the effect of stagger and sweepback.

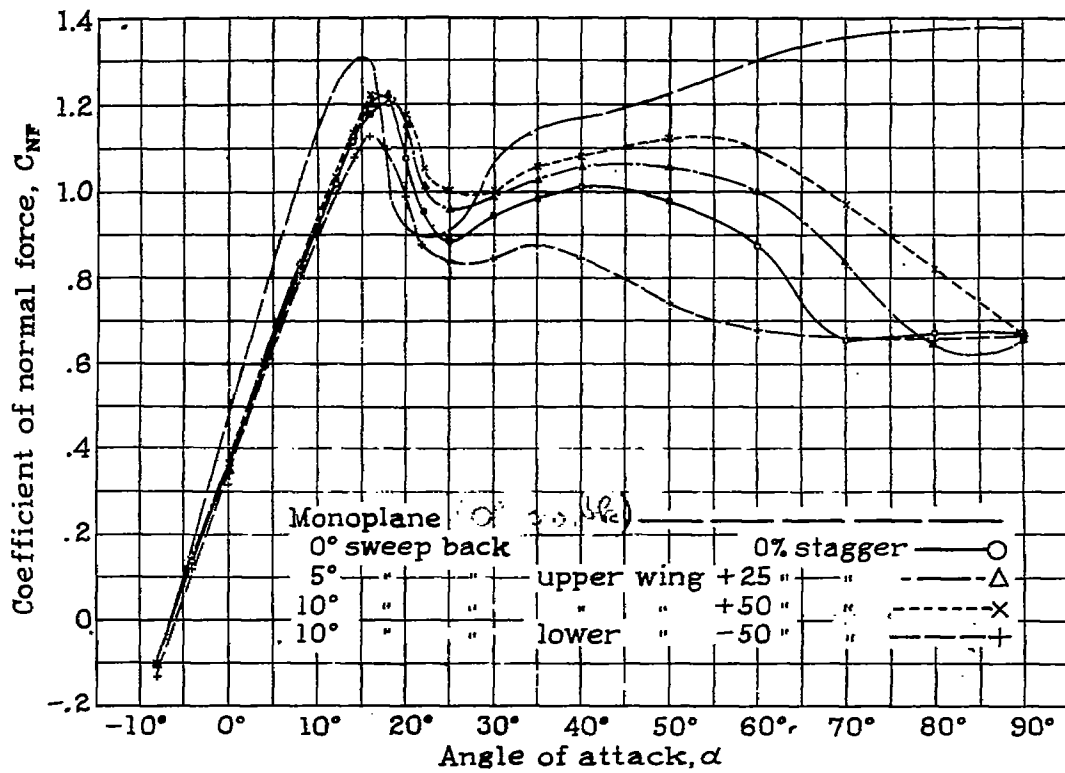


Fig. 12 Effect of stagger and sweep back on cellule coefficient of normal force.

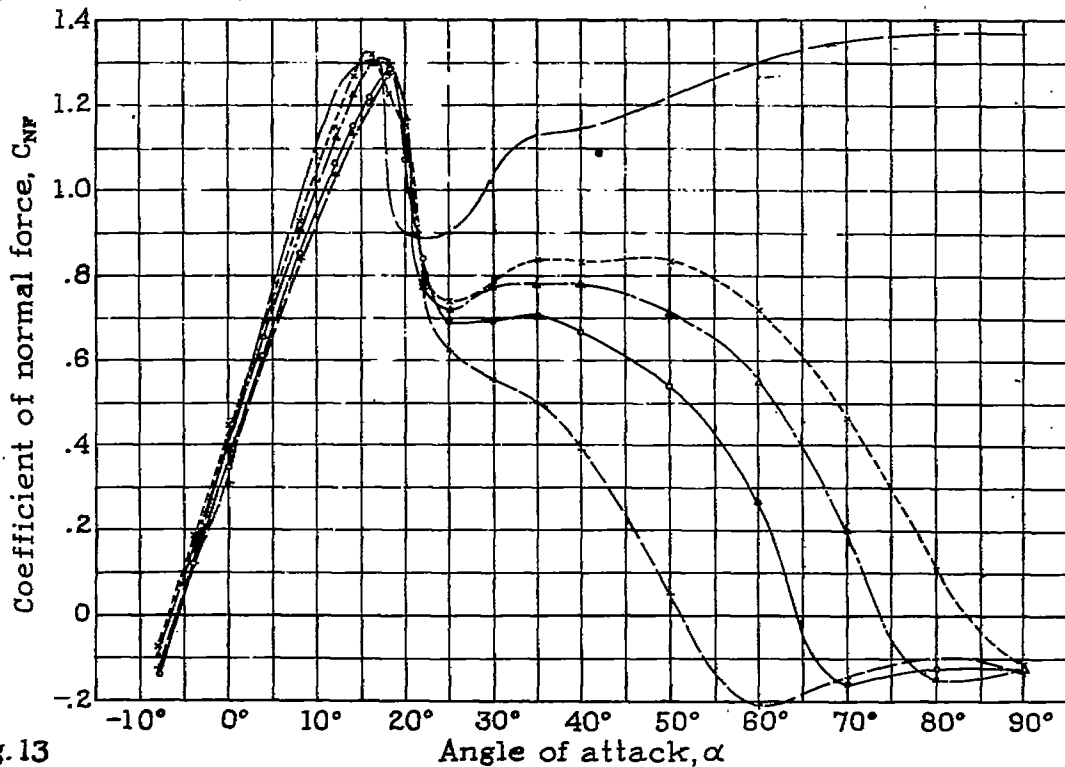


Fig. 13 Effect of stagger and sweep back on upper wing coefficient of normal force.

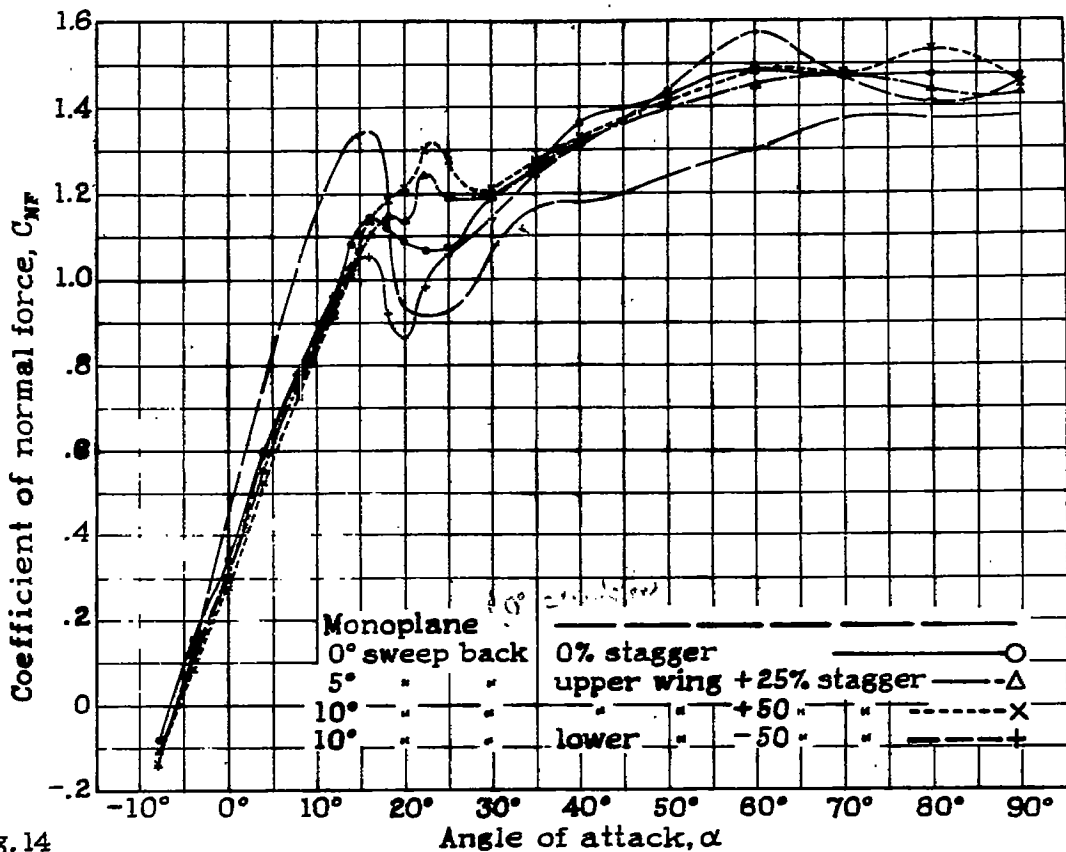


Fig. 14 Effect of stagger and sweep back on lower wing coefficient of normal force.

