NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

REPORT No. 400

THE AERODYNAMIC CHARACTERISTICS OF A SLOTTED CLARK Y WING AS AFFECTED BY THE AUXILIARY AIRFOIL POSITION

By CARL J. WENZINGER and JOSEPH A. SHORTAL

1931

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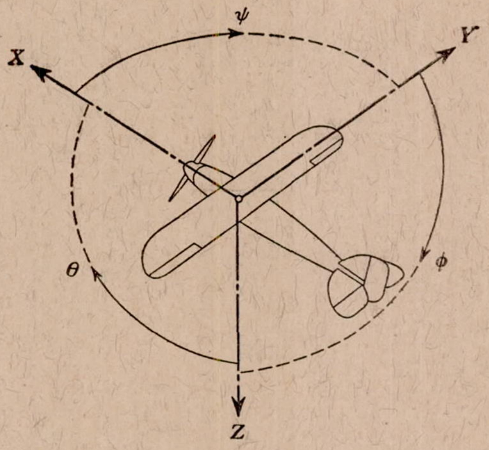

Positive directions of axes and angles (forces and moments) are shown by arrows

Axis		Force (parallel to axis) symbol	Moment about axis			Angle		Velocities	
Designation	Symbol		Designation	Symbol	Positive direction	Designation	Symbol	Linear (component along axis)	Angular
Longitudinal	X	X	rolling	L	$Y \longrightarrow Z$	roll	ϕ	u	p
Lateral	Y	Y	pitching	M	$Z \longrightarrow X$	pitch	θ	v	q
Normal	Z	Z	yawing	N	$X \longrightarrow Y$	yaw	ψ	w	r

Absolute coefficients of moment

$$C_l = \frac{L}{qbS} \qquad C_m = \frac{M}{qcS} \qquad C_n = \frac{N}{qbS}$$

Angle of set of control surface (relative to neutral position), δ. (Indicate surface by proper subscript.)

4. PROPELLER SYMBOLS

D, Diameter.
p, Geometric pitch.
p/D, Pitch ratio.
V', Inflow velocity.
V_s, Slipstream velocity.
T, Thrust, absolute coefficient $C_T = \frac{T}{\rho n^2 D^4}$
Q, Torque, absolute coefficient $C_Q = \frac{Q}{\rho n^2 D^5}$

P, Power, absolute coefficient $C_P = \frac{P}{\rho n^3 D^5}$.
C_s, Speed power coefficient $= \sqrt[5]{\frac{\rho V^5}{P n^2}}$.
η, Efficiency.
n, Revolutions per second, r. p. s.
Φ, Effective helix angle $= \tan^{-1}\left(\frac{V}{2\pi r n}\right)$

5. NUMERICAL RELATIONS

1 hp = 76.04 kg/m/s = 550 lb./ft./sec.
1 kg/m/s = 0.01315 hp
1 mi./hr. = 0.44704 m/s
1 m/s = 2.23693 mi./hr.

1 lb. = 0.4535924277 kg
1 kg = 2.2046224 lb.
1 mi. = 1609.35 m = 5280 ft.
1 m = 3.2808333 ft.

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NAVY BUILDING, WASHINGTON, D. C.

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SUMMARY

Aerodynamic force tests on a slotted Clark Y wing were conducted in the vertical wind tunnel of the National Advisory Committee for Aeronautics to determine the best position for a given auxiliary airfoil with respect to the main wing. A systematic series of 100 changes in location of the auxiliary airfoil were made to cover all the probable useful ranges of slot gap, slot width, and slot depth. The results of the investigation may be applied to the design of automatic or controlled slots on wings with geometric characteristics similar to the wing tested.

An increase of 41.5 per cent in the maximum lift above that of the plain wing was obtained for the slotted Clark Y wing. At the same time, the angle of attack for maximum lift was increased 13°. It was found that a maximum increase of about 30° was possible in the highest stalling angle, but at a maximum lift coefficient slightly less than that of the plain wing. However, with one slot position, an increase of 25°, together with an increase in the maximum lift coefficient of 23.3 per cent, was obtained. The best positions of the auxiliary airfoil were covered by the range of the tests, and the position for desired aerodynamic characteristics may easily be obtained from charts prepared especially for the purpose.

INTRODUCTION

Lateral stability and control up to large angles of attack form an important part in the program of research relating to safety in flight now being conducted by the National Advisory Committee for Aeronautics. A series of tests, comparing a large number of devices for obtaining lateral control and stability, has been started in the atmospheric wind tunnels. A wing with slots and ailerons (one of the standard forms in common use) will be tested among the first, to serve as a basis of comparison for special devices.

By the use of slots, a large increase in the maximum lift coefficient is obtained and the angle of attack is raised considerably above that at which the plain wing would ordinarily stall. The slots prevent the air flow over the wing from breaking away at the usual stalling speed, and so cause the wing to retain its lift and the controls to function normally.

A study was made of the available data on slotted wings, the development of which has been due largely to G. Lachmann and Handley Page. The study showed that the total ranges in geometric characteristics of the auxiliary airfoil had been about as follows (references 1 to 12, inclusive):

Item	Maximum, per cent chord	Minimum, per cent chord	Average of best results, per cent chord
Auxiliary airfoil chord	28.80	8.34	14.70
Cut-off	2.00	(1)	1.85
Maximum thickness	2.80	(1)	2.50
Slot gap	3.75	2.08	2.50
Slot width	17.50	6.68	13.00
Slot depth	[2] 4.00	[3] 3.31	[2] 3.00

[1] Thin plate. [2] Below "C." [3] Above "C."

The geometric variables of the auxiliary airfoil and main wing are defined in Figure 1. All dimensions are given as percentages of the main wing chord with the slot closed.

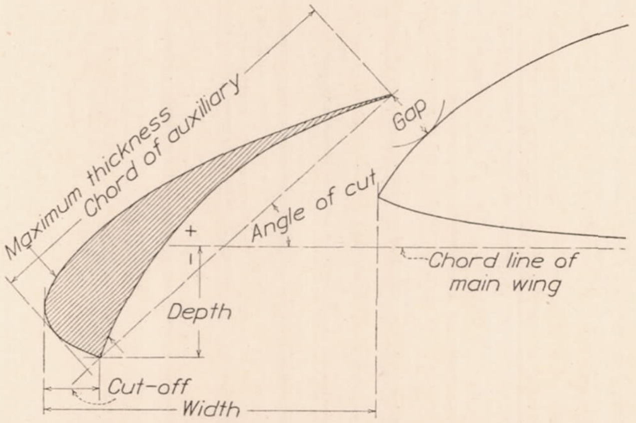


FIGURE 1.—Variable geometric factors—slotted Clark Y wing

The total ranges covered were large, but individual tests each included only a small portion of the total, and as a result the information obtained was inadequate to definitely determine the best slot for a given wing. However, from a consideration of the effects of the geometric variables on the highest maximum lift obtainable it was concluded that the shape and size of the auxiliary airfoil were not of great consequence, but that the position of a given auxiliary airfoil for best results was fairly critical. Listed in the order of their effectiveness as regards position, it appears that the factors are slot gap, slot width, and slot depth.

In order to obtain greater detailed information concerning the effects of changes of the auxiliary airfoil position, the investigation described in this report was undertaken. The best slot for the given main wing and auxiliary airfoil combination could then be found from the best aerodynamic characteristics obtained. The tests, which were made in the vertical wind tunnel (reference 13) of the National Advisory Committee for Aeronautics, included all the probable useful ranges of the auxiliary airfoil location. The results may be applied to the design of automatic or controlled slots for wings having geometric characteristics similar to those of the wing tested.

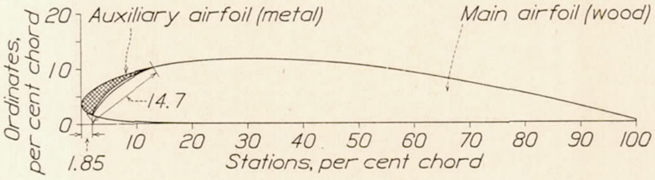


FIGURE 2.—Profile and ordinates of slotted Clark Y wing

Auxiliary airfoil			Main wing			Main wing		
Stations	Ordinates		Stations	Ordinates		Stations	Ordinates	
From leading edge	Upper surface	Lower surface	From leading edge	Upper surface	Lower surface	Form leading edge	Upper surface	Lower surface
Per cent chord	*Per cent chord*	*Per cent chord*	*Per cent chord*	*Per cent chord*	*Per cent chord*	*Per cent chord*	*Per cent chord*	*Per cent chord*
0.00	3.50	3.50	1.85	1.65	1.65	40.00	11.40	--------
1.25	5.45	1 93	2.50	(2)	1.47	50.00	10.51	--------
1.85	--------	1.65	5.00	--------	.93	60.00	9.15	--------
2.50	6.50	(1)	7.50	--------	.63	65.00	8.30	--------
5.00	7.90	--------	10.00	--------	.42	70.00	7.35	--------
7.50	8.85	--------	13.00	10.07	--------	80.00	5.22	--------
10.00	9.60	--------	15.00	10.69	.15	90.00	2.80	--------
13.00	10.27	10.07	20.00	11.36	.03	95.00	1.49	--------
			30.00	11.70	--------	100.00	.12	--------

[1] Use radius of 15.0 per cent c from sta. 1.85 to sta. 13.00 and corresponding ordinates.

[2] Use radius of 20.0 per cent c from sta. 1.85 to sta. 13.00 and corresponding ordinates.

METHOD AND APPARATUS

When these tests were undertaken the vertical wind tunnel was the only tunnel available. As the test results were to be applied directly to the design of large wings that would be tested in the 7 by 10 foot horizontal tunnel, it was desirable that the tests be made at the same Reynolds Number in both tunnels. The air speeds were the same, so the wing chords were made the same, 10 inches. However, the test section of the vertical tunnel being only 5 feet in diameter, a full-span wing of aspect ratio 6 could not be used. A half-span wing was therefore used, the remaining half span being replaced by a "reflection" plane placed at the dividing line. This plane extended across the jet and several chord lengths upstream and downstream from the model position. It was mounted normal to the wing chord and to the wing span.

As a result of the previous study of slotted wings, it was decided to use an auxiliary airfoil based on the average dimensions of the best of those tested elsewhere. Figure 2 shows the combination of auxiliary airfoil and main wing that was adopted. The chord of the auxiliary airfoil was 14.7 per cent and the "cut-off" (shown in fig. 1) was 1.85 per cent of the main wing chord. The trailing edge of the auxiliary airfoil extended back 13.0 per cent from the leading edge of the whole wing.

With the slot closed, the profile of the whole wing was that of a normal Clark Y. The upper surface of the auxiliary airfoil was therefore part of the profile of the nose of a Clark Y. Because of its small size, the auxiliary airfoil was made of aluminum alloy; the main wing was built of laminated mahogany. In the construction of the models, the ordinates were held accurate to within ±0.01 inch of those specified in Figure 2.

To provide a support for the auxiliary airfoil, a thin plate was mounted on each end of the main wing as shown in Figure 3. These plates were drilled with 16 holes and fitted with slots as shown. A small plate containing two pins, one of which fitted any of the holes, and the other of which fitted the slots, was fastened to each end of the auxiliary airfoil. Thus, it was possible to vary either the width or depth of the wing slot, keeping the gap and one of the other variables constant. A movable, thin metal clip was hinged at the trailing edge of the auxiliary airfoil at midspan and fastened firmly to the main wing to prevent the auxiliary airfoil from deflecting appreciably under the applied air loads.

Four sets of the drilled plates were designed so that the ranges of the variables of slot position were covered as follows:

Slot gap—1.5 to 3.5 per cent chord.
Slot width—3.35 to 15.0 per cent chord.
Slot depth—3.5 above to 4.0 per cent chord below the main wing chord.

The above total range was investigated by 100 different positions of the auxiliary airfoil, in addition to the slot closed condition, so that the best aerodynamic characteristics might be obtained.

