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WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS

XIII - VARIOUS FLAP OVERHANGS USED WITH A 30-PERCENT-CHORD FLAP ON AN NACA 66-009 AIRFOIL

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SUMMARY

Force tests in two-dimensional flow have been made on an NACA 66-009 airfoil with a flap having a chord 30 percent of the airfoil chord and a tab having a chord 20 percent of the flap chord. A plain flap and flaps having overhangs of 35 and 50 percent of the flap chord were tested with two gap variations, sealed and unsealed. The results are presented as aerodynamic section characteristics.

The results indicated that the lift-curve slope was generally greater for this airfoil than for the previously tested NACA 0009 and NACA 0015 airfoils and the slope was decreased by unsealing the gap. Increasing the overhang increased slightly the lift effectiveness of the flap, and unsealing the gap caused a loss of effectiveness for the plain flap but increased the effectiveness for the balanced flaps. The slopes of the hinge-moment-coefficient curves were generally more negative for the NACA 66-009 airfoil than for the other two airfoils. Some overbalance occurred with the 50-percent-flap-chord overhangs. Unsealing the gap gave a slightly more negative slope to the curves of hinge-moment coefficient against angle of attack and had little effect on the variation of hinge-moment coefficient with flap deflection. The tab was effective in producing increments of lift and flap hinge moments for all conditions tested and was more effective when deflected in opposition to the flap.

INTRODUCTION

An extensive two-dimensional-flow investigation of the aerodynamic section characteristics of airfoils with flaps has been undertaken by the National Advisory Committee for Aeronautics to provide data for the design of control surfaces. Force tests have been made of NACA 0009 and NACA 0015 airfoils equipped with 30-percent-airfoil-chord (0.30c) flaps and 20-percent-flap-chord ($0.20c_f$) tabs and having various flap modifications. Some of the modifications that have been tested are: altered flap profile, flap nose shape, balance length, and gap size. The results of the tests pertinent to the present investigation are discussed in references 1 to 8.

The present series of tests was made of an NACA 66-009 airfoil with a 0.30c flap and a $0.20c_f$ tab. A plain flap and a flap with aerodynamic balances or overhangs of 35 percent and 50 percent of the flap chord were tested for comparison with the results given in references 1 to 8.

APPARATUS AND MODEL

The tests were made in the NACA vertical tunnel described in reference 9, modified to a closed rectangular 4- by 6-foot test section for force tests of models in two-dimensional flow. A three-component balance system is used to measure the lift, drag, and pitching moment of the airfoil. The hinge moments of the flap and of the tab were measured individually by special cantilever-beam strain gages built into the model.

The 2-foot-chord by 4-foot-span model (fig. 1) was made of laminated mahogany, except for a brass tab, to the NACA 66-009 profile. (See table I.) The model was equipped with a 0.30c flap and a $0.20c_f$ plain tab. Three flap arrangements were tested: a plain flap, a flap having a $0.35c_f$ overhang, and a flap having a $0.50c_f$ overhang. A blunt nose shape was used for all flaps. The blunt-nose flap overhang was defined by the normal airfoil contour with a nose radius of approximately one-half the airfoil thickness (fig. 1). The overhangs were made in the form of interchangeable nose blocks and were matched with interchangeable blocks in the airfoil forward of the flap. The tab was made of brass, with a nose radius approximately one-half the airfoil thickness at the tab hinge axis.

The gaps at the nose of the flap and of the tab were 0.005c and 0.001c, respectively, and, when sealed-gap tests were made, both gaps were filled with light grease.

L-314

The model, when mounted in the tunnel, completely spanned the test section. With this type of installation two-dimensional flow is approximated; and the section characteristics of the airfoil, flap, and tab may be determined. The model was attached to the balance frame by torque tubes that extended through the sides of the tunnel. The angle of attack was set from outside the tunnel by rotating the torque tubes with an electric drive. Flap and tab deflections were set inside the tunnel by templets and were held by friction clamps on the cantilever beams that were used in measuring the hinge moments.

TESTS

The tests were made at a dynamic pressure of 15 pounds per square foot, which corresponds to a velocity of approximately 76 miles per hour at standard sea-level conditions. The effective Reynolds number of the tests was approximately 2,760,000. (Effective Reynolds number = test Reynolds number × turbulence factor. The turbulence factor for the 4- by 6-foot vertical tunnel is 1.93.)