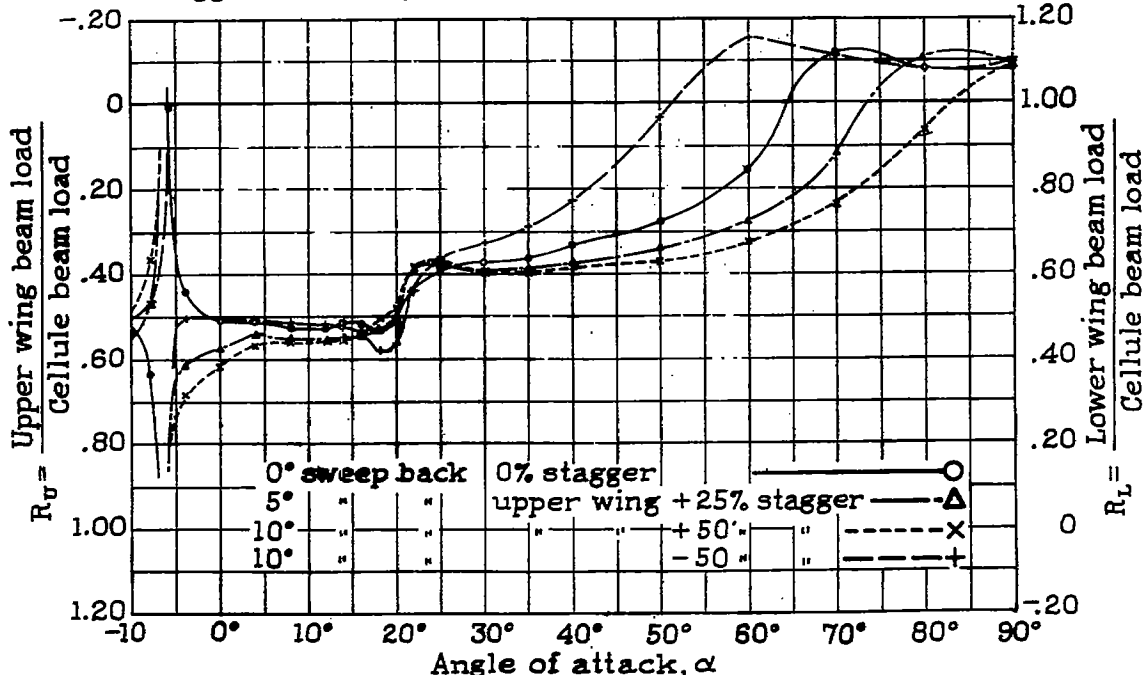


Fig. 15 Effect of stagger and sweep back on wing load ratio.

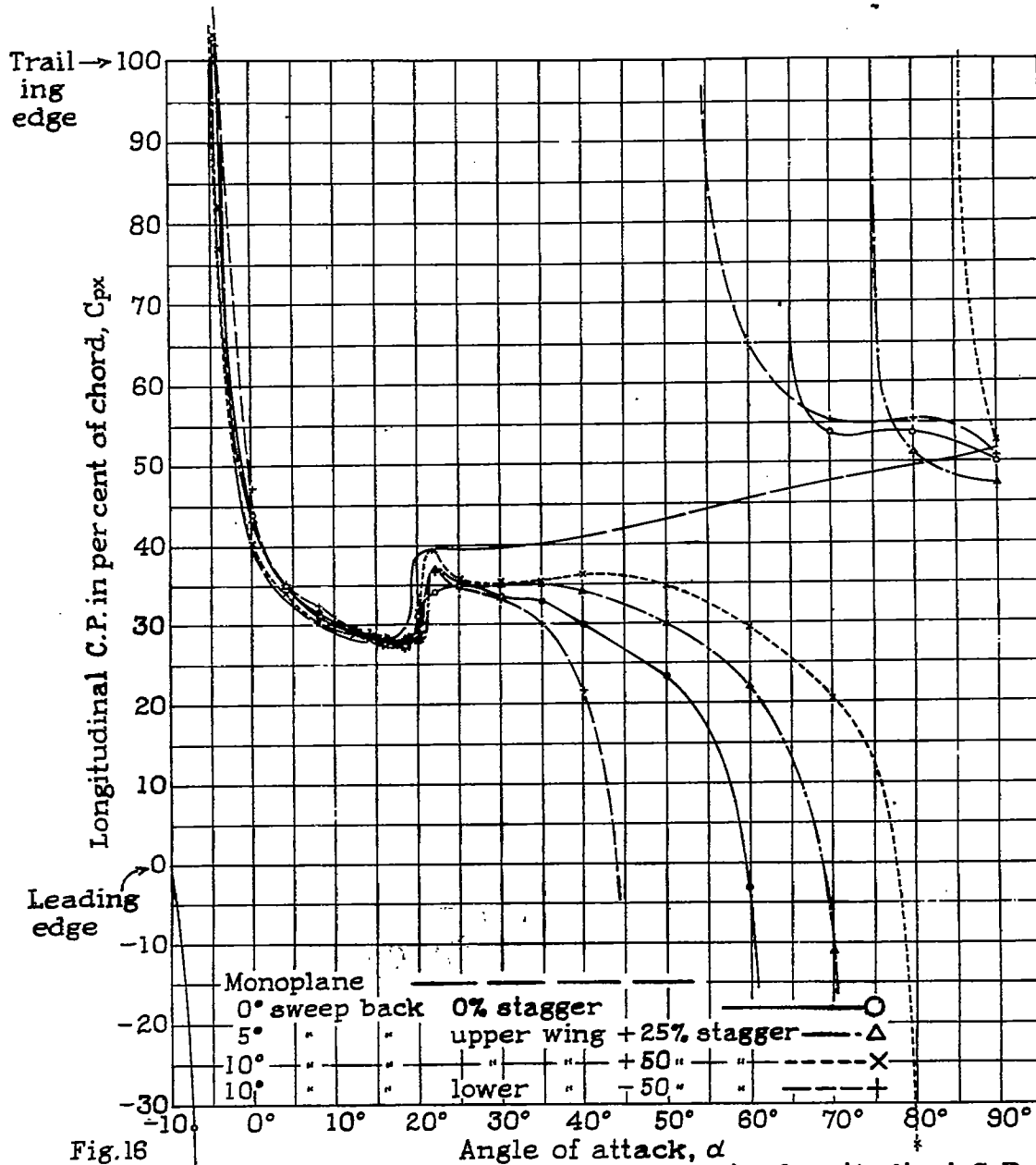


Fig. 16 Effect of stagger and sweep back on upper wing longitudinal C. P.

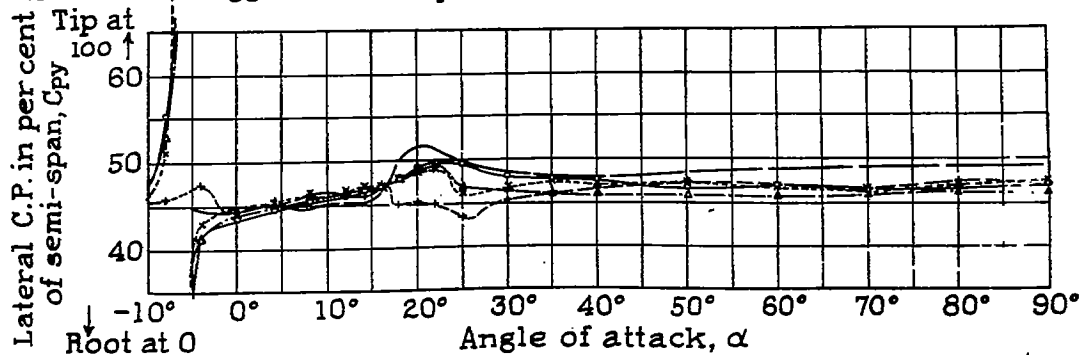


Fig. 19 Effect of stagger and sweep back on lower wing lateral C. P.