The set-up of the semispan wing with the reflection plane and other apparatus is shown diagrammatically in Figure 4. The drag forces were transmitted by two fine wires to a platform balance mounted above the top of the tunnel. One wire was fastened to the wing near the root, and the other wire was located 1-chord length from the wing tip. These wires, which were parallel and vertical, passed inside two streamlined tubes extending through the upper set of tunnel guide vanes.

The lift forces were transmitted by a system of rigid steel rods and ball-bearing bell cranks to two balances mounted on the tunnel test floor. The rod carrying

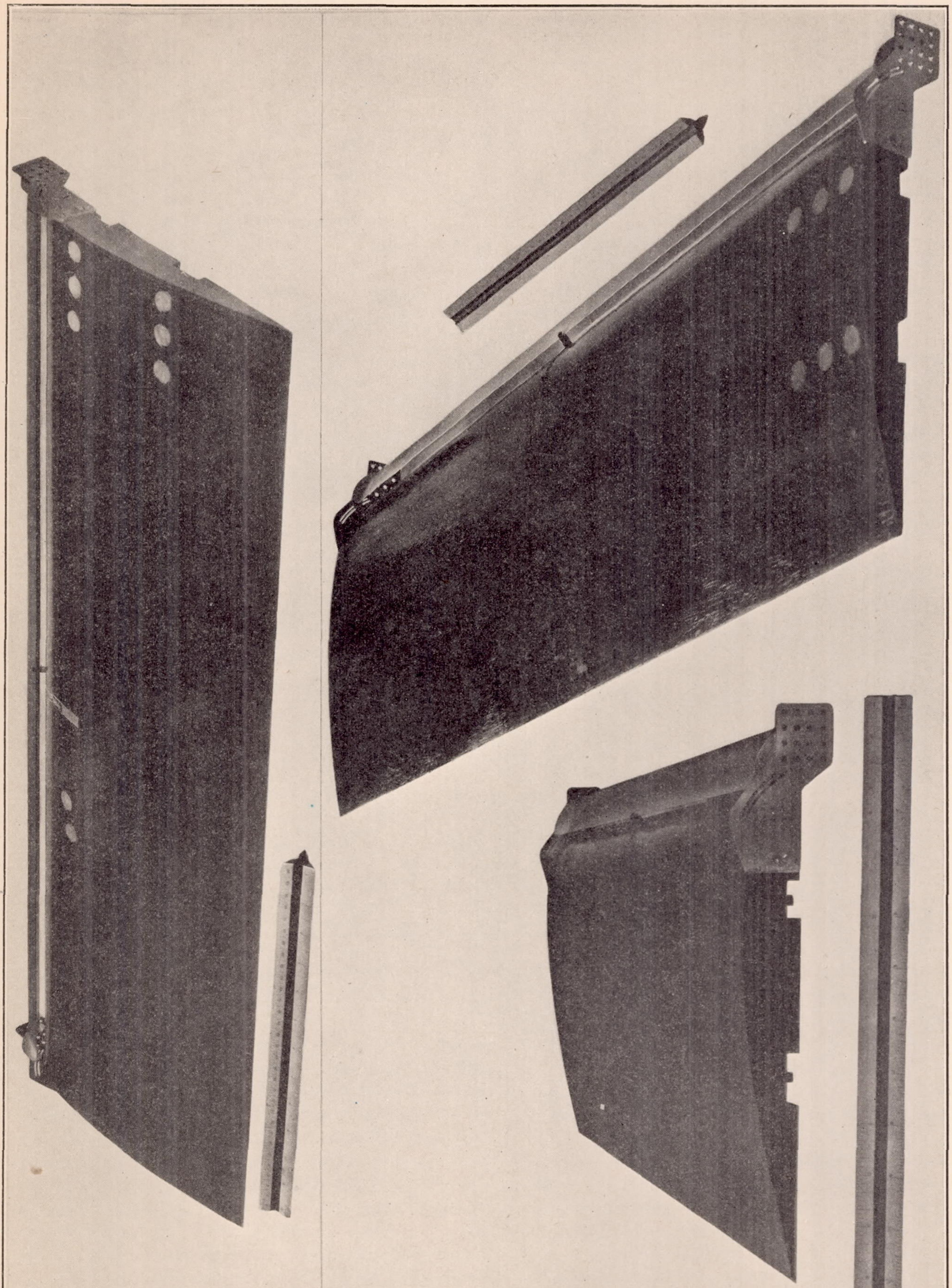


FIGURE 3.—Slotted Clark Y wing

most of the lift was fastened by a pin joint 1-chord length from the wing tip. Two other rods were attached behind the reflection plane near the wing root as shown in Figure 4, so as to balance the pitching moments of the wing and, in addition, to carry the remainder of the lifting forces. These two rods were horizontal and were both perpendicular to the wing span, being arranged to form a parallel linkage system.

The angle of attack was changed by turning a small gear meshed with a quadrant attached to the wing. The gear was fastened to a vertical rod forming one end of the above-mentioned linkage system. The lift of the wing was given by the sum of the two lift balance readings; in addition, rolling moments could be obtained by taking the differences between the products of each balance reading and the appropriate moment arms. This system was installed so that the effectiveness of different methods of control could be tested on the same set-up, if desired.

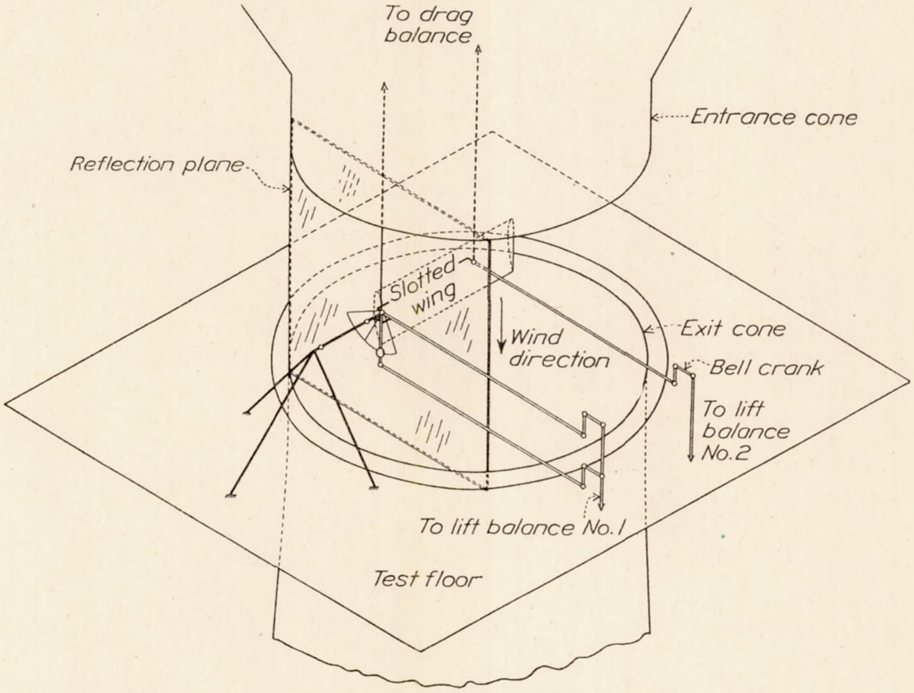


FIGURE 4.—Slotted Clark Y wing set-up in vertical tunnel

TESTS

The tests were all made at a dynamic pressure of 16.37 pounds per square foot, corresponding to an air speed of 80 miles per hour at standard atmospheric conditions. The Reynolds Number, based on the wing chord of 10 inches, was 609,000. The angle of attack range varied from $-6°$ to as high as $+46°$, depending on the stalling angle of the slot combination being tested.

Force tests were made with the auxiliary airfoil screwed tight to the main wing and faired with plasticine, as a basis for comparison between the results of the plain wing and those with the slot open at the 100 different combinations. Several readings were taken at 1-degree intervals to cover the region of minimum drag, and then the maximum lift was obtained in a similar manner. Tests were made also at a few intermediate angles of attack in order to determine the shapes of the lift and drag curves.

The lift balances were sensitive to within 0.06 pound, and the drag balance was sensitive to within 0.03 pound. The angle of attack setting was accurate to $\pm 0.1°$, and the dynamic pressure was maintained constant to within ± 0.5 per cent. From a comparison of the results of check tests, the variation between values of the maximum lift was found to amount to about ± 1.0 per cent.

RESULTS

The results, uncorrected for tunnel wall effects, are presented as absolute coefficients of lift and drag (C_L and C_D), in tabular and in chart form. The lift and drag coefficients, C_L and C_D, plotted against angle of attack for the various auxiliary airfoil positions are shown in Figures 5 to 24, inclusive. The wing area with the slot closed was used as the basic area in the calculations of C_L and C_D from these tests. Each figure gives the results with slot closed and faired and with five different slot widths at a given slot depth and constant slot gap. With this combination a series of four figures covers the results for one slot gap condition. Tables I to V, inclusive, give the values of the maximum lift coefficients ($C_{L\ max}$) and the corresponding values of the angles of attack for maximum lift ($\alpha_{C_{L\ max}}$) for all the auxiliary airfoil positions.

Contours of the maximum lift coefficients and of the corresponding angles of attack for maximum lift

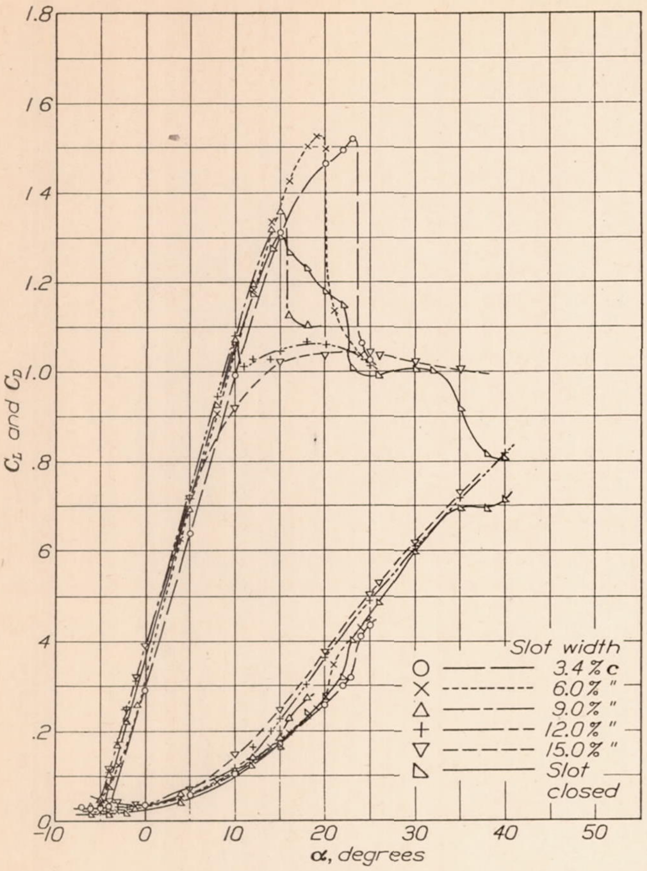


FIGURE 5.—C_L and C_D versus α. Slot gap =1.5 per cent c. Slot depth =3.5 per cent c above c