The flap defelctions used were 0°, 1°, 2°, 5°, and in 5° increments to 20°, 25°, or 30°, depending upon the balance size. The tab was deflected in 5° increments from 0° to -20° with the flap neutral for all three flaps tested and in 5° increments from 20° to -20° with the plain flap deflected 10° and 20°. The flap tests were made with both the flap and the tab gaps sealed and unsealed. The lift, drag, and pitching moment of the airfoil and the hinge moments of the flap and the tab were measured. For each flap setting, force tests were made throughout most of the angle-of-attack range at 2° increments from the negative stall to the positive stall. When either stall position was approached, the increment was reduced to 1°. For some of the tab tests, increments of 3° were used. All tab tests were made with unsealed gaps.

RESULTS

Symbols

The coefficients and the symbols used in this paper are defined as follows:

c_l airfoil section lift coefficient (l/qc)

c_{d_o} airfoil section profile-drag coefficient (d_o/qc)

c_m airfoil section pitching-moment coefficient (m/qc^2)

c_{h_f} flap section hinge-moment coefficient (h_f/qc_f^2)

c_{h_t} tab section hinge-moment coefficient (h_t/qc_t^2)

where

l airfoil section lift

d_o airfoil section profile drag

m airfoil section pitching moment about quarter-chord point of airfoil

h_f flap section hinge moment

h_t tab section hinge moment

c chord of basic airfoil with flap and tab neutral

c_f flap chord

c_t tab chord

q dynamic pressure

and

α_o angle of attack for airfoil of infinite aspect ratio

δ_f flap deflection with respect to airfoil

δ_t tab deflection with respect to flap

When subscripts are used outside the parentheses, they represent the factors held constant during the measurement of the parameters.

The term "overhang" is used to indicate the part of the flap projecting ahead of the hinge line; thus, the plain flap has an overhang of $0.113c_f$ but this amount of overhang does not contribute any aerodynamic balance.

L-314

Precision

The accuracy of the lift and pitching-moment data is indicated by the variation in lift and pitching-moment coefficients at an angle of attack of 0° and a flap deflection of 0° among the tests with various overhangs and gap conditions. The maximum error in effective angle of attack appears to be $\pm 0.2^{\circ}$. The small amount of positive lift obtained at 0° angle of attack for all tests with flap neutral indicates some inaccuracy in model construction or installation. Flap deflections were set within $\pm 0.2^{\circ}$ at small deflections. At the high deflections the angular displacement of the flap under load slightly exceeded this value. Tab deflections were set to within $\pm 1.5^{\circ}$. Tunnel corrections experimentally determined in the NACA 4- by 6-foot vertical tunnel were applied only to lift. The hinge moments are probably slightly higher than would be obtained in free air and, consequently, the values presented are considered conservative. The increments of profile-drag coefficient are believed to be accurate within ± 0.001 for small flap deflections and within ± 0.003 for large flap deflections and should be reasonably independent of tunnel effect, although the absolute value is subject to an unknown correction. Inaccuracies in the section data presented are thought to be negligible relative to inaccuracies that will be incurred in the application of the data to finite airfoils.

Presentation of Data

The aerodynamic section characteristics of the NACA 66-009 airfoil with a 0.30c flap are presented in figures 2 to 7. The effect of flap deflection on the characteristics is shown in figure 2 for the plain flap, in figure 3 for the flap with a $0.35c_f$ overhang, and in figure 4 for the flap with a $0.50c_f$ overhang. Figures 2(a), 3(a), and 4(a) show the results for the sealed-gap condition and figures 2(b), 3(b), and 4(b) for a gap of 0.005c at the flap nose. Figures 5, 6, and 7 show the effect of tab deflection on the characteristics of the airfoil with the plain flap, the flap with a $0.35c_f$ overhang, and the flap with a $0.50c_f$ overhang, respectively. Figure 5(a) shows the effect of tab deflection with the flap neutral; figure

5(b), with the flap deflected 10°; and figure 5(c), with the flap deflected 20°.