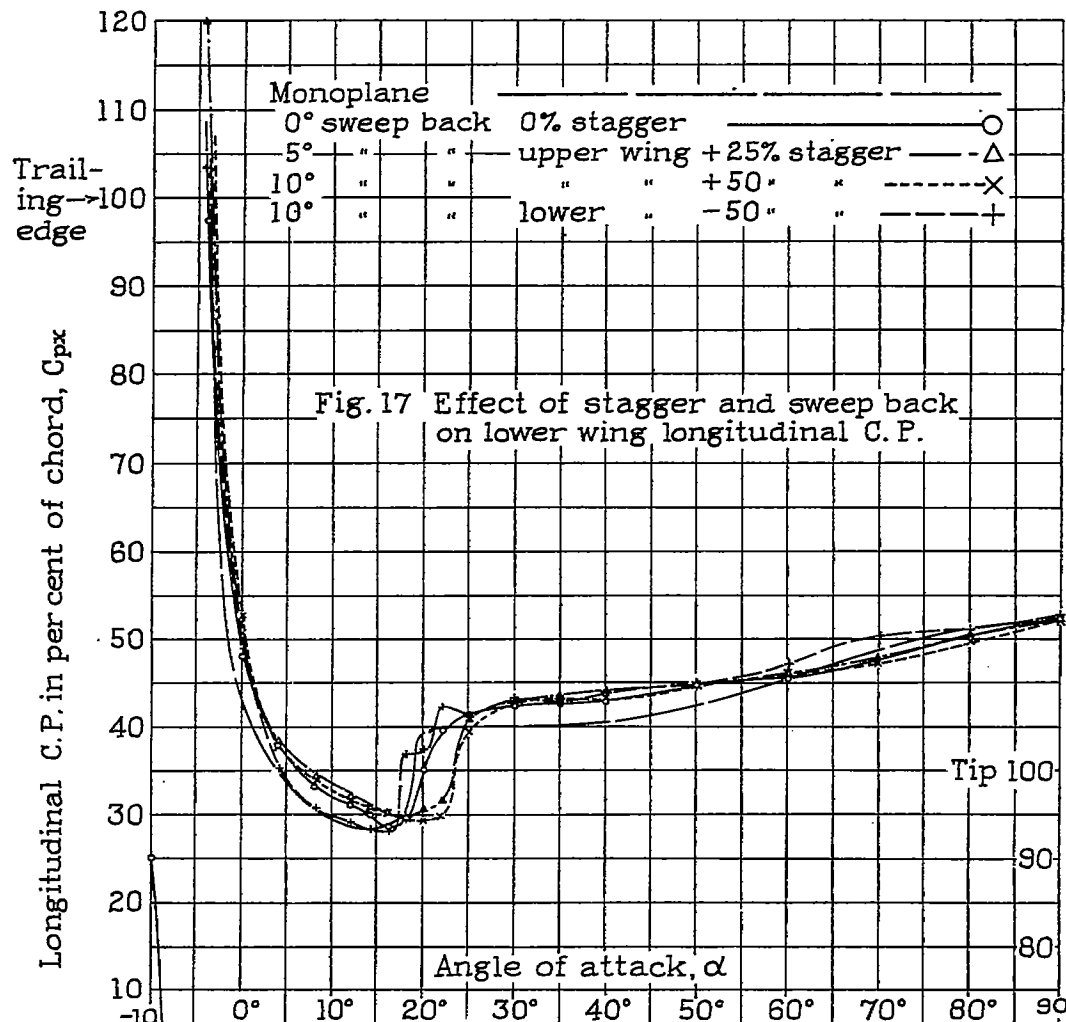


Fig. 17 Effect of stagger and sweep back on lower wing longitudinal C. P.

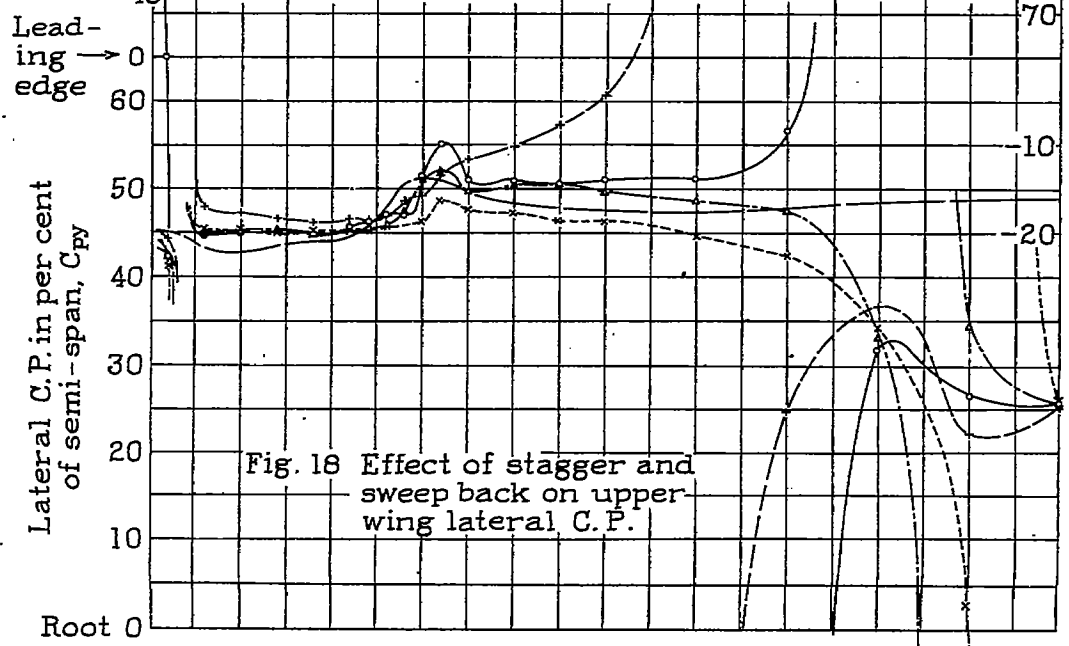
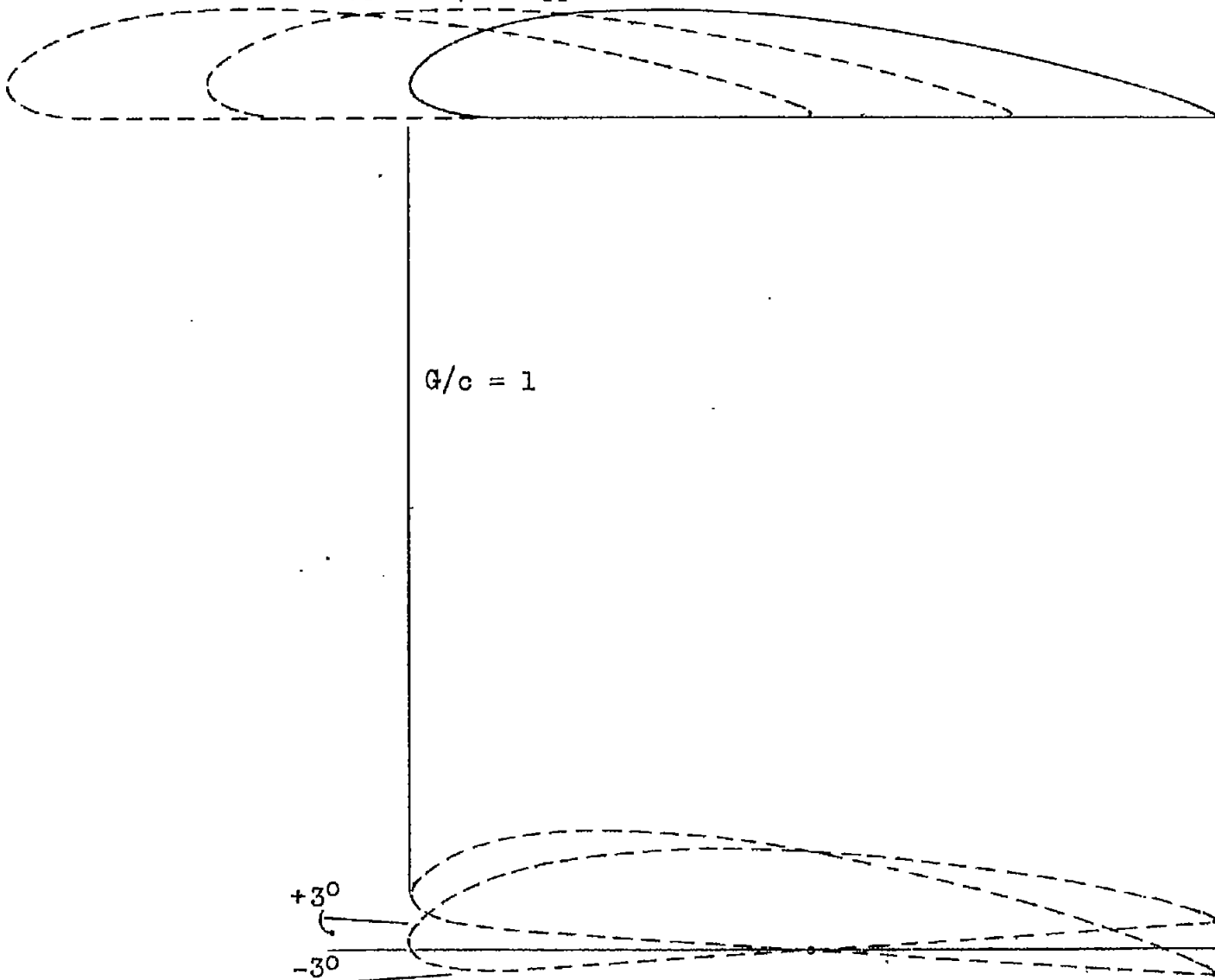


Fig. 18 Effect of stagger and sweep back on upper wing lateral C. P.