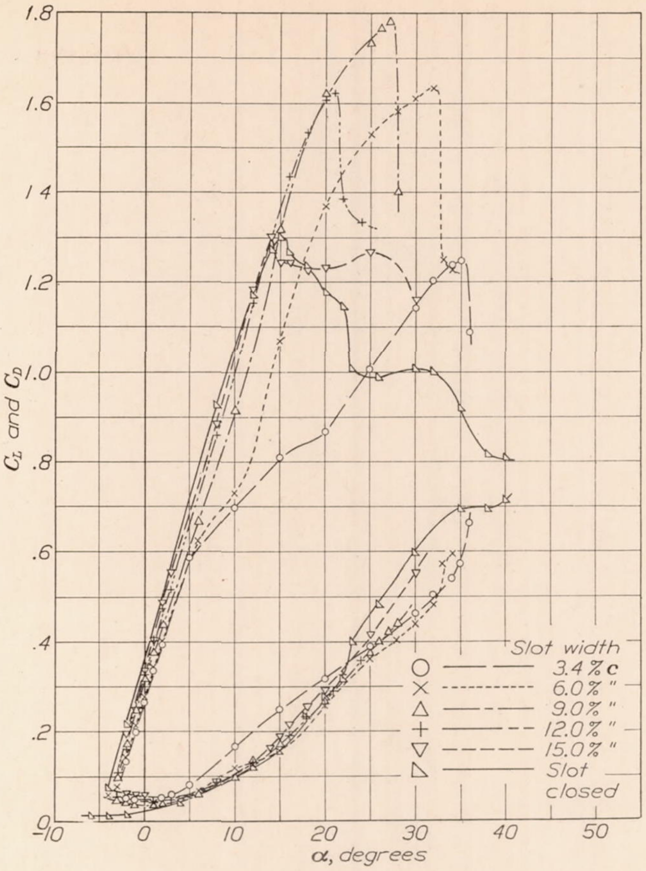


FIGURE 7.—C_L and C_D versus α. Slot gap =1.5 per cent c. Slot depth =1.5 per cent c below c

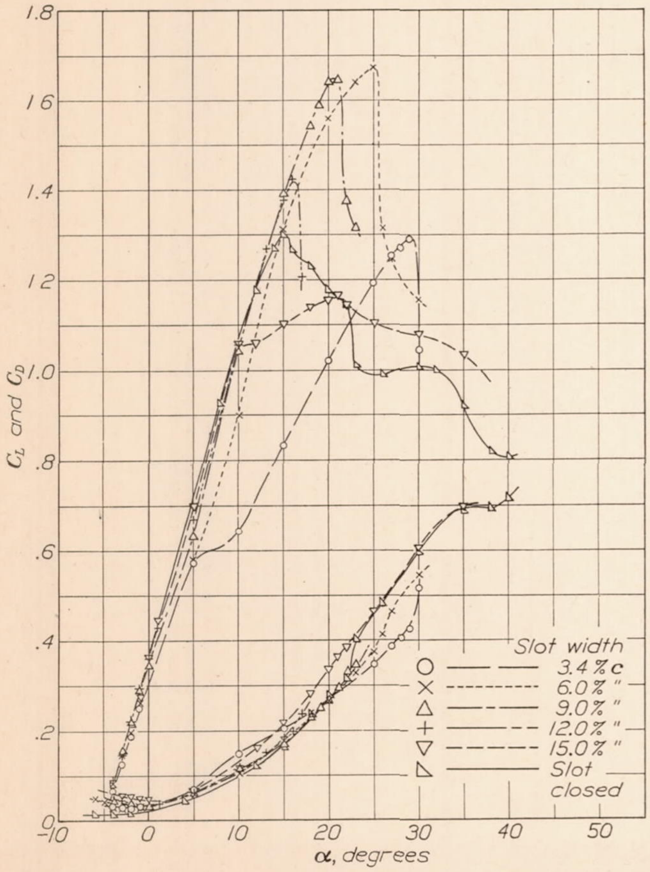


FIGURE 6.—C_L and C_D versus α. Slot gap =1.5 per cent c. Slot depth =1.0 per cent c above c

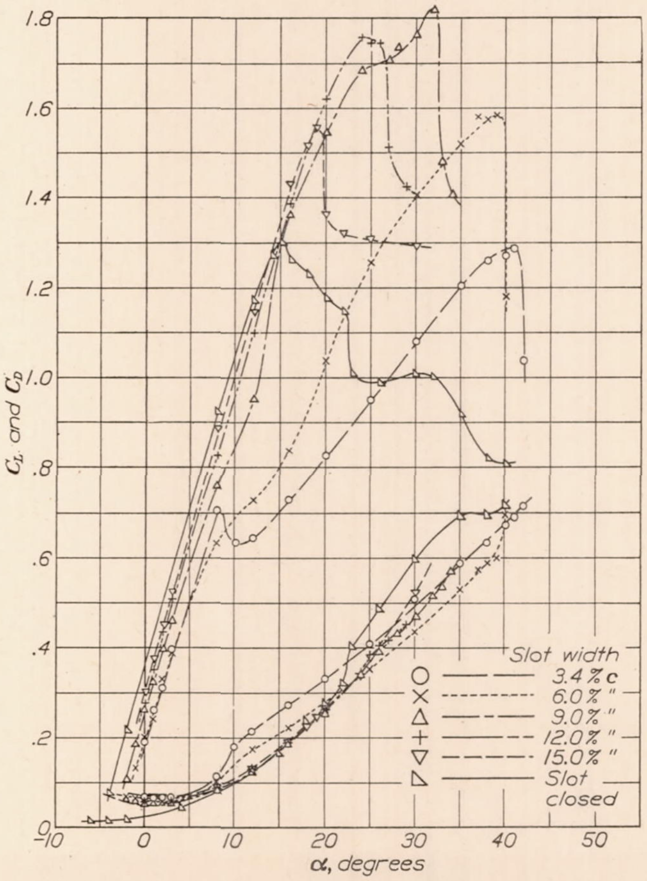


FIGURE 8.—C_L and C_D versus σ. Slot gap =1.5 per cent c. Slot depth =4.0 per cent c below c

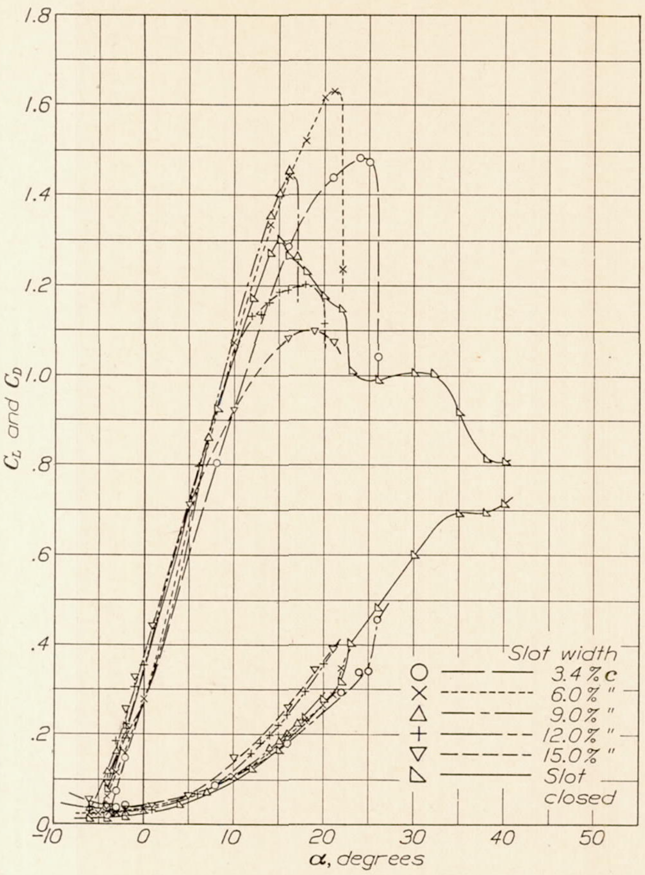


FIGURE 9.—C_L and C_D versus α. Slot gap=2.0 per cent c. Slot depth=3.5 per cent c above c

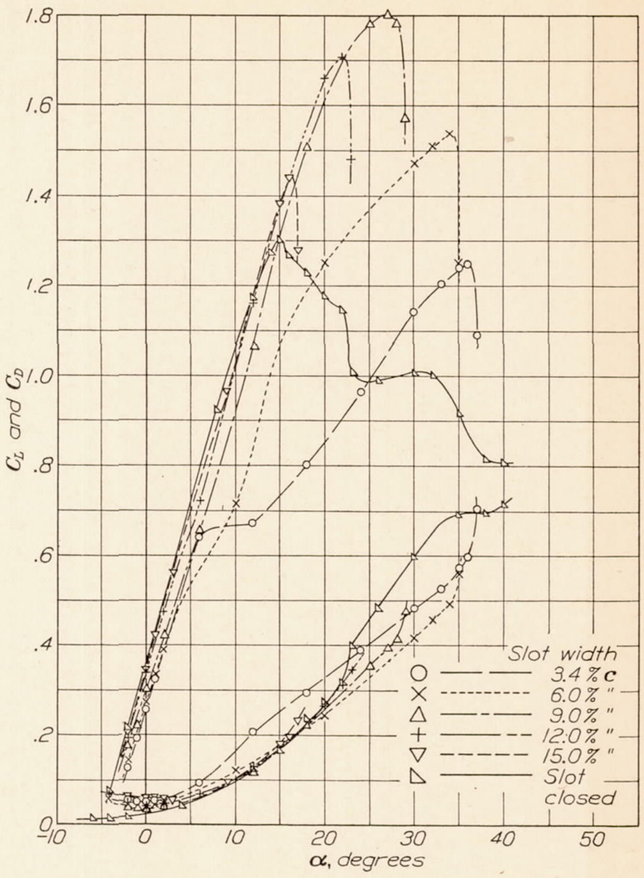


FIGURE 11.—C_L and C_D versus α. Slot gap=2.0 per cent c. Slot depth=1.5 per cent c below c

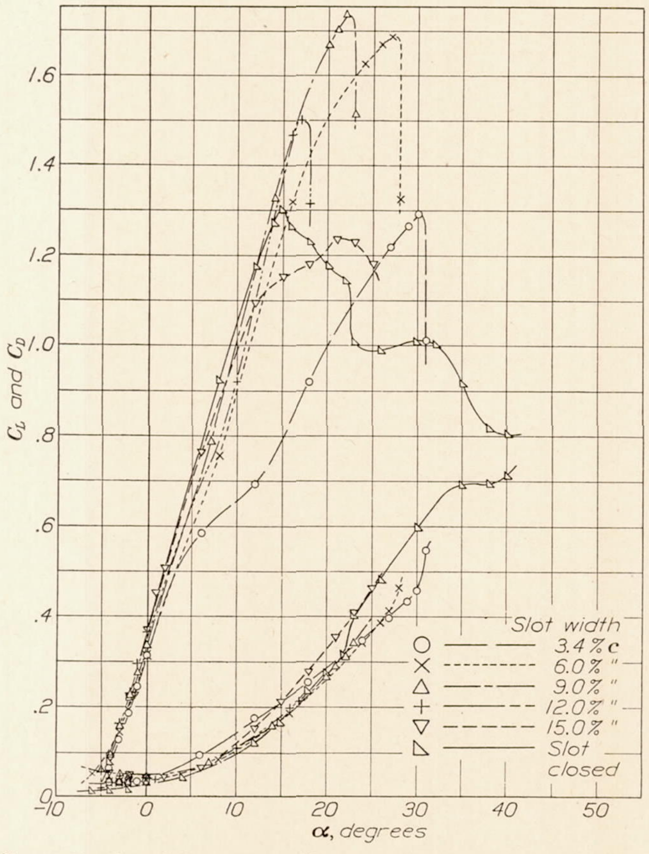


FIGURE 10.—C_L and C_D versus α. Slot gap=2.0 per cent c. Slot depth=1.0 per cent c above c