Increments of profile-drag coefficient caused by flap deflection are shown in figure 8 for the three flap arrangements tested. The increments were obtained by subtracting the drag for the flap-neutral condition at angles of attack of −4°, 0°, and 4° from the drag for the flap-deflected condition at the same angles of attack.

The data for the NACA 66-009 airfoil are compared with the data for the NACA 0009 airfoil from references 1 to 4 and with the data for the NACA 0015 airfoil from references 6 to 8.

DISCUSSION OF AERODYNAMIC SECTION CHARACTERISTICS

Lift

Apparently the nature of the air flow over the NACA 66-009 airfoil is different from that over the NACA 0009 and NACA 0015 airfoils as evidenced by the nonlinearity of the lift curves of figures 2, 3, and 4. Separation seems to begin at rather low angles of attack and causes the lift-curve slope to decrease appreciably before the stall is reached. The NACA 66-009 airfoil stalls at smaller angles of attack than the NACA 0015 airfoil and at approximately the same angles of attack as the NACA 0009 airfoil. For any given flap deflection, therefore, the NACA 66-009 airfoil has a maximum lift coefficient slightly below that of the NACA 0009 airfoil and considerably below that of the NACA 0015 airfoil. The loss of lift at the stall is more gradual for the NACA 66-009 airfoil than for the NACA 0009 airfoil. It should be noted that the results of the present tests represent the condition of the airfoil in a turbulent stream at a low Reynolds number. Because this airfoil is designed for use on tail surfaces, the tests are probably representative of the actual operating conditions for the tail surface, which is normally in the region affected by the slipstream. The effect of Reynolds number on the maximum lift will probably be similar on all three airfoils.

Several additional effects that were not evident on the NACA 0009 and NACA 0015 airfoils are noticeable at large flap deflections in the lift curves of figures 2, 3, and 4. The plain flap maintained some lift effectiveness to the highest deflection tested (30°) at nearly all angles of attack except those near the negative stall. At this point the lift decreased rapidly at flap deflections of 25° and 30°. The loss of lift under these conditions did not occur on the other two airfoils. When the larger flap overhangs were used, the airfoil experienced a loss of lift at large flap deflections and at angles of attack near 0°, as is usual when large overhangs are used. At larger positive angles of attack just below the stall, however, the lift was recovered with the result that for all cases tested with the large overhangs the maximum lift of the airfoil occurred with the highest flap deflection, even when this high deflection had been ineffective at all other angles of attack.

The horizontal tail surface in landing has a positive angle of attack and a large negative flap deflection. This condition is represented on the symmetrical airfoil of the present tests by the region at negative angles of attack and large positive flap deflections. In this region the flaps with overhang produced greater increments of lift from zero flap deflection than the plain flap for a given flap deflection. The plain flap, however, maintained some effectiveness at higher deflections than the flaps with overhang. As a result, the total increments of lift given by the maximum effective flap deflection in the landing condition were generally greater for the plain flap than for the flaps with overhang when the gaps were sealed and were greater for the flaps with overhang when the gaps were unsealed.

The lift-curve slope for the NACA 66-009 airfoil through the small linear range was generally larger than for the NACA 0009 and NACA 0015 airfoils. Unsealing the gap decreased $(\partial c_l/\partial \alpha_0)_{\delta_f, \delta_t}$; the decrease was greater for the larger overhangs.

The tests and the discussion in reference 5 showed that the airfoil and flap characteristics could be changed by modifying the thickness and shape of the airfoil surface near the trailing edge. Decreasing the angle between the two surfaces at the trailing edge will alter the pressure distribution so as to increase the lift over the rear portion of the airfoil. Thus, the greater lift-curve slope of the NACA 66-009 airfoil could be expected because of the smaller included angle near the trailing edge.