+50% stagger +25% stagger 0% stagger



N.A.C.A. Technical Note No. 330

Fig. 20

Fig. 20 Wing model arrangements used in tests on the effect of stagger and decalage.

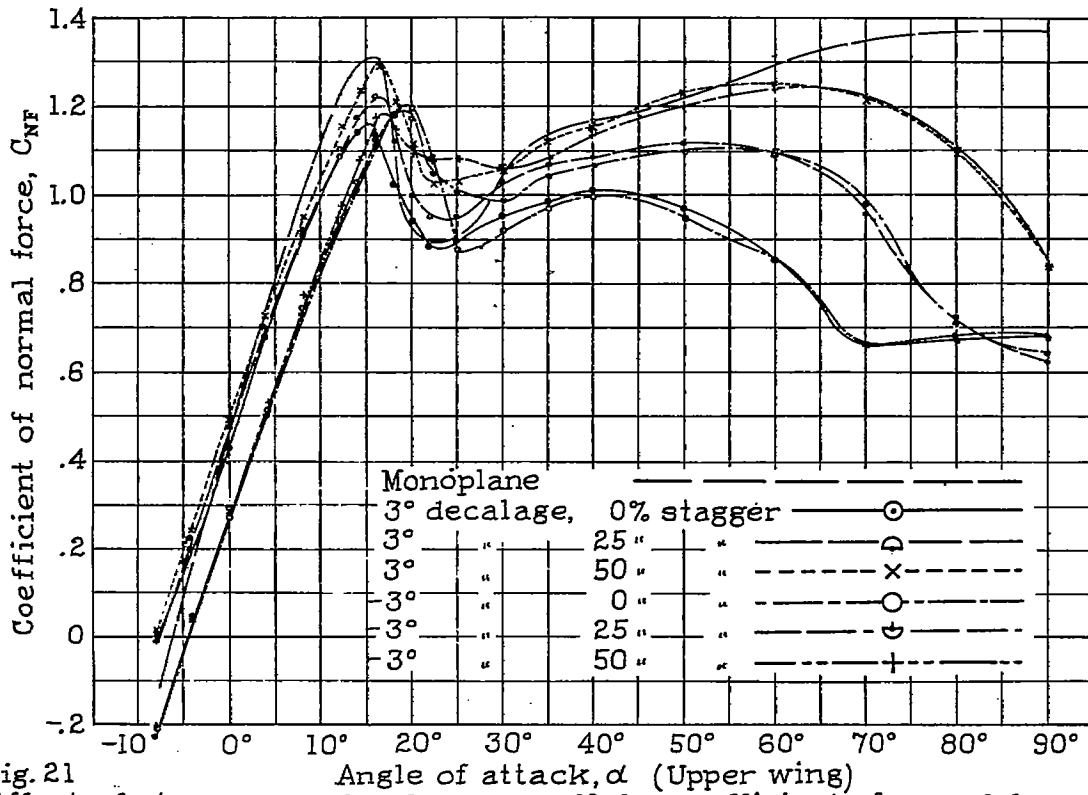


Fig. 21 Effect of stagger and decalage on cellule coefficient of normal force.

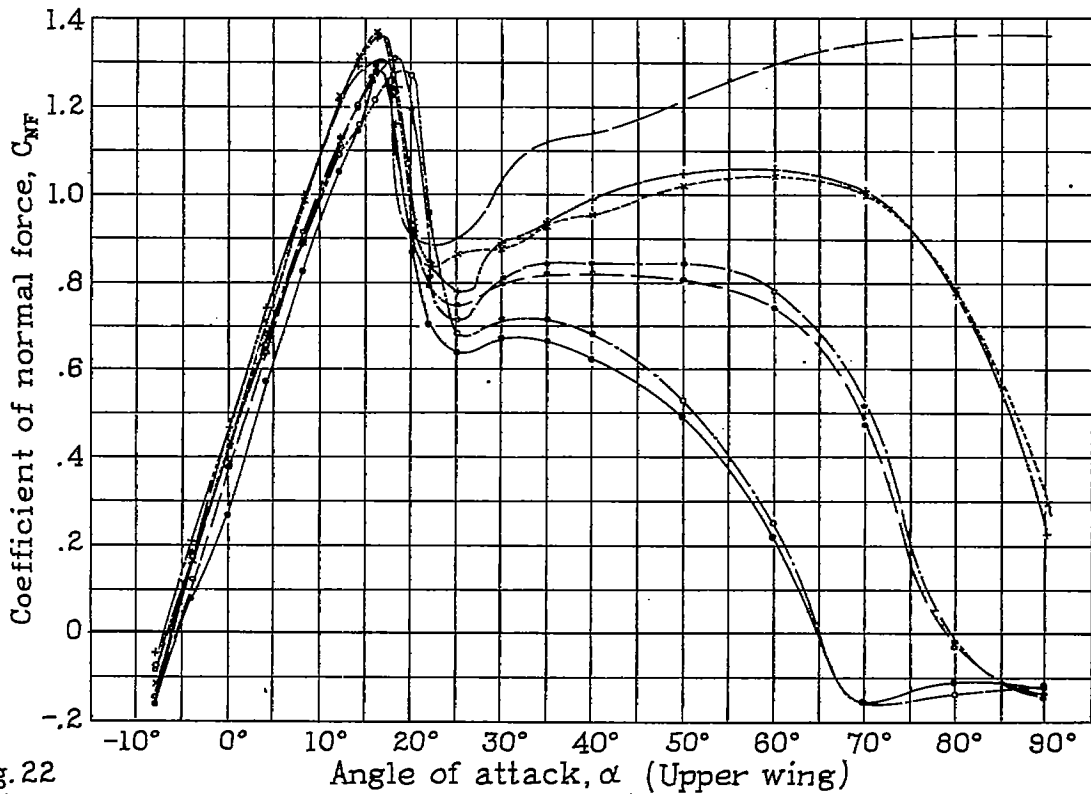


Fig. 22 Effect of stagger and decalage on upper wing coefficient of normal force.