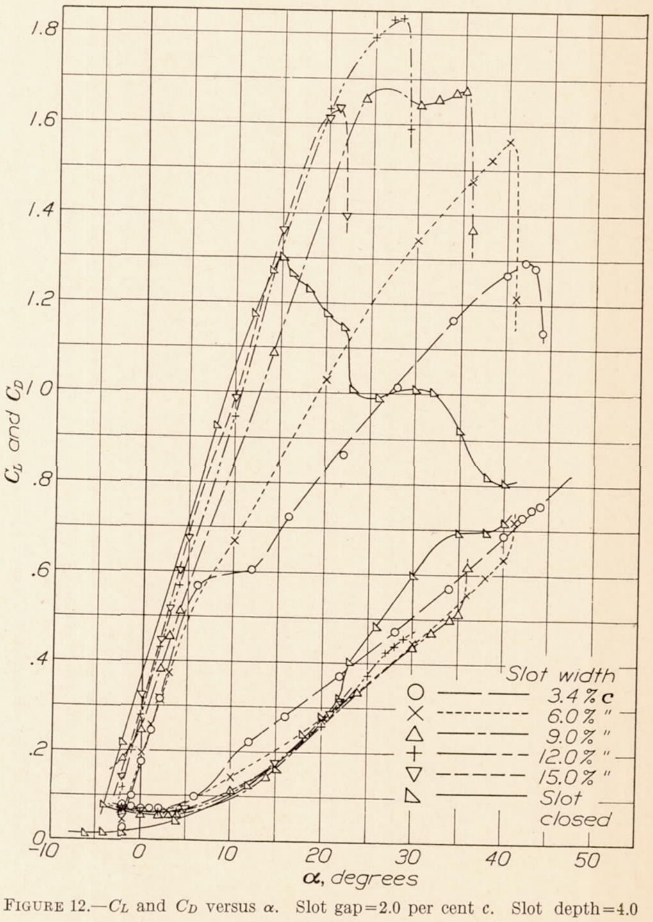


FIGURE 12.—C_L and C_D versus α. Slot gap=2.0 per cent c. Slot depth=4.0 per cent c below c

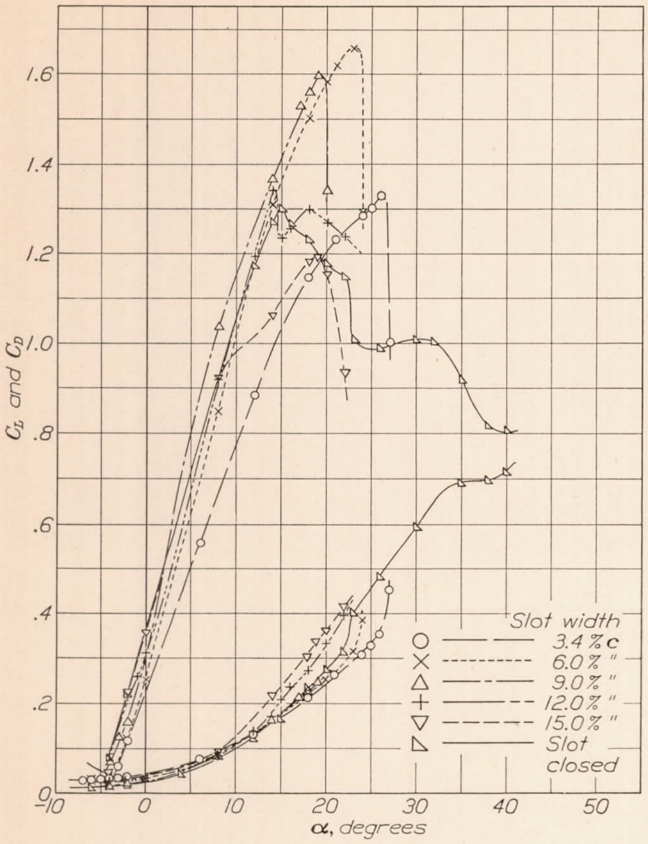


FIGURE 13.—C_L and C_D versus α. Slot gap=2.5 per cent c. Slot depth=3.5 per cent c above c

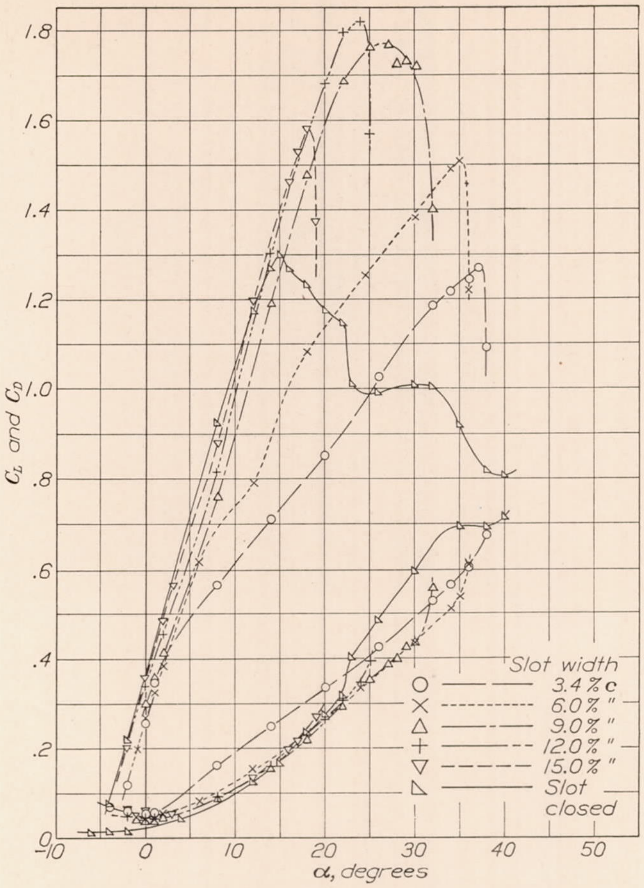


FIGURE 15.—C_L and C_D versus α. Slot gap=2.5 per cent c. Slot depth=1.5 per cent c below c

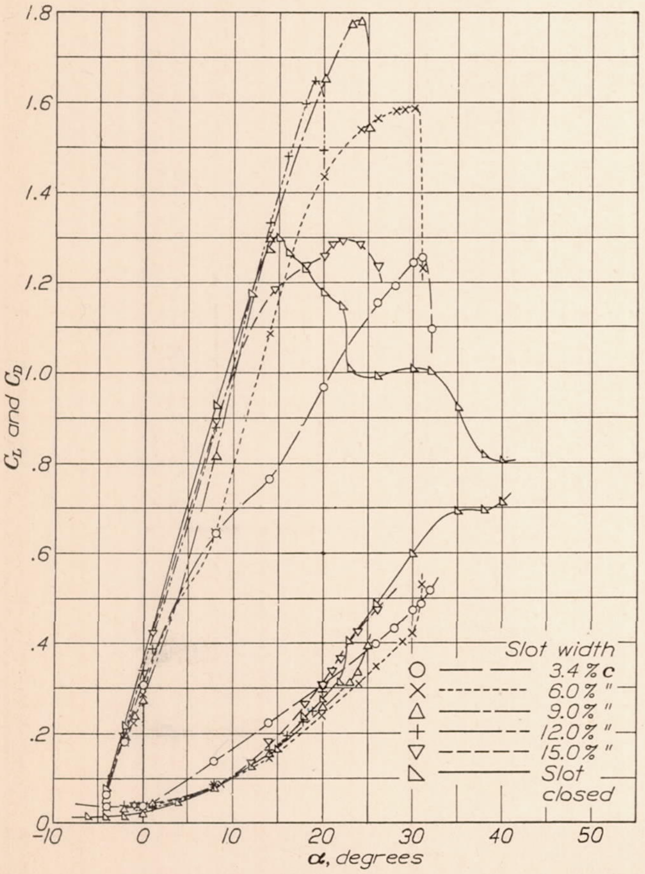


FIGURE 14.—C_L and C_D versus α. Slot gap=2.5 per cent c. Slot depth=1.0 per cent c above c

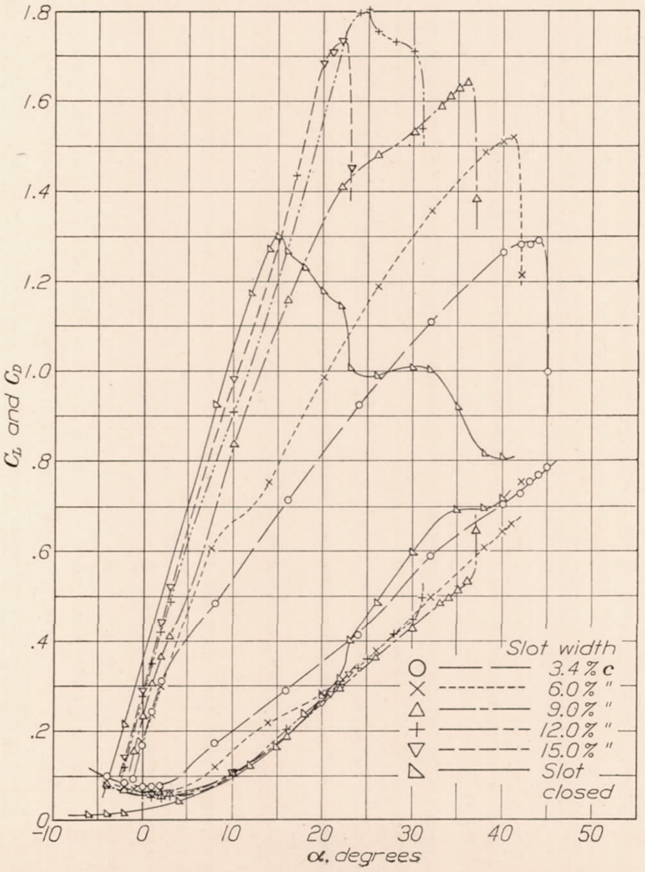


FIGURE 16.—C_L and C_D versus α. Slot gap=2.5 per cent c. Slot depth=4.0 per cent c below c

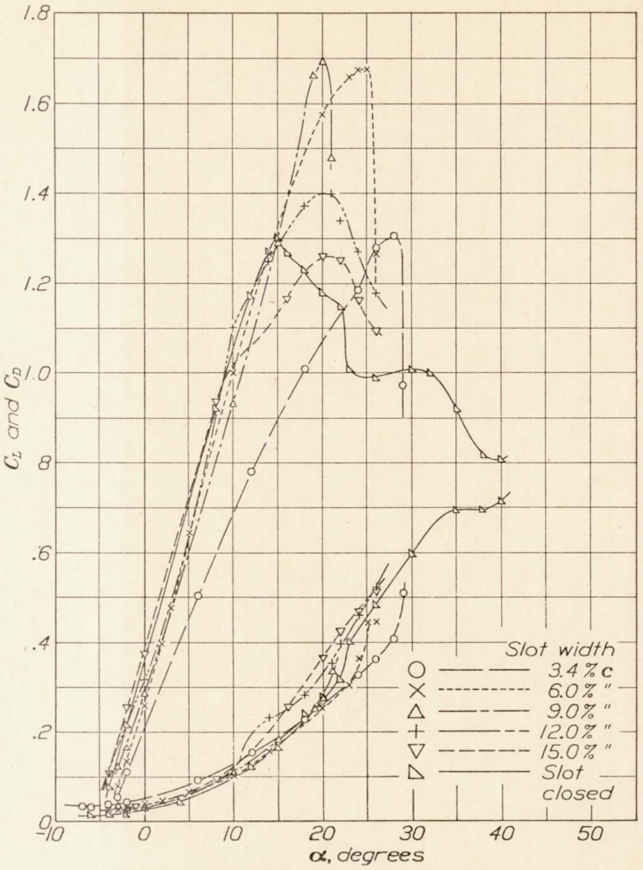


FIGURE 17.—C_L and C_D versus α. Slot gap=3.0 per cent c. Slot depth=3.5 per cent c above c