The flap lift-effectiveness parameter $(\partial\alpha_o/\partial\delta_f)_{c_l,\delta_t}$ (table II) was approximately the same as for the NACA 0009 airfoil and generally greater than for the NACA 0015 airfoil. With the plain flap $(\partial\alpha_o/\partial\delta_f)_{c_l,\delta_t}$ was slightly reduced by unsealing the gap; whereas $(\partial\alpha_o/\partial\delta_f)_{c_l,\delta_t}$ for the flaps with the larger overhangs became greater when the gap was unsealed

Flap Hinge Moments

The hinge-moment-coefficient curves for the plain flap (fig. 2) are approximately linear throughout most of the angle-of-attack range at flap deflections up to 10°. The hinge-moment parameters of table II, which cover this linear range, are slightly more negative than the parameters for a plain flap on the NACA 0009 airfoil and considerably more negative than those for a plain flap on the NACA 0015 airfoil. For flap deflections greater than 10°, however, the departure of the curves from linearity is very marked, more so than for either of the other two airfoils. The maximum hinge-moment coefficients measured for the plain flap on the NACA 66-009 airfoil at a flap deflection of 30° are about 10 percent larger than for the NACA 0009 airfoil and about 20 percent larger than for the NACA 0015 airfoil. At positive angles of attack just below the stall the hinge-moment coefficients generally decrease slightly but increase as the airfoil stalls. Unsealing the gap has very little effect on the hinge moments of the plain flap.

The hinge-moment parameters for the flaps with $0.35c_f$ and $0.50c_f$ overhangs are given in table II. The values of $(\partial c_{h_f}/\partial\delta_f)_{\alpha_o,\delta_t}$ were measured over a flap-deflection range of about 0° to 5° to give a general indication of the balancing effect of the overhangs. Because of the general nonlinearity of the curves of hinge-moment coefficient plotted against flap deflection, the parameters should not be used without reference to the curves (figs. 2 to 7). The test at $\delta_f = 0°$ with the $0.35c_f$ overhang unsealed appeared to be somewhat inaccurate because of a probable inaccuracy in tab setting; therefore this curve was not used in measuring $(\partial c_{h_f}/\partial\delta_f)_{\alpha_o,\delta_t}$.

Except for the $0.50c_f$ overhang with sealed gap the hinge-moment parameters were more negative for the NACA 66-009 airfoil than for the NACA 0009 and NACA 0015 airfoils with similar flap overhangs. Some overbalance occurred with the $0.50c_f$ overhang with both sealed and unsealed gap. For all conditions tested with the $0.35c_f$ and $0.50c_f$ overhangs the maximum negative value of $(\partial c_{h_f}/\partial \delta_f)_{\alpha_0,\delta_t}$ occurred at zero flap deflection. The variation in slope over the low deflection range may be important in considering the control-free stability of the airplane. The increased effectiveness of the balance at large deflections is probably caused by the high velocity over the nose of the balance as it protrudes from the airfoil surface. Although no tests were made at flap deflections smaller than 5° on the flaps with large overhangs on the NACA 0009 and NACA 0015 airfoils, the decreased effectiveness of the balance was evident even at 5° deflection and would probably be more evident at smaller deflections, as on the NACA 66-009 airfoil. The balancing effectiveness of the overhang was greater when the flap deflection and the angle of attack were of opposite sign. A rather abrupt loss of balance occurred, however, at positive lift coefficients and at flap deflections greater than 10°. When this loss of balance occurred, the hinge-moment coefficients assumed negative values greater than those for either the NACA 0009 or the NACA 0015 airfoils under similar conditions. At large positive angles of attack when the lost lift effectiveness was recovered, as previously mentioned, the hinge-moment coefficients remained nearly constant or became more positive in some instances. The hinge-moment coefficients did not become more positive for the NACA 0009 and NACA 0015 airfoils. The main effects of unsealing the gap were to make $(\partial c_{h_f}/\partial \alpha_0)_{\delta_f,\delta_t}$ more negative and to decrease slightly the lift coefficient at which the balancing effectiveness of the overhangs was lost.

The more negative values of the hinge-moment parameters on the NACA 66-009 airfoil are a further indication of the effect of the smaller trailing-edge angle in building up greater lift over the trailing edge of the airfoil.