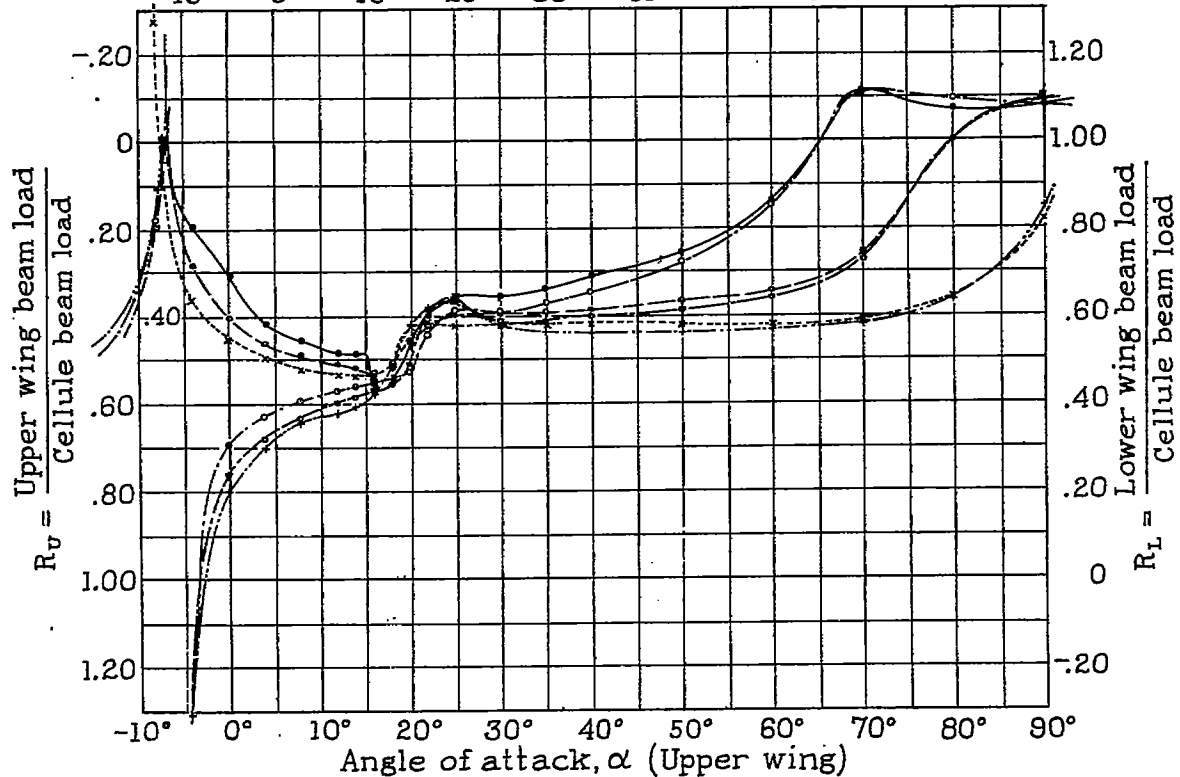
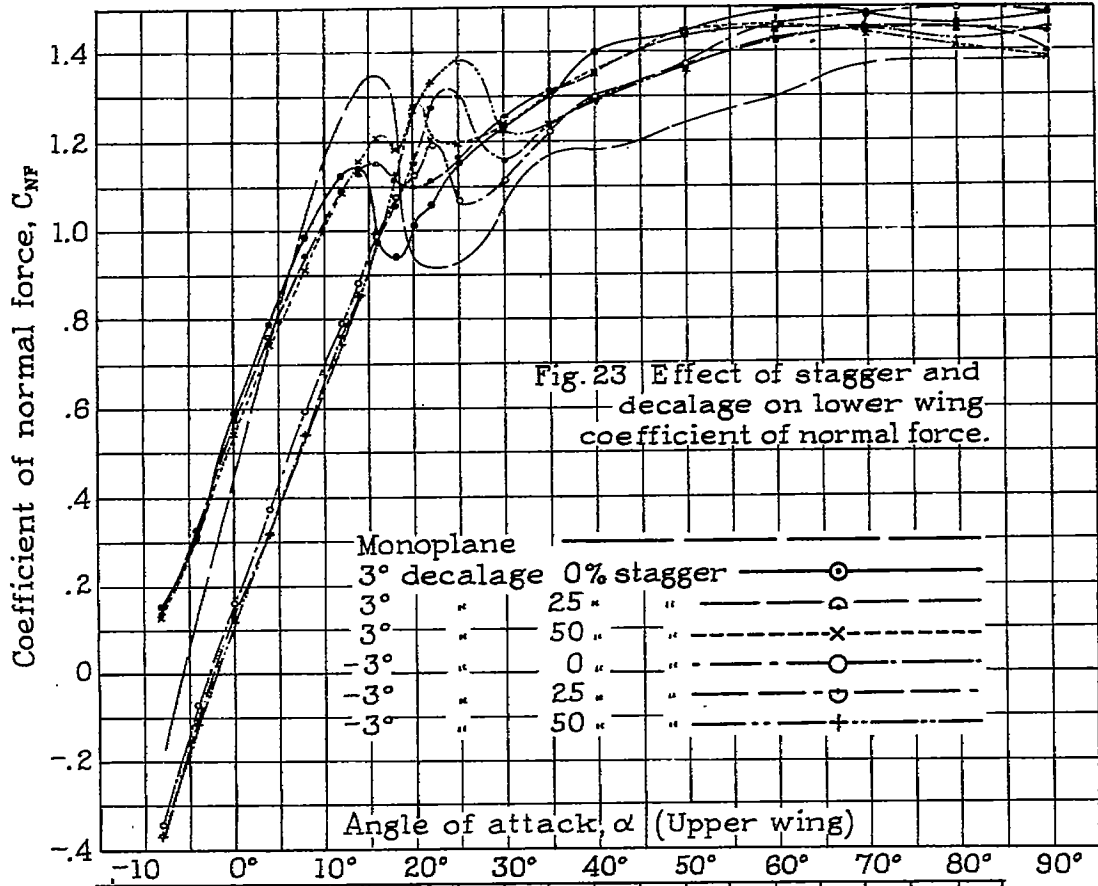
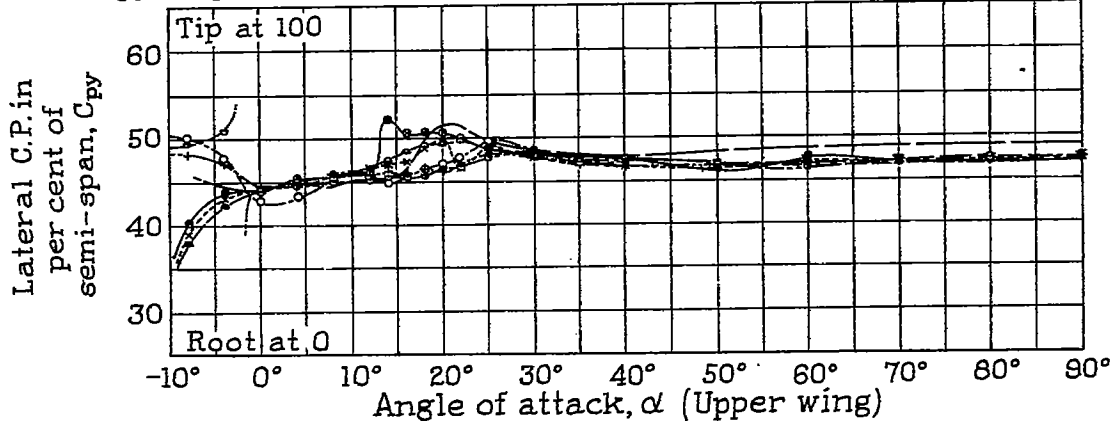
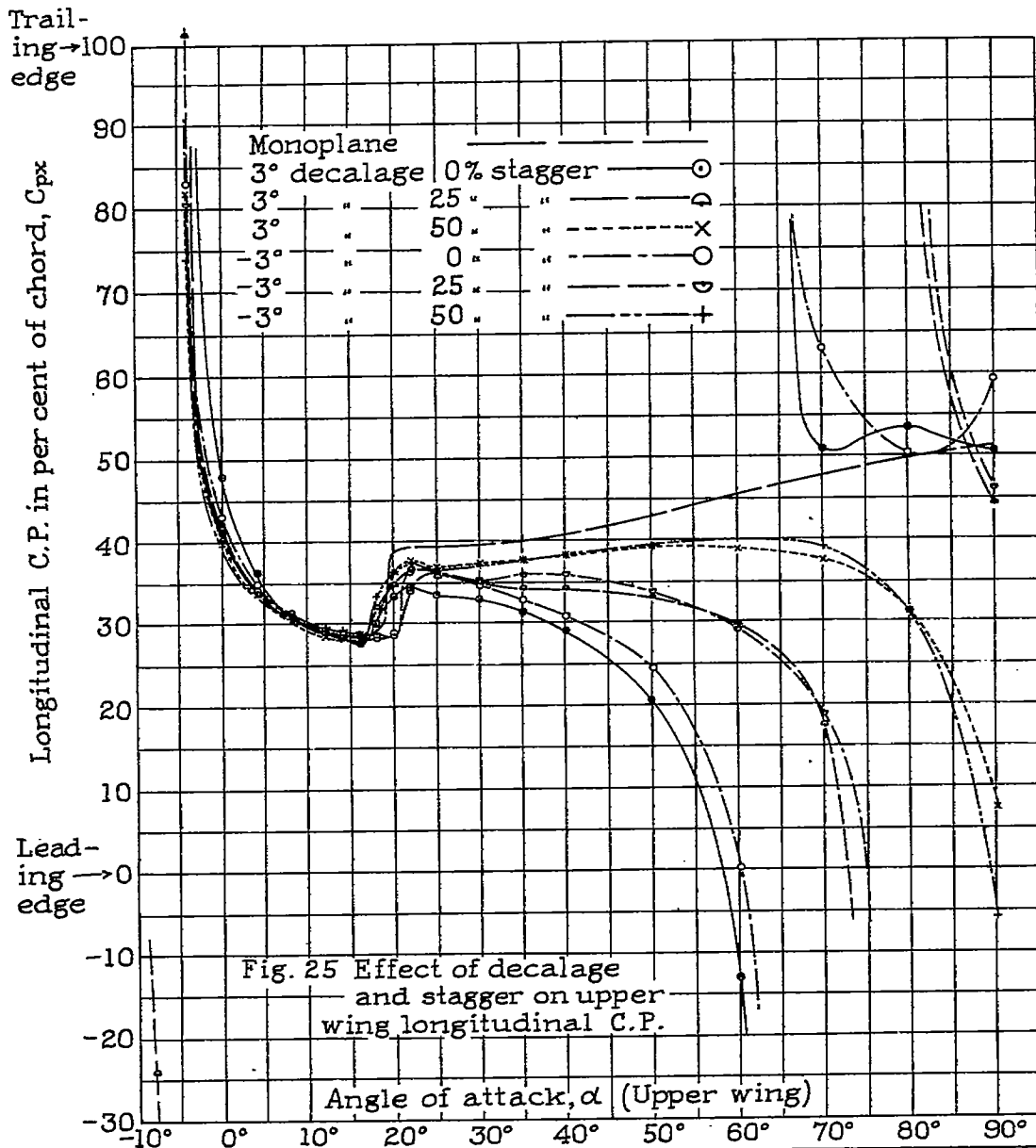


Fig. 24 Effect of decalage and stagger on wing load ratio.