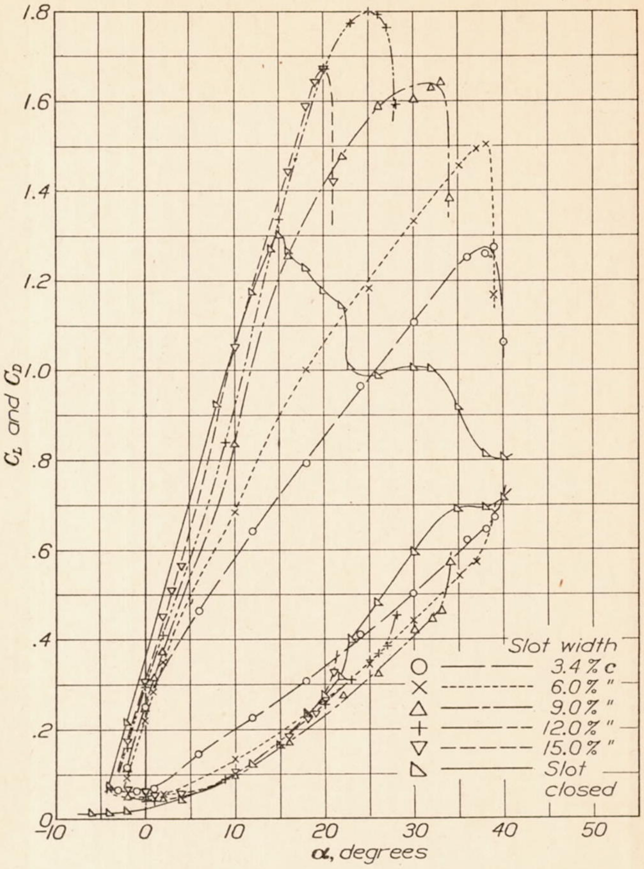


FIGURE 19.—C_L and C_D versus α. Slot gap=3.0 per cent c. Slot depth=1.5 per cent c below c

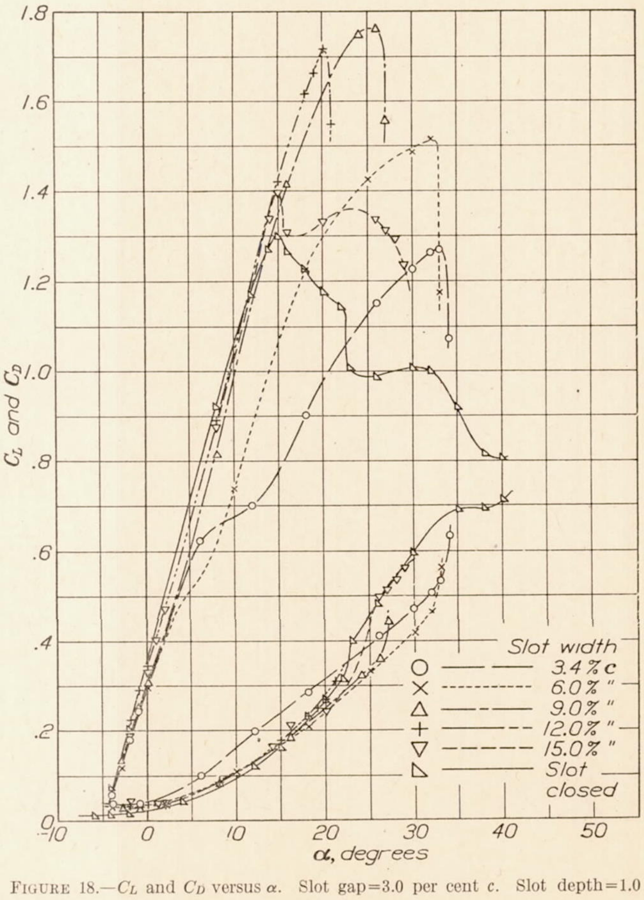


FIGURE 18.—C_L and C_D versus α. Slot gap=3.0 per cent c. Slot depth=1.0 per cent c above c

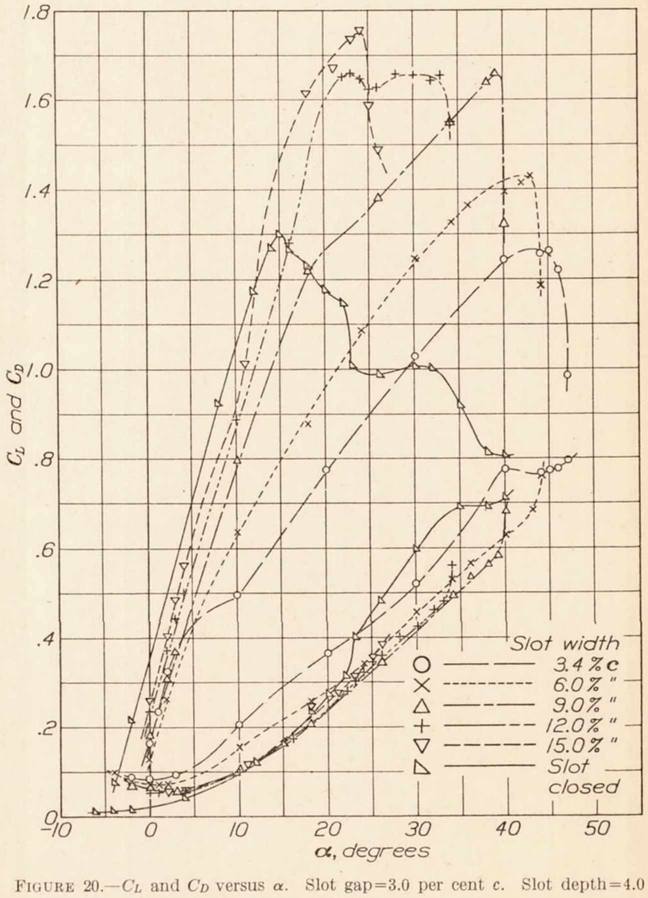


FIGURE 20.—C_L and C_D versus α. Slot gap=3.0 per cent c. Slot depth=4.0 per cent c below c

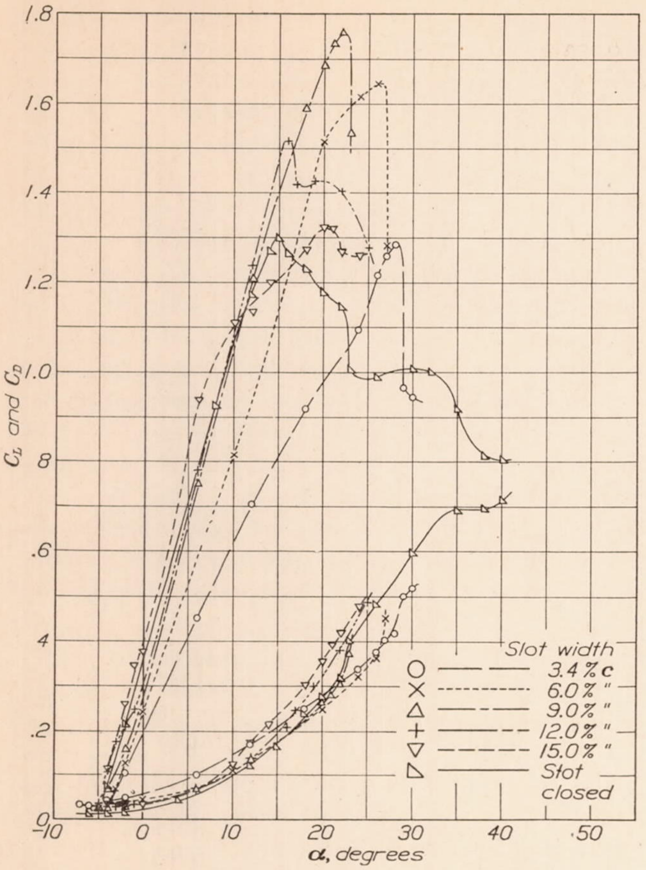


FIGURE 21.—C_L and C_D versus α. Slot gap=3.5 per cent c. Slot depth=3.5 per cent c above c

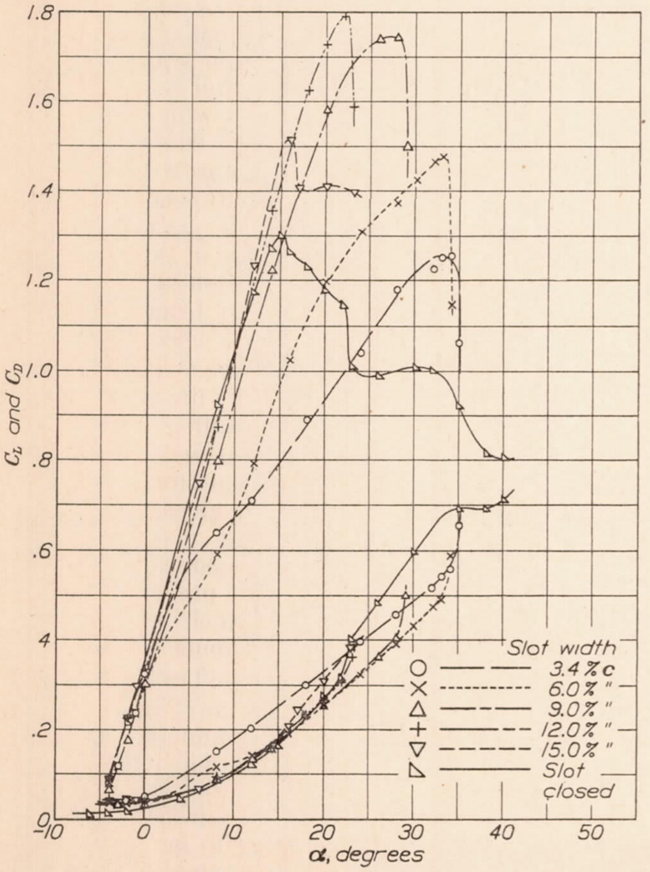


FIGURE 22.—C_L and C_D versus α. Slot gap=3.5 per cent c. Slot depth=1.0 per cent c above c

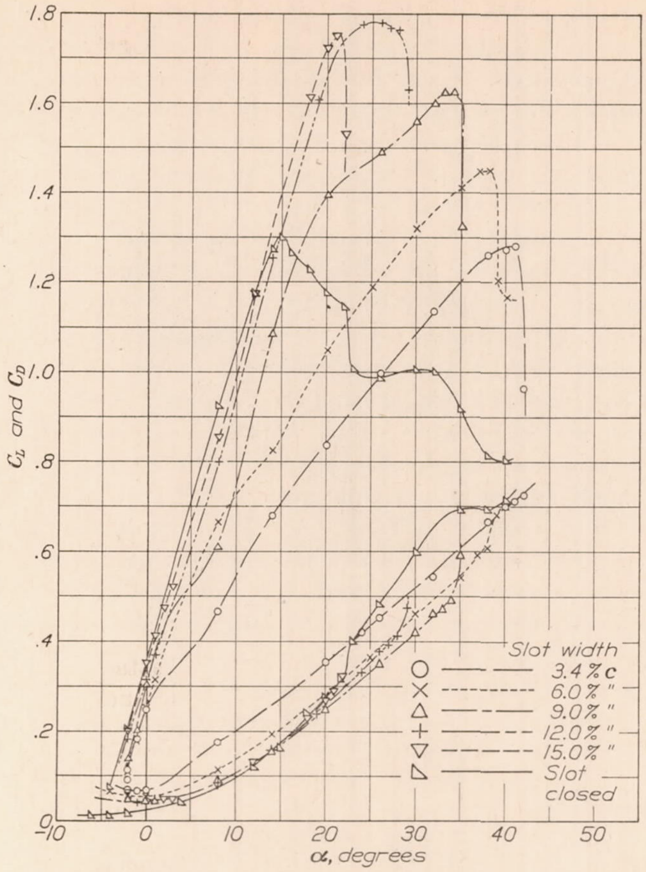


FIGURE 23.—C_L and C_D versus α. Slot gap=3.5 per cent c. Slot depth=1.5 per cent c below c