Pitching Moments

The values of the parameters $(\partial c_m/\partial c_l)_{\alpha_0}$ and $(\partial c_m/\partial c_l)_{\delta_f}$ in table II give the position of the aerodynamic center of the airfoil, which is important in stability calculations. When the lift was varied by changing the angle of attack at a flap deflection of 0°, the aerodynamic center of the airfoil was at the 0.244c point for the plain flap and at the quarter-chord point for each of the larger overhangs with a sealed gap. When the lift was varied by changing the flap deflection at an angle of attack of 0°, the aerodynamic center was at approximately the 0.43c point for all flaps tested. Unsealing the gap had little effect on the position of the aerodynamic center. The positions of the aerodynamic center for the various conditions on the NACA 66-009 airfoil were slightly behind those for similar conditions on the NACA 0009 and NACA 0015 airfoils, which is another result of the increased lift near the trailing edge of the NACA 66-009 airfoil.

Drag

The NACA 66-009 is one of the NACA series of low-drag airfoils, but the turbulence of the 4- by 6-foot vertical tunnel made it impossible for the low-drag condition to be realized during the present tests. The measured values of drag, therefore, cannot be considered absolute and are not presented in this report. Any increase in drag caused by the increased size of the break in the airfoil surface when larger overhangs were used was within the experimental accuracy of the tests. The increments of profile-drag coefficient caused by flap deflection, as shown in figure 8, should be of approximately the right magnitude for the airfoil in a turbulent air stream. During the analysis of the data, the profile-drag coefficients were plotted for some of the tests at large flap deflections to obtain more information on the action of the flap with large overhangs in the region near 0° angle of attack and large flap deflections, where the lift effectiveness is lost. The profile-drag coefficient in this region shows a large increase which, with the loss in lift effectiveness, indicates a separation of the flow over the flap surface. This fact is also evident in the greatly increased hinge moments in the same region. As the angle of attack is increased, the profile-drag coefficient shows a gradual increase until at the point near the stall where the lift is recovered the drag is approximately the same at equal flap deflections for the plain flap and for the flap with large overhangs.

Tab Characteristics

As shown in figures 5, 6, and 7 the tab was effective in producing increments of lift coefficient and flap hinge-moment coefficient at all tab deflections tested. The value of $(\partial c_{h_f}/\partial \delta_t)_{\alpha_0, \delta_f}$ was -0.013 with the plain flap neutral, a value that is slightly greater than that for a similar tab on the NACA 0009 and NACA 0015 airfoils. The parameter decreases slightly with an increase of overhang and also decreases with increased flap deflection. The tab was more effective when deflected in opposition to the flap.

The variation of tab hinge-moment coefficient with tab deflection was approximately linear with a slope $(\partial c_{h_t}/\partial \delta_t)_{\alpha_0, \delta_f}$ of about -0.009 for all overhangs at 0° flap deflection compared with a value of -0.007 for the NACA 0009 airfoil and -0.005 for the NACA 0015 airfoil. Increasing the flap deflection decreases $(\partial c_{h_t}/\partial \delta_t)_{\alpha_0\ \delta_f}$ to approximately -0.006 for both 10° and 20° flap deflections. The slope $(\partial c_{h_t}/\partial \alpha_0)_{\delta_f, \delta_t}$ was negative for all conditions. Under the same conditions a similar tab on the NACA 0015 airfoil had positive values of $(\partial c_{h_t}/\partial \alpha_0)_{\delta_f, \delta_t}$ through a small range of angles of attack, a fact that can probably be attributed to the relatively large included angle at the airfoil trailing edge. Because of the errors possible in setting the tab deflections, the tab parameters in table II were measured from faired curves through a range of about 10° tab deflection in order to minimize the effect of any inaccuracy in the individual settings.

Because the flap with a 0.50c_f overhang was overbalanced, this flap cannot be used without some modification. If a tab is used and deflected in the same direction as the flap, the overbalance of the flap may be eliminated and the effectiveness of the flap increased. (See reference 2.)

The effectiveness of the tab $(\partial \alpha_0/\partial \delta_t)_{c_l, \delta_f}$ on the plain flap (fig. 5) was slightly less than for a similar tab on the NACA 0015 airfoil and approximately the same as for a similar tab on the NACA 0009 airfoil (references 1 and 6).

CONCLUSIONS

The results of the tests of the NACA 66-009 airfoil having a blunt-nose 30-percent-chord flap with three overhangs indicated the following conclusions when compared with the results of similar flap arrangements on the NACA 0009 and NACA 0015 airfoils:

1. The slope of the lift curve at small angles of attack was slightly greater for the NACA 66-009 airfoil than for the NACA 0009 and NACA 0015 airfoils. Unsealing the gap reduced the slope.