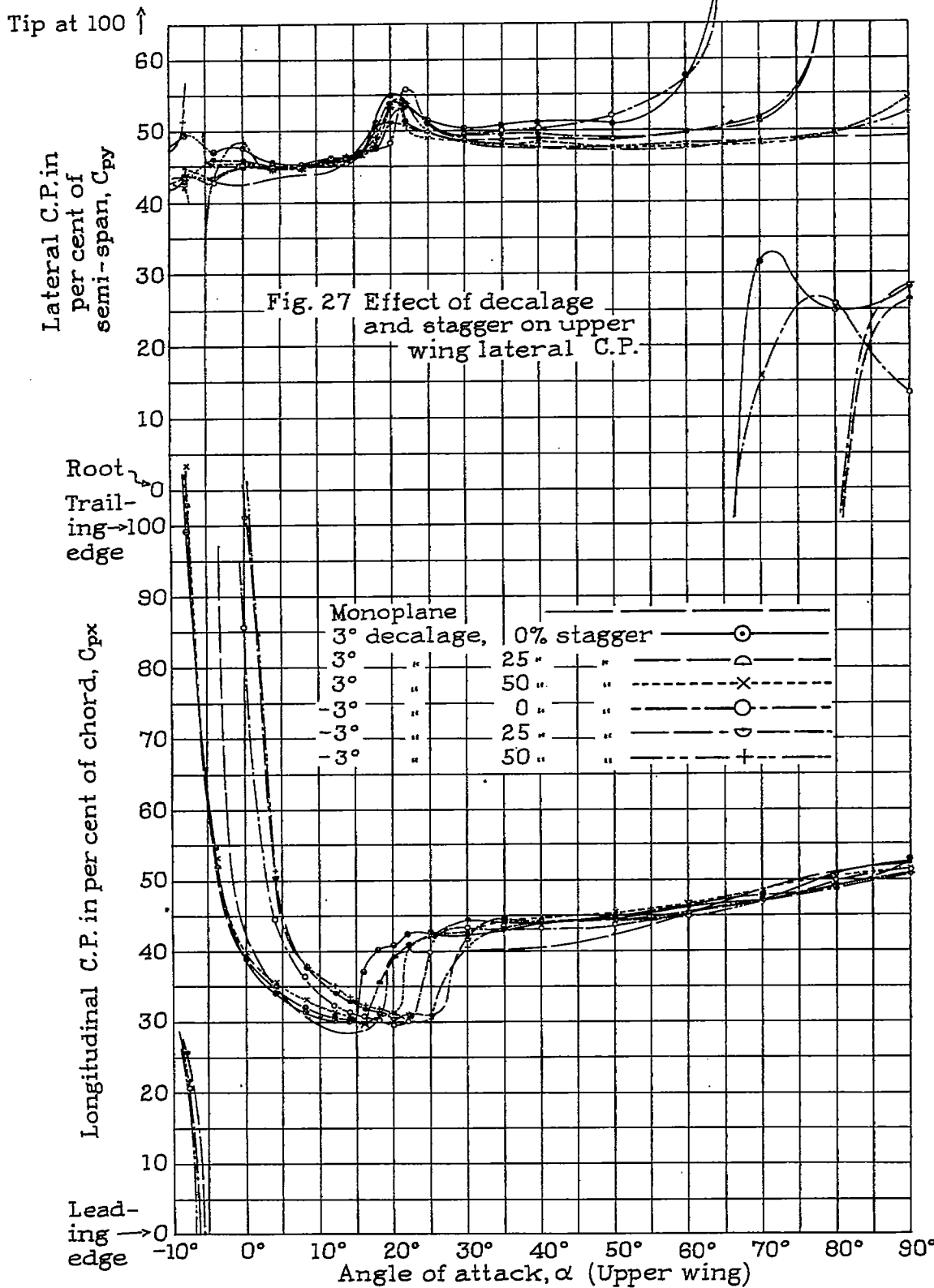


Fig. 27 Effect of decalage and stagger on upper wing lateral C.P.

Fig. 26 Effect of decalage and stagger on lower wing longitudinal C.P.

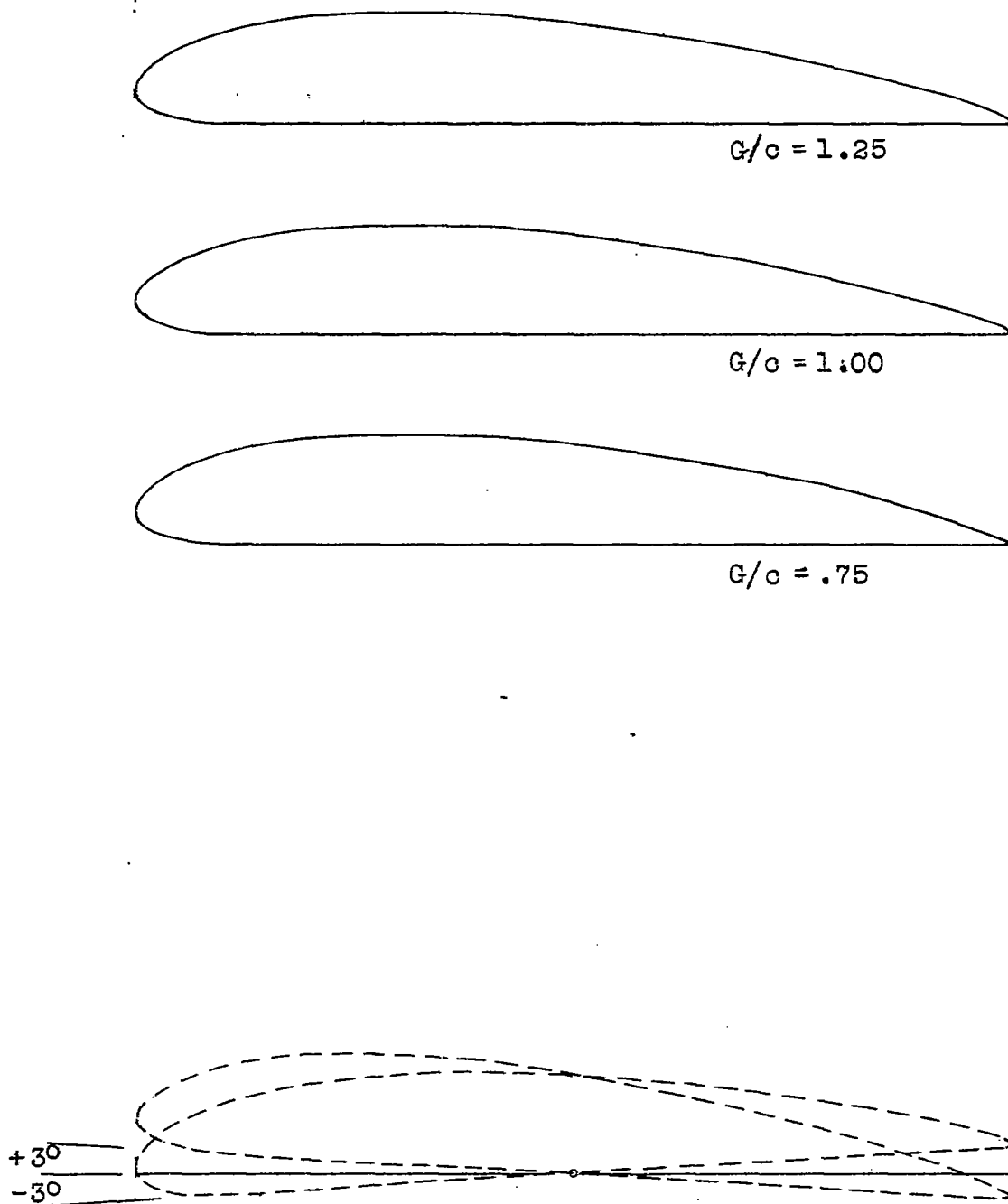


Fig.29 Wing model arrangements used in tests on the effect of gap and decalage.