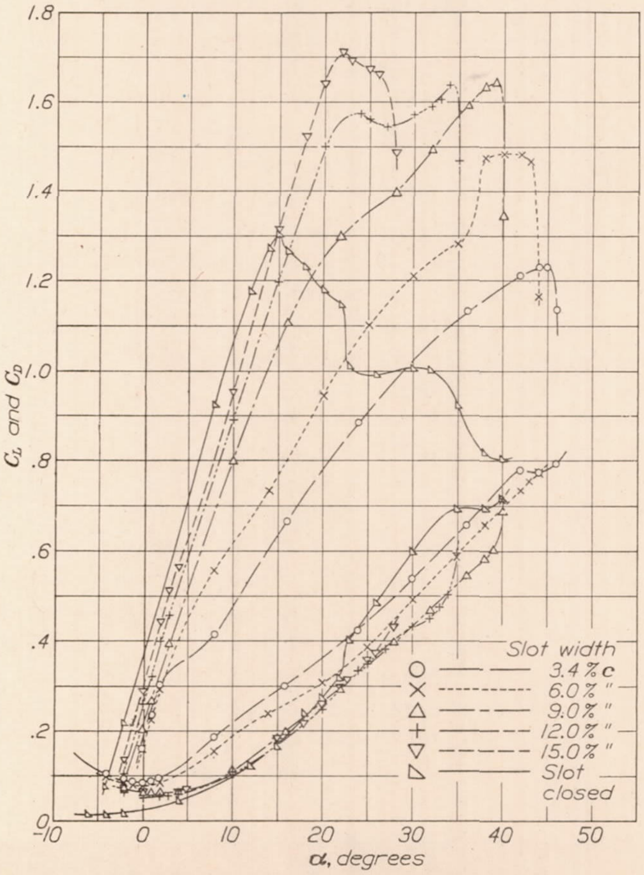


FIGURE 24.—C_L and C_D versus α. Slot gap=3.5 per cent c. Slot depth=4.0 per cent c below c

obtainable at given positions of the auxiliary airfoil with respect to the main wing are given in Figures 25 to 29, inclusive. Each contour line connects points of equal value of the maximum lift coefficient or of angle of attack for maximum lift. If the cut-off point (point X, figs. 25 to 29) of the auxiliary airfoil is placed at the position for a desired $C_{L\ max}$, the corresponding value of the angle of attack for maximum lift will be given by the same position on the contours of $\alpha_{C_{L\ max}}$. Each figure thus shows the possible combinations of maximum lift coefficient and corresponding angle of attack for maximum lift obtainable for any slot condition with a constant slot gap.

The best obtainable values of the maximum lift coefficients and of the highest angles of attack for maximum lift at given slot gaps, depths, and best widths are recorded in Table VI. The highest values of the maximum lift coefficients are tabulated first, followed by the corresponding values of the angles of attack for maximum lift. Then the highest values of the angles of attack for maximum lift are given, followed by their corresponding values of the maximum lift coefficients. The curves of highest maximum lift coefficients are shown in Figure 30 and the curves of highest angles of attack for maximum lift are given on Figure 31.

DISCUSSION

Although these tests were not made at full scale, the scale effect is probably small because the Reynolds Number is relatively large (609,000) and above the critical range. This value is about one-third of that for an ordinary small airplane while landing, the condition for which the results are of particular interest. The discussion of the results has been divided into four main parts: First, a general discussion of the effect of changes in the auxiliary airfoil position on the curves of lift and drag coefficients; second, a discussion of the effects of the position of the auxiliary airfoil on the maximum lift coefficients; third, the effects of the auxiliary airfoil location on the angles of attack for maximum lift; fourth, the choice of the optimum position of the auxiliary airfoil.

General.—The shapes of the curves of lift and drag coefficients are affected by changes in the slot widths for given slot depths (slot gaps constant) as shown in Figures 5 to 24, inclusive. It will be noted that large increases in the maximum lift are possible under certain conditions, and that under certain other conditions large increases in the angle of attack for maximum lift are obtainable. It can be seen that some of the lift coefficient curves are well rounded at the peaks, while others drop off quite sharply after the maximum has been reached. Up to the stalling angle of the wing with slot closed, it should be noted that the lift coefficient at a given angle of attack is generally somewhat lower for the wing with slot open than for the one with slot closed. The charts indicate also that the slopes of the lift coefficient curves for the slot open arrangements are, in general, somewhat increased by increasing the slot width at a given depth (slot gap constant). The tendency is to approach the curve for the wing with slot closed. (See figs. 5 to 24, inclusive.)

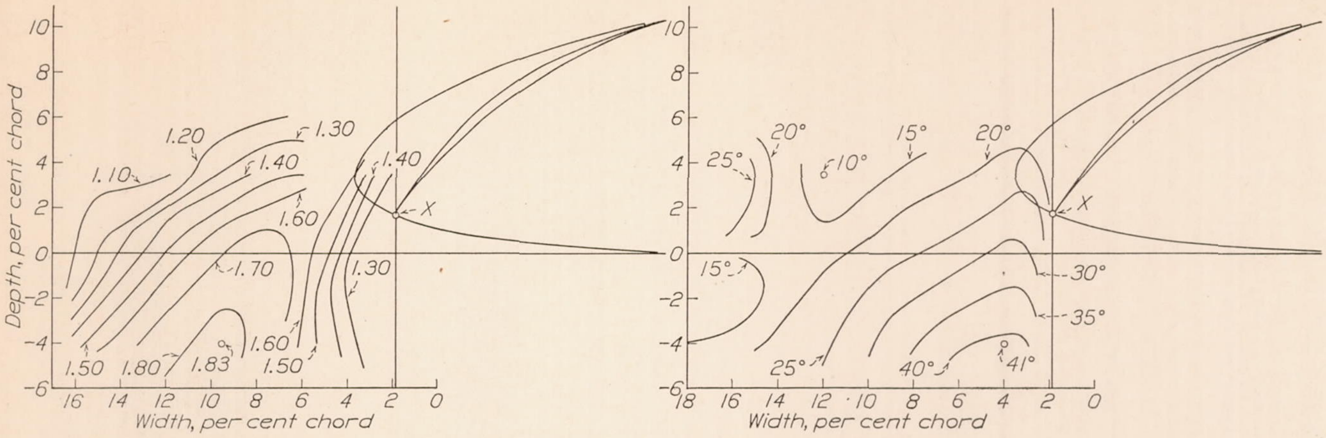
Although the tests were made with the view of applying the results to automatic slots, it may be noted that the widest slot width gives, in general, the highest drag values in the vicinity of zero lift. The drag values in this region are also increased by locating the auxiliary airfoil below rather than above the chord line of the main wing. However, at the high angles of attack between 24° and the stalling angle of the slotted wing, the drag of the slotted wing is lower than that of the wing with slot closed. (Figs. 5 to 24, inclusive.) An increase in the slot gap, other factors remaining the same, is also accompanied by an increase in the drag for the above range of angles of attack.

Maximum lift coefficient.—The manner in which the maximum lift coefficients are affected by changes in the auxiliary airfoil position may be seen by reference to the contours of $C_{L\ max}$. (Figs. 25 to 29, inclusive.) It will be noted that, for a constant slot gap, there is a best position of the auxiliary airfoil to give the highest maximum lift cœfficient. In this position the nose of the auxiliary airfoil is below and well forward of the nose of the main wing. Further displacement of the auxiliary airfoil (slot gap constant) back and upwards or down and forwards causes only small changes in the maximum lift coefficients for considerable displacements.

As the slot gap is increased, the nose of the auxiliary airfoil must be raised to obtain the highest maximum lift coefficient, while the distance out from the main airfoil varies somewhat but not in a clearly defined manner. Changes in the slot gap cause no appreciable differences in the highest maximum lift coefficients obtainable (fig. 30), the variations falling practically within the experimental error of the tests.

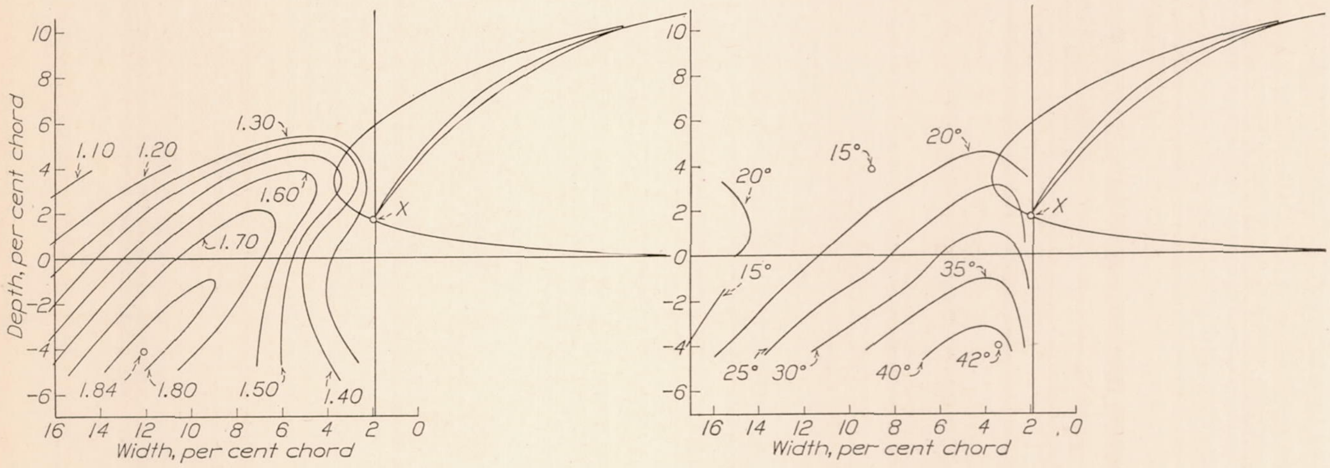
The largest increase in the maximum lift coefficient, from 1.297 (slot closed) to 1.835 (highest recorded), indicates an obtainable gain in the maximum lift coefficient of 41.5 per cent for the slotted Clark Y wing. This value compares favorably with previous results on slotted medium-thick wings in which increases up to 40 per cent were obtained. (Reference 3.)

Angle of attack for maximum lift.—There is a best position of the auxiliary airfoil (slot gap constant) for the highest angles of attack for maximum lift. (Figs. 25 to 29, inclusive.) This best position, however, is considerably different from that for the highest maximum lift coefficient. For the highest angles the nose of the auxiliary airfoil is found to be well below but close in to the nose of the main wing. Displacement of the auxiliary airfoil either upward or outward



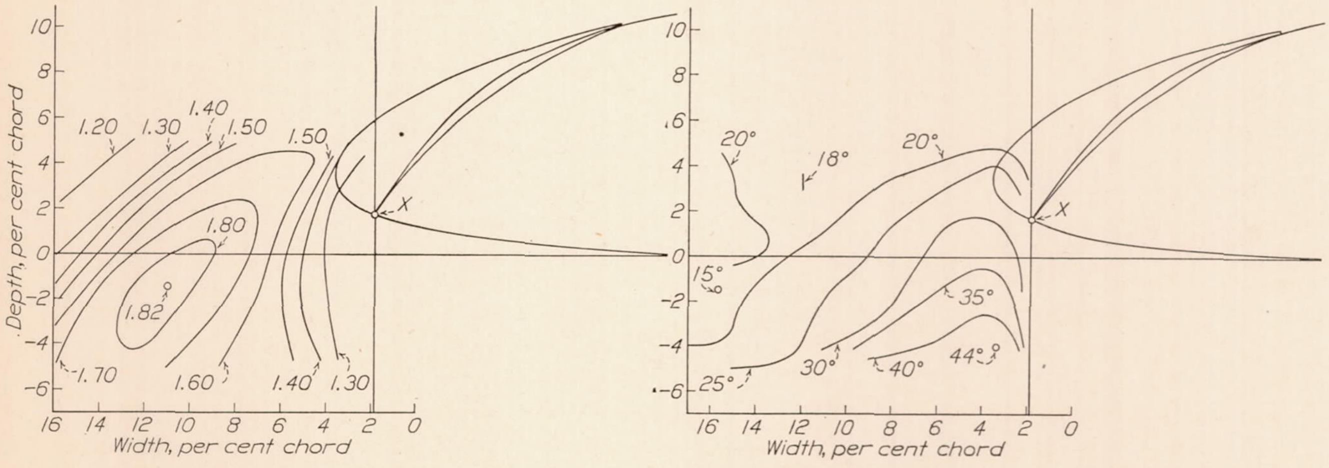
Maximum lift coefficient, $c_{L\ max.}$ Angle of attack for maximum lift, $\alpha_{c_{L\ max.}}$