2. The flap lift effectiveness $(\partial\alpha_{0}/\partial\delta_f)_{c_l,\delta_t}$ was approximately the same as for the NACA 0009 airfoil and slightly greater than for the NACA 0015 airfoil. The lift effectiveness increased slightly with overhang. Unsealing the gap caused a slight loss of effectiveness for the plain flap but increased the effectiveness of the flap with overhangs 35 percent and 50 percent of the flap chord.

3. The hinge-moment-coefficient curves generally had greater negative slopes than those for the NACA 0009 and NACA 0015 airfoils. Unsealing the gap had little effect on the variation of hinge-moment coefficient with flap deflection but caused a slight increase in the variation of hinge-moment coefficient with angle of attack.

4. The pitching-moment-coefficient curves showed that the aerodynamic center for an angle-of-attack change at a constant flap deflection remained near the quarter-chord point for all overhangs and gap conditions. For a flap deflection at a constant angle of attack the aerodynamic center was at the 43-percent-chord point.

5. The tab was effective in producing increments of lift coefficient and flap hinge-moment coefficient for tab deflections throughout the range tested (from 20° to -20°) and was more effective when deflected opposite to the deflection of the flap.

6. The effect of the smaller included angle at the

trailing edge in building up greater lift over the airfoil trailing edge was evident in the increased lift-curve slope, the more negative hinge-moment coefficients, and the further rearward position of the aerodynamic center on the NACA 66-009 airfoil as compared with the NACA 0009 and NACA 0015 airfoils.

L-314

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L-314

TABLE I

ORDINATES FOR NACA 66-009 AIRFOIL

[Stations and ordinates in percent of airfoil chord]

Station	Ordinate
0	0
.50	.70
.75	.84
1.25	1.05
2.5	1.41
5	1.94
7.5	2.34
10	2.67
15	3.19
20	3.59
25	3.91
30	4.16
35	4.33
40	4.44
45	4.50
50	4.49
55	4.40
60	4.21
65	3.91
70	3.46
75	2.84
80	2.22
85	1.60
90	.92
95	.37
100	(.10)
100	0
L.E. radius: 0.558	

TABLE II

PARAMETER VALUES FOR 0.30c BLUNT-NOSE FLAP WITH THREE OVERHANGS AND A 0.20c_f PLAIN TAB ON AN NACA 66-009 AIRFOIL

[Except as noted in the text, the parameters listed were measured over a small range of angles of attack and flap deflections where the curves are more nearly linear. Because of the general nonlinearity of the curves, however, the parameters should not be used without reference to figs. 2 to 7.]

Overhang \ Parameter	$\left(\frac{\partial c_l}{\partial \alpha_0}\right)_{\delta_f,\delta_t}$	$\left(\frac{\partial \alpha_0}{\partial \delta_f}\right)_{c_l,\delta_t}$	$\left(\frac{\partial c_{h_f}}{\partial \alpha_0}\right)_{\delta_f,\delta_t}$	$\left(\frac{\partial c_{h_f}}{\partial \delta_f}\right)_{\alpha_0,\delta_t}$	$\left(\frac{\partial c_m}{\partial c_l}\right)_{\delta_f,\delta_t}$	$\left(\frac{\partial c_m}{\partial c_l}\right)_{\alpha_0,\delta_t}$	$\left(\frac{\partial \alpha_0}{\partial \delta_t}\right)_{c_l,\delta_f}$	$\left(\frac{\partial c_{h_f}}{\partial \delta_t}\right)_{\alpha_0,\delta_f}$	$\left(\frac{\partial c_{h_t}}{\partial \delta_t}\right)_{\alpha_0,\delta_f}$	$\left(\frac{\partial c_{h_t}}{\partial \alpha_0}\right)_{\delta_f,\delta_t}$
0.113c_f (plain flap)										
Gaps sealed	0.102	-0.57	-0.0074	-0.0120	0.006	-0.180	-----	------	------	------
Gaps unsealed	.095	-.55	-.0083	-.0128	0	-.180	-0.16	-0.013	-0.010	-0.004
0.35c_f										
Gaps sealed	.099	-.59	-.0045	-.0060	0	-.167	-----	------	------	------
Gaps unsealed	.087	-.62	-.0070	-.0066	-.001	-.180	-.15	-.008	-.008	-.006
0.50c_f										
Gaps sealed	.102	-.61	0	0	0	-.175	-----	------	------	------
Gaps unsealed	.081	-.66	-.0009	-.0014	-.008	-.180	-.16	-.008	-.008	-.008