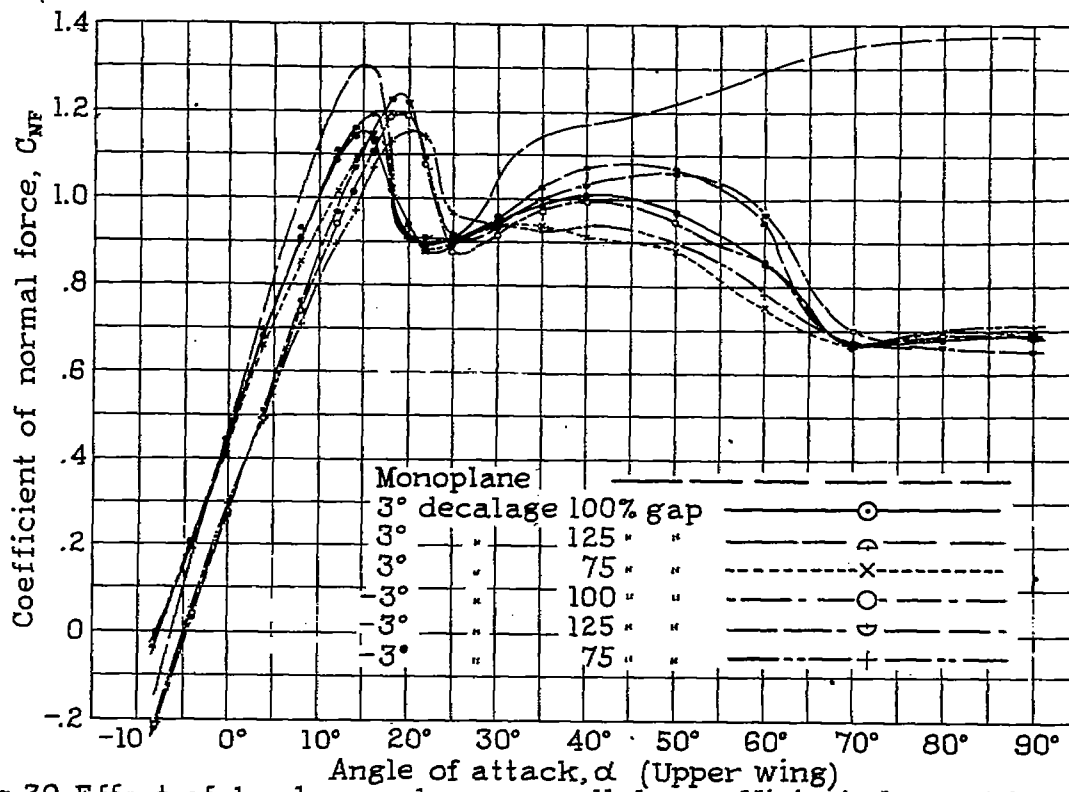


Fig.30 Effect of decalage and gap on cellule coefficient of normal force.

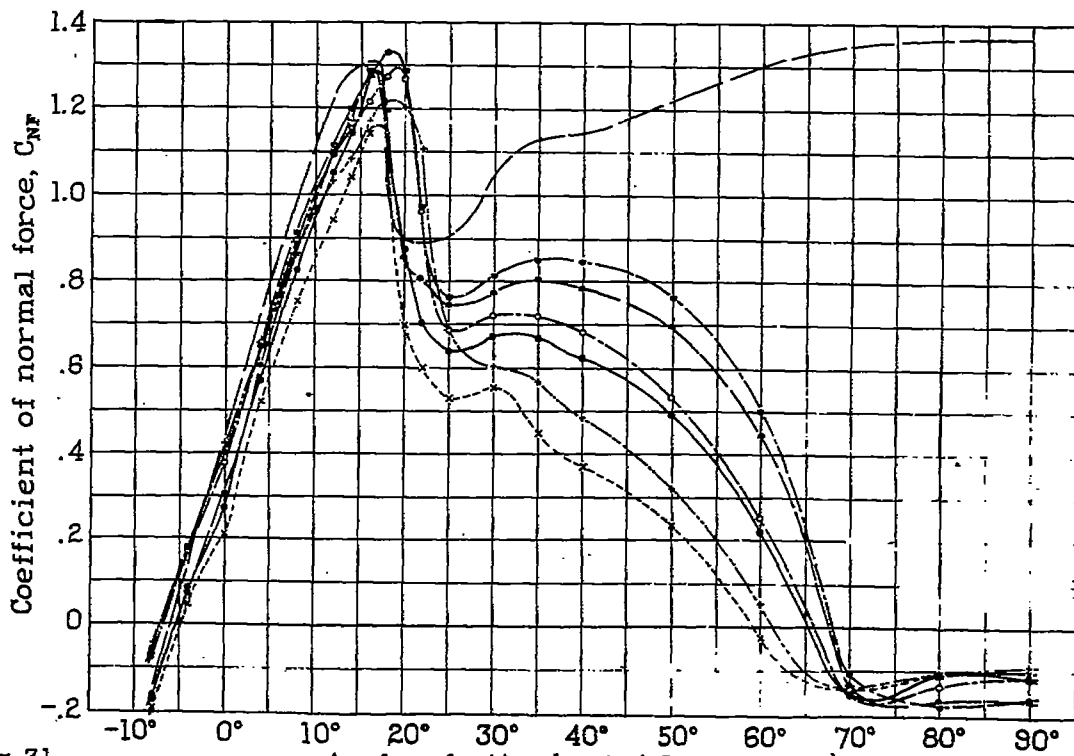


Fig.31 Effect of decalage and gap on upper wing coefficient of normal force.

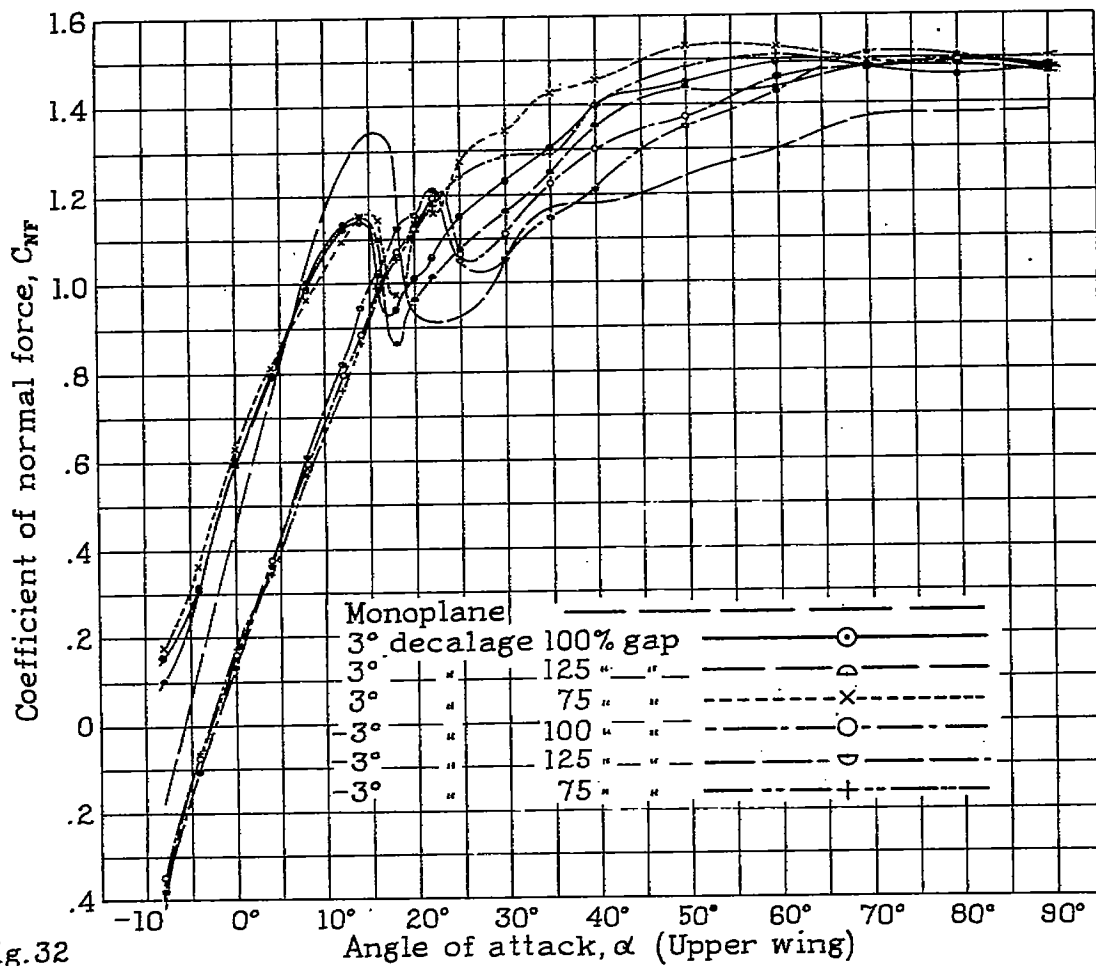


Fig.32 Effect of decalage and gap on lower wing coefficient of normal force.