FIGURE 25.—Locus of point X to obtain various airfoil characteristics. Gap=1.5 per cent c



Maximum lift coefficient, $c_{L\ max.}$ Angle of attack for maximum lift, $\alpha_{c_{L\ max.}}$

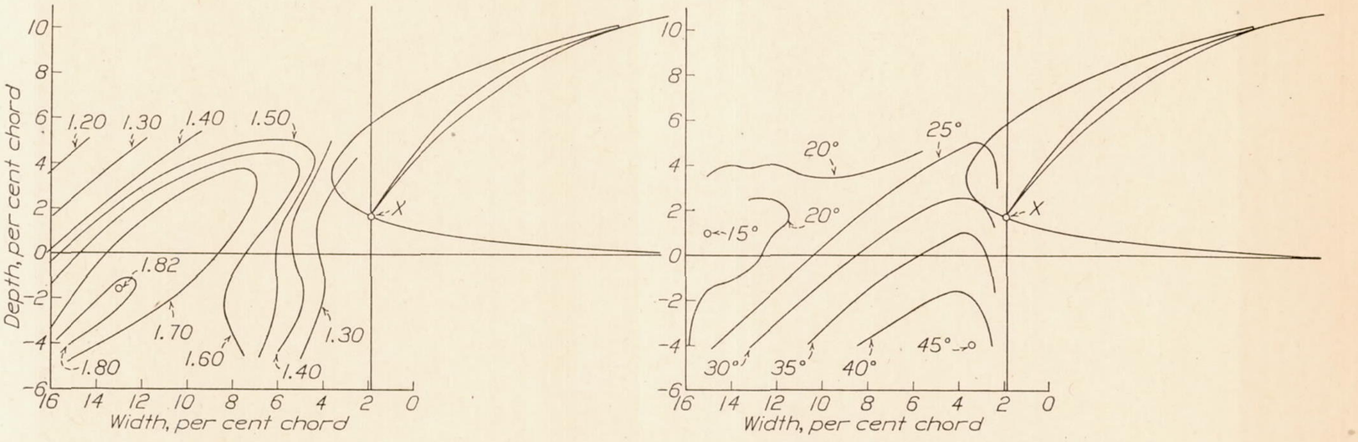
FIGURE 26.—Locus of point X to obtain various airfoil characteristics. Gag=2 per cent c



Maximum lift coefficient, $c_{L\ max.}$ Angle of attack for maximum lift, $\alpha_{c_{L\ max.}}$

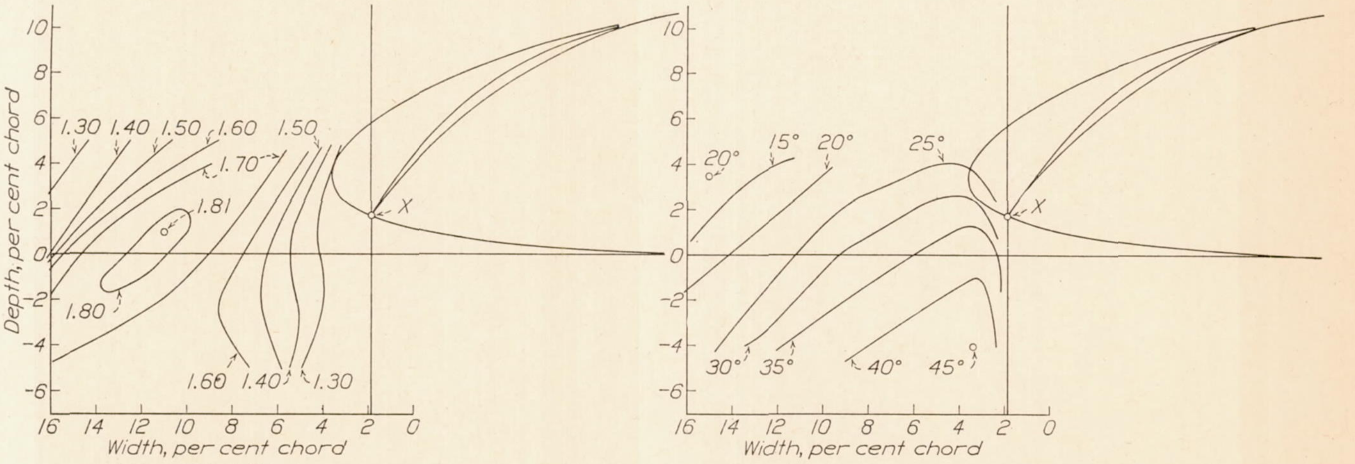
FIGURE 27.—Locus of point X to obtain various airfoil characteristics. Gap=2.5 per cent c

from the best position decreases the angle of attack for maximum lift. The highest angles of attack for maximum lift are obtained with the largest slot gaps. (See fig. 31.)



Maximum lift coefficient, $c_{L_{max}}$. Angle of attack for maximum lift, $\alpha_{c_{L_{max}}}$

FIGURE 28.—Locus of point X to obtain various airfoil characteristics. Gap=3.0 per cent c



Maximum lift coefficient, $c_{L_{max}}$. Angle of attack for maximum lift, $\alpha_{c_{L_{max}}}$.

FIGURE 29.—Locus of point X to obtain various airfoil characteristics. Gap=3.5 per cent c

The highest angle of attack for maximum lift obtained in this series of tests was 45° (figs. 28 and 29) as compared with the highest of 29° found in one of the available previous tests of slotted wings. (Reference 2.) Inasmuch as the angle of attack for maximum lift for the wing with the slot closed was 15°, the maximum attained in this investigation gives an increase in that angle of 30°. Although the high angles of attack for maximum lift are probably not of particular interest in connection with the use of full-span slots, they may be considered in the case of wing-tip slots in order to obtain the required lateral stability.

Choice of optimum position of the auxiliary airfoil.—The choice of the auxiliary airfoil position is dependent upon the most desired aerodynamic characteristics of the slotted wing. It is evident from the discussion of the effects of changes in the auxiliary airfoil position on the highest maximum lift coefficients and greatest angles of attack for maximum lift that these two values are not obtained simultaneously. A compromise must therefore be effected.

As mentioned previously, changes in the slot gap over the range tested have little effect on the highest values of the maximum lift coefficient. The highest value (1.84) was obtained for a slot gap of 2.0 per cent chord. Reference to Figure 26 then shows that, with the point X of the auxiliary airfoil at the position for $C_{L\ max}$ of 1.84, the slot width is 12.0 per cent chord, and the slot depth is 4.0 per cent chord below the main wing chord. The corresponding angle of attack for maximum lift is found to be about 28°. Figure 1 also shows the above geometrical arrangement to scale.

A high maximum lift coefficient, together with a high angle of attack for maximum lift, may be obtained with a larger slot gap than that above. Using a slot gap of 3.0 per cent chord (fig. 28), it may be seen, for example, that a maximum lift coefficient of 1.60 is obtainable with a corresponding angle of attack for maximum lift of 40°. These values are for a position of the auxiliary airfoil at a slot width of 8.0 per cent chord and a slot depth of 3.6 per cent chord below the main wing chord.

CONCLUSIONS

1. The best auxiliary airfoil locations, based on the highest maximum lift, have been found for the slotted wing tested, but the locations for highest maximum lift coefficients and highest angles of attack for maximum lift are not coincident.

2. An increase of 41.5 per cent in the maximum lift coefficient from the slot closed to the best open positions was obtained for a slotted Clark Y wing, with a corresponding increase of about 13° in the angle of attack for this maximum lift.

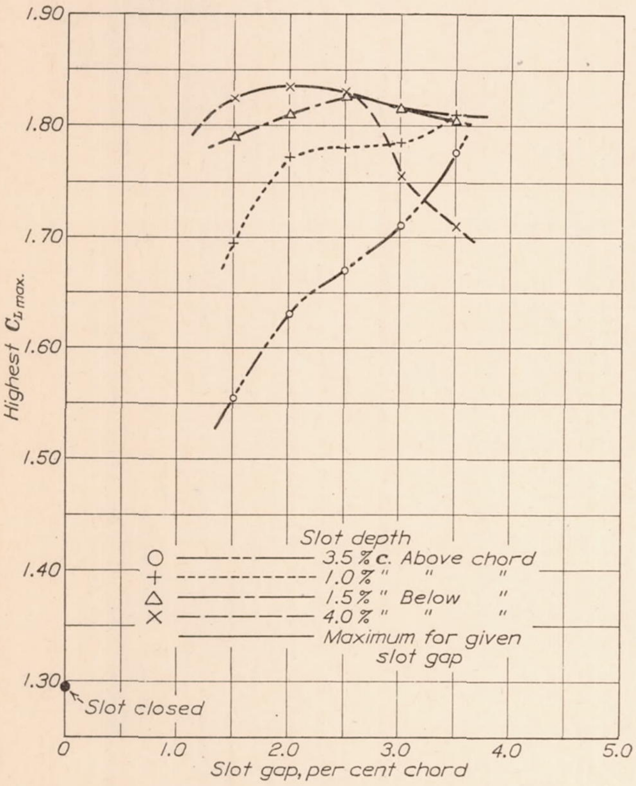


FIGURE 30.—Effect of slot gap on highest $c_{L\,max.}$ for a given slot depth

3. An increase of 30° in the angle of attack for maximum lift was attained with the given main wing and auxiliary airfoil combination, although at a maximum lift coefficient slightly lower than that of the plain wing.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., *May 27, 1931.*

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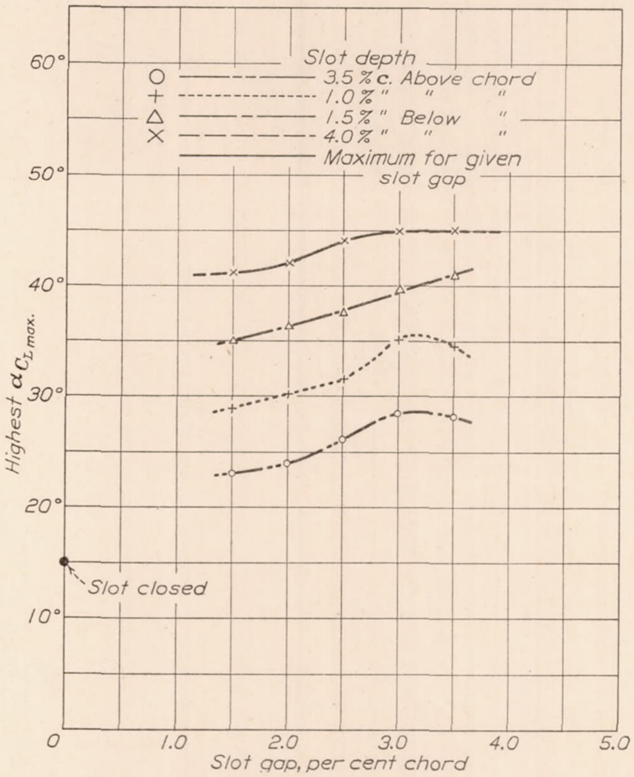

FIGURE 31.—Effect of slot gap on highest angle of attack for $c_{L\,max.}$ for a given slot depth