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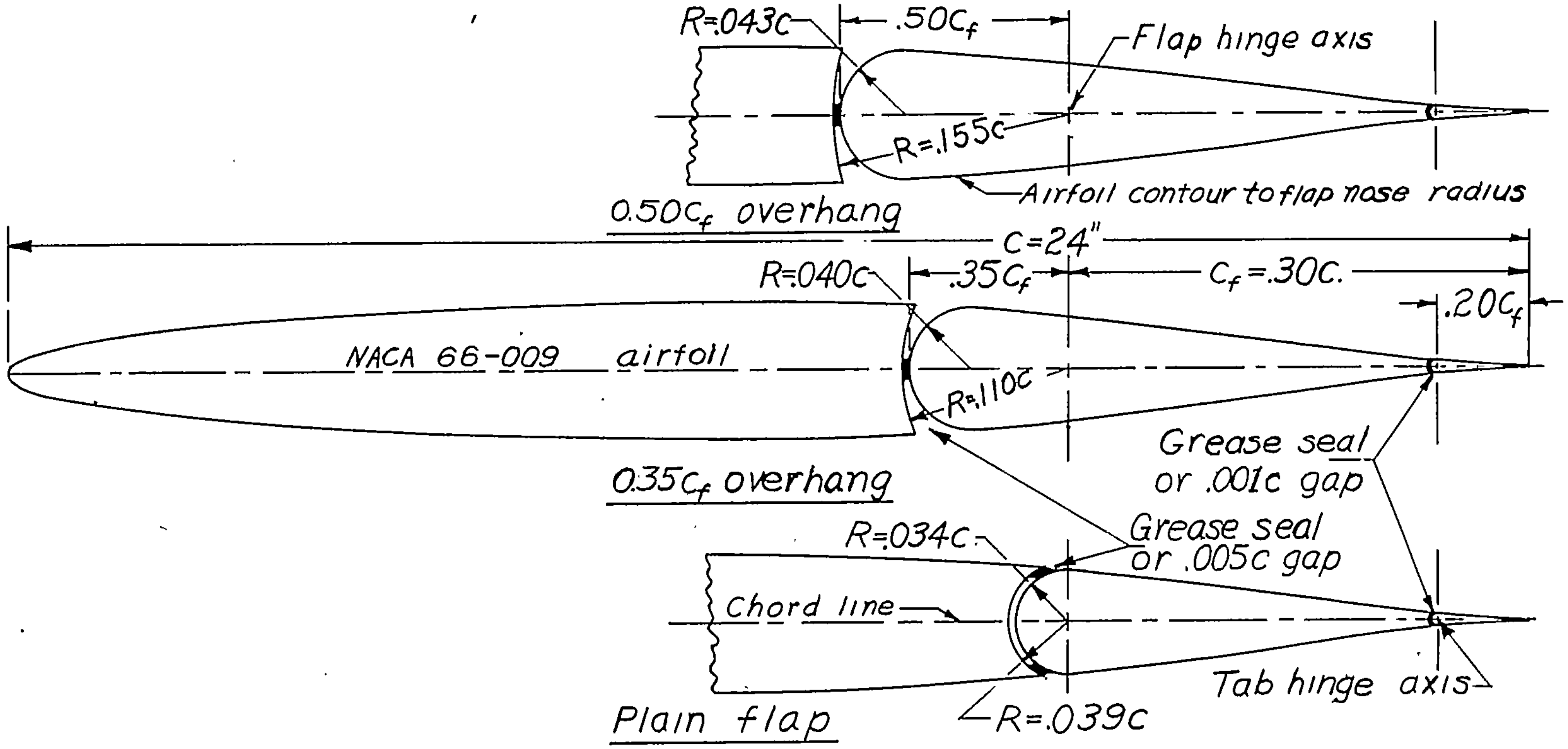