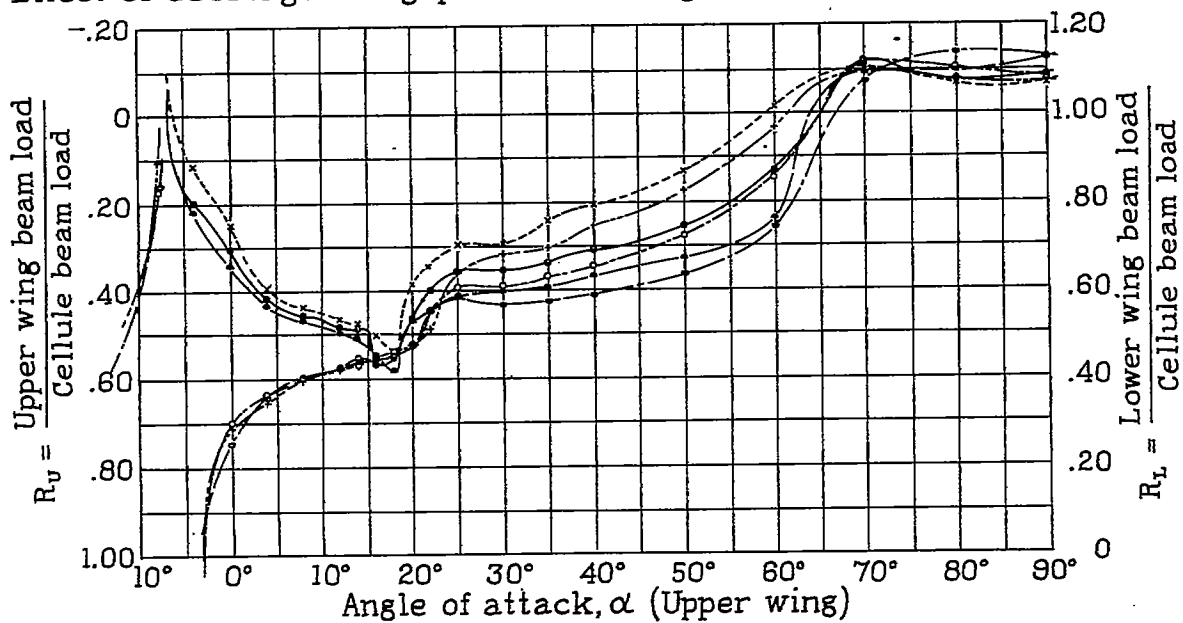


Fig.33 Effect of decalage and gap on wing load ratio.

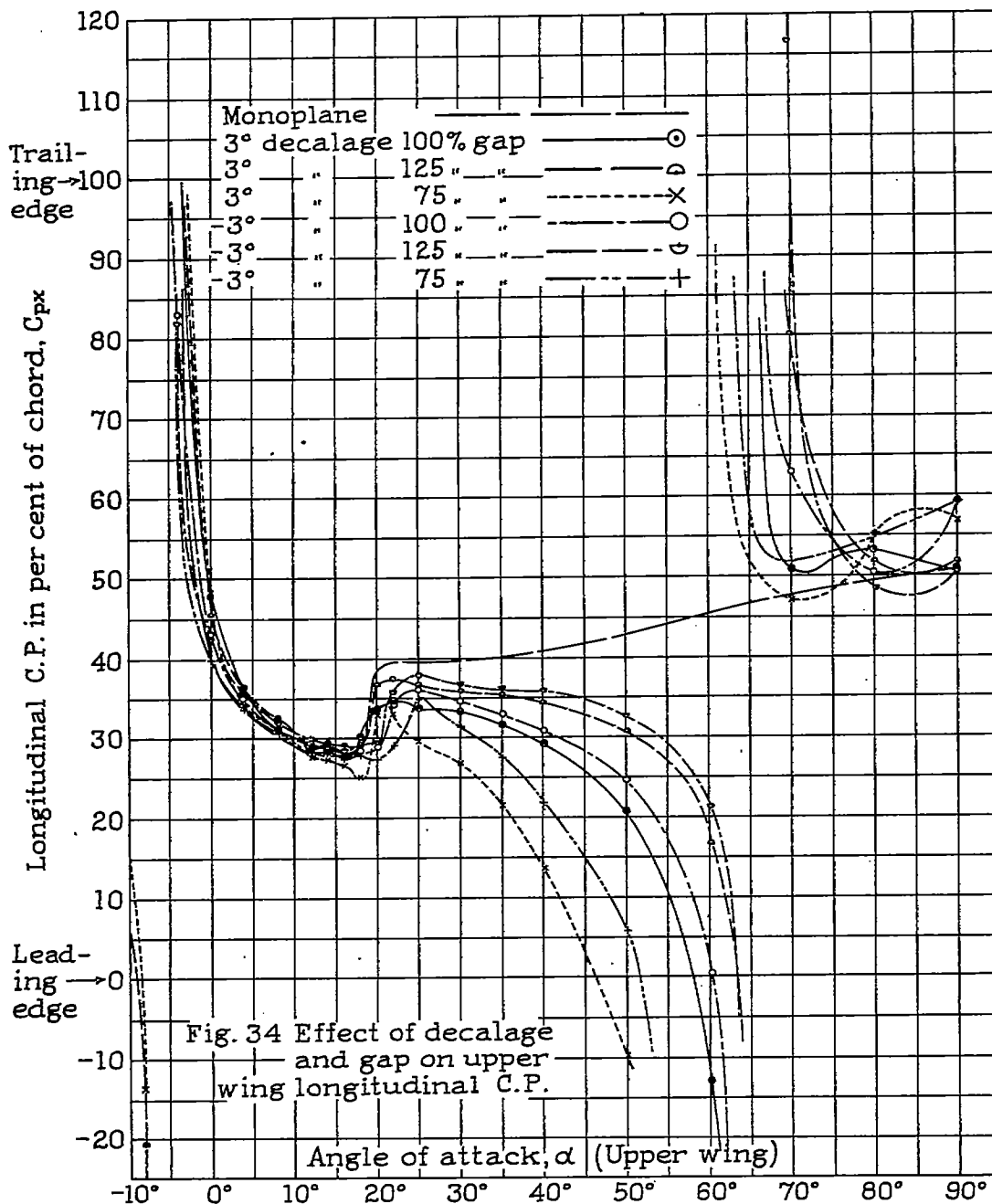


Fig. 34 Effect of decalage and gap on upper wing longitudinal C.P.

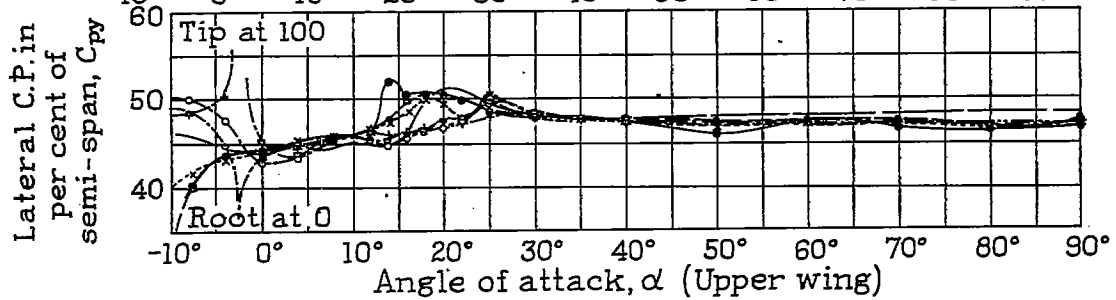


Fig. 37 Effect of decalage and gap on lower wing lateral C.P.