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TABLE I

SLOTTED CLARK Y CHARACTERISTICS. SLOT GAP=1.50 PER CENT CHORD

10-in. chord. 80 m. p. h. R. N.=609,000

Gap, per cent chord	Depth, per cent chord	Width, per cent chord	$C_{L\,max}$	$\alpha_{C_{L\,max}}$ degrees
	Slot closed		1.297	15.0
1.5	3.5	3.4	1.519	23.0
1.5	3.5	6.0	1.527	19.0
1.5	3.5	9.0	1.355	15.0
1.5	3.5	12.0	1.073	10.0
1.5	3.5	15.0	1.041	25.0
1.5	1.0	3.4	1.290	29.0
1.5	1.0	6.0	1.671	25.0
1.5	1.0	9.0	1.645	21.0
1.5	1.0	12.0	1.421	16.0
1.5	1.0	15.0	1.164	21.0
1.5	−1.5	3.4	1.248	35.0
1.5	−1.5	6.0	1.635	32.0
1.5	−1.5	9.0	1.781	27.0
1.5	−1.5	12.0	1.621	21.0
1.5	−1.5	15.0	1.302	14.0
1.5	−4.0	3.4	1.289	41.0
1.5	−4.0	6.0	1.582	39.0
1.5	−4.0	9.0	1.820	32.0
1.5	−4.0	12.0	1.757	24.0
1.5	−4.0	15.0	1.558	19.0

TABLE II

SLOTTED CLARK Y CHARACTERISTICS. SLOT GAP=2.0 PER CENT CHORD

10-in. chord. 80 m. p. h. R. N.=609,000

Gap, per cent chord	Depth, per cent chord	Width, per cent chord	$C_{L\,max}$	$\alpha_{C_{L\,max}}$ degrees
	Slot closed		1.297	15.0
2.0	3.5	3.4	1.482	24.0
2.0	3.5	6.0	1.630	21.0
2.0	3.5	9.0	1.451	16.0
2.0	3.5	12.0	1.200	18.0
2.0	3.5	15.0	1.100	19.0
2.0	1.0	3.4	1.292	30.0
2.0	1.0	6.0	1.684	27.0
2.0	1.0	9.0	1.736	22.0
2.0	1.0	12.0	1.500	17.0
2.0	1.0	15.0	1.239	21.0
2.0	−1.5	3.4	1.249	36.0
2.0	−1.5	6.0	1.542	34.0
2.0	−1.5	9.0	1.805	27.0
2.0	−1.5	12.0	1.705	22.0
2.0	−1.5	15.0	1.440	16.0
2.0	−4.0	3.4	1.295	42.0
2.0	−4.0	6.0	1.565	40.0
2.0	−4.0	9.0	1.675	35.0
2.0	−4.0	12.0	1.835	28.0
2.0	−4.0	15.0	1.635	21.0

TABLE III

SLOTTED CLARK Y CHARACTERISTICS. SLOT GAP=2.5 PER CENT CHORD

10-in. chord. 80 m. p. h. R. N.=609,000

Gap, per cent chord	Depth, per cent chord	Width, per cent chord	$C_{L\,max}$	$\alpha_{C_{L\,max}}$ degrees
	Slot closed		1.297	15.0
2.5	3.5	3.4	1.329	26.0
2.5	3.5	6.0	1.657	23.0
2.5	3.5	9.0	1.599	19.0
2.5	3.5	12.0	1.300	18.0
2.5	3.5	15.0	1.183	18.0
2.5	1.0	3.4	1.253	31.0
2.5	1.0	6.0	1.586	30.0
2.5	1.0	9.0	1.780	24.0
2.5	1.0	12.0	1.645	19.0
2.5	1.0	15.0	1.293	22.0
2.5	−1.5	3.4	1.270	37.0
2.5	−1.5	6.0	1.510	35.0
2.5	−1.5	9.0	1.769	27.0
2.5	−1.5	12.0	1.818	24.0
2.5	−1.5	15.0	1.580	18.0
2.5	−4.0	3.4	1.290	44.0
2.5	−4.0	6.0	1.520	41.0
2.5	−4.0	9.0	1.641	36.0
2.5	−4.0	12.0	1.804	25.0
2.5	−4.0	15.0	1.733	22.0

TABLE IV

SLOTTED CLARK Y CHARACTERISTICS. SLOT GAP=3.0 PER CENT CHORD

10-in. chord. 80 m. p. h. R. N.=609,000

Gap, per cent chord	Depth, per cent chord	Width, per cent chord	$C_{L\,max}$	$\alpha_{C_{L\,max}}$ degrees
	Slot closed		1.297	15.0
3.0	3.5	3.4	1.305	28.0
3.0	3.5	6.0	1.675	25.0
3.0	3.5	9.0	1.690	20.0
3.0	3.5	12.0	1.398	21.0
3.0	3.5	15.0	1.258	20.0
3.0	1.0	3.4	1.270	33.0
3.0	1.0	6.0	1.518	32.0
3.0	1.0	9.0	1.762	26.0
3.0	1.0	12.0	1.719	20.0
3.0	1.0	15.0	1.398	15.0
3.0	−1.5	3.4	1.285	39.0
3.0	−1.5	6.0	1.505	38.0
3.0	−1.5	9.0	1.644	33.0
3.0	−1.5	12.0	1.800	25.0
3.0	−1.5	15.0	1.672	20.0
3.0	−4.0	3.4	1.262	45.0
3.0	−4.0	6.0	1.431	43.0
3.0	−4.0	9.0	1.660	39.0
3.0	−4.0	12.0	1.659	23.0
3.0	−4.0	15.0	1.758	24.0

TABLE V

SLOTTED CLARK Y CHARACTERISTICS. SLOT GAP=3.5 PER CENT CHORD

10-in. chord. 80 m. p. h. R. N.=609,000

Gap, per cent chord	Depth, per cent chord	Width, per cent chord	$C_{L\,max}$	$\alpha_{C_{L\,max}}$ degrees
	Slot closed		1.297	15.0
3.5	3.5	3.4	1.285	28.0
3.5	3.5	6.0	1.647	26.0
3.5	3.5	9.0	1.760	22.0
3.5	3.5	12.0	1.517	16.0
3.5	3.5	15.0	1.324	20.0
3.5	1.0	3.4	1.255	34.0
3.5	1.0	6.0	1.476	33.0
3.5	1.0	9.0	1.747	28.0
3.5	1.0	12.0	1.790	22.0
3.5	1.0	15.0	1.512	16.0
3.5	−1.5	3.4	1.283	41.0
3.5	−1.5	6.0	1.451	38.0
3.5	−1.5	9.0	1.627	34.0
3.5	−1.5	12.0	1.780	26.0
3.5	−1.5	15.0	1.752	21.0
3.5	−4.0	3.4	1.230	45.0
3.5	−4.0	6.0	1.481	42.0
3.5	−4.0	9.0	1.641	39.0
3.5	−4.0	12.0	1.635	34.0
3.5	−4.0	15.0	1.711	22.0

TABLE VI

HIGHEST C_{LMAX}, AND HIGHEST $\alpha_{C_{L\,MAX}}$

(Slot width varied to give maximum values for given slot depth)

SLOTTED CLARK Y WING

10-in. chord. 80 m. p. h. R. N.=609,000.

Slot gap, per cent chord	Slot depth, per cent chord	Slot width, per cent chord	Highest C_{Lmax}	$\alpha_{C_{L\,max}}$ degrees	Slot width, per cent chord	Highest $\alpha_{C_{L\,max}}$ degrees	$C_{L\,max}$
1.5	3.5	5.0	1.555	21.8	3.4	23.0	1.518
1.5	1.0	7.0	1.695	23.6	3.4	29.0	1.290
1.5	−1.5	8.0	1.790	28.2	3.4	35.0	1.290
1.5	−4.0	10.0	1.825	30.7	4.0	41.2	1.350
2.0	3.5	6.0	1.630	23.5	3.8	24.0	1.535
2.0	1.0	8.0	1.773	25.0	3.8	30.2	1.317
2.0	−1.5	10.0	1.810	28.4	4.0	36.4	1.295
2.0	−4.0	12.0	[1] 1.835	28.0	3.4	42.0	1.300
2.5	3.5	7.0	1.670	21.7	3.9	26.2	1.410
2.5	1.0	9.0	1.780	24.4	4.2	31.6	1.315
2.5	−1.5	11.0	1.825	24.5	4.0	37.6	1.292
2.5	−4.0	13.0	1.830	23.0	3.4	44.0	1.290
3.0	3.5	8.0	1.710	21.2	4.0	28.4	1.350
3.0	1.0	10.0	1.785	24.0	3.8	35.0	1.281
3.0	−1.5	13.0	1.815	23.0	4.4	39.7	1.310
3.0	−4.0	15.0	1.755	22.0	3.4	[1] 45.0	1.260
3.5	3.5	8.0	1.775	23.5	3.4	28.0	1.285
3.5	1.0	11.0	1.810	24.0	4.4	34.5	1.310
3.5	−1.5	13.0	1.805	24.0	3.4	41.0	1.281
3.5	−4.0	15.0	1.710	22.0	3.4	[1] 45.0	1.232

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[1] Highest maximum values.

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AERONAUTICAL SYMBOLS

1. FUNDAMENTAL AND DERIVED UNITS

	Symbol	Metric		English	
		Unit	Symbol	Unit	Symbol
Length	l	meter	m	foot (or mile)	ft. (or mi.)
Time	t	second	s	second (or hour)	sec. (or hr.)
Force	F	weight of one kilogram	kg	weight of one pound	lb.
Power	P	kg/m/s		horsepower	hp
Speed		km/h	k. p. h.	mi./hr.	m. p. h.
		m/s	m. p. s.	ft./sec.	f. p. s.

2. GENERAL SYMBOLS, ETC.

W, Weight $= mg$

g, Standard acceleration of gravity $= 9.80665$ m/s^2 $= 32.1740$ ft./sec.^{2}

m, Mass $= \frac{W}{g}$

ρ, Density (mass per unit volume).

Standard density of dry air, 0.12497 (kg-m^{-4} s^2) at 15° C. and 750 mm $= 0.002378$ (lb.-ft.$^{-4}$ sec.^{2}).

Specific weight of "standard" air, 1.2255 kg/m^3 $= 0.07651$ lb./ft.^{3}.

mk^2, Moment of inertia (indicate axis of the radius of gyration k, by proper subscript).

S, Area.

S_w, Wing area, etc.

G, Gap.

b, Span.

c, Chord.

$\frac{b^2}{S}$, Aspect ratio.

μ, Coefficient of viscosity.

3. AERODYNAMICAL SYMBOLS

V, True air speed.

q, Dynamic (or impact) pressure $= \frac{1}{2} \rho V^2$.

L, Lift, absolute coefficient $C_L = \frac{L}{qS}$

D, Drag, absolute coefficient $C_D = \frac{D}{qS}$

D_o, Profile drag, absolute coefficient $C_{D_o} = \frac{D_o}{qS}$

D_i, Induced drag, absolute coefficient $C_{D_i} = \frac{D_i}{qS}$

D_p, Parasite drag, absolute coefficient $C_{D_p} = \frac{D_p}{qS}$

C, Cross-wind force, absolute coefficient $C_C = \frac{C}{qS}$

R, Resultant force.

i_w, Angle of setting of wings (relative to thrust line).

i_t, Angle of stabilizer setting (relative to thrust line).

Q, Resultant moment.

Ω, Resultant angular velocity.

$\rho \frac{Vl}{\mu}$, Reynolds Number, where l is a linear dimension.

e. g., for a model airfoil 3 in. chord, 100 mi./hr. normal pressure, at 15° C., the corresponding number is 234,000;

or for a model of 10 cm chord 40 m/s, the corresponding number is 274,000.

C_p, Center of pressure coefficient (ratio of distance of $c. p.$ from leading edge to chord length).

α, Angle of attack.

ϵ, Angle of downwash.

α_o, Angle of attack, infinite aspect ratio.

α_i, Angle of attack, induced.

α_a, Angle of attack, absolute.
(Measured from zero lift position.)

γ, Flight path angle.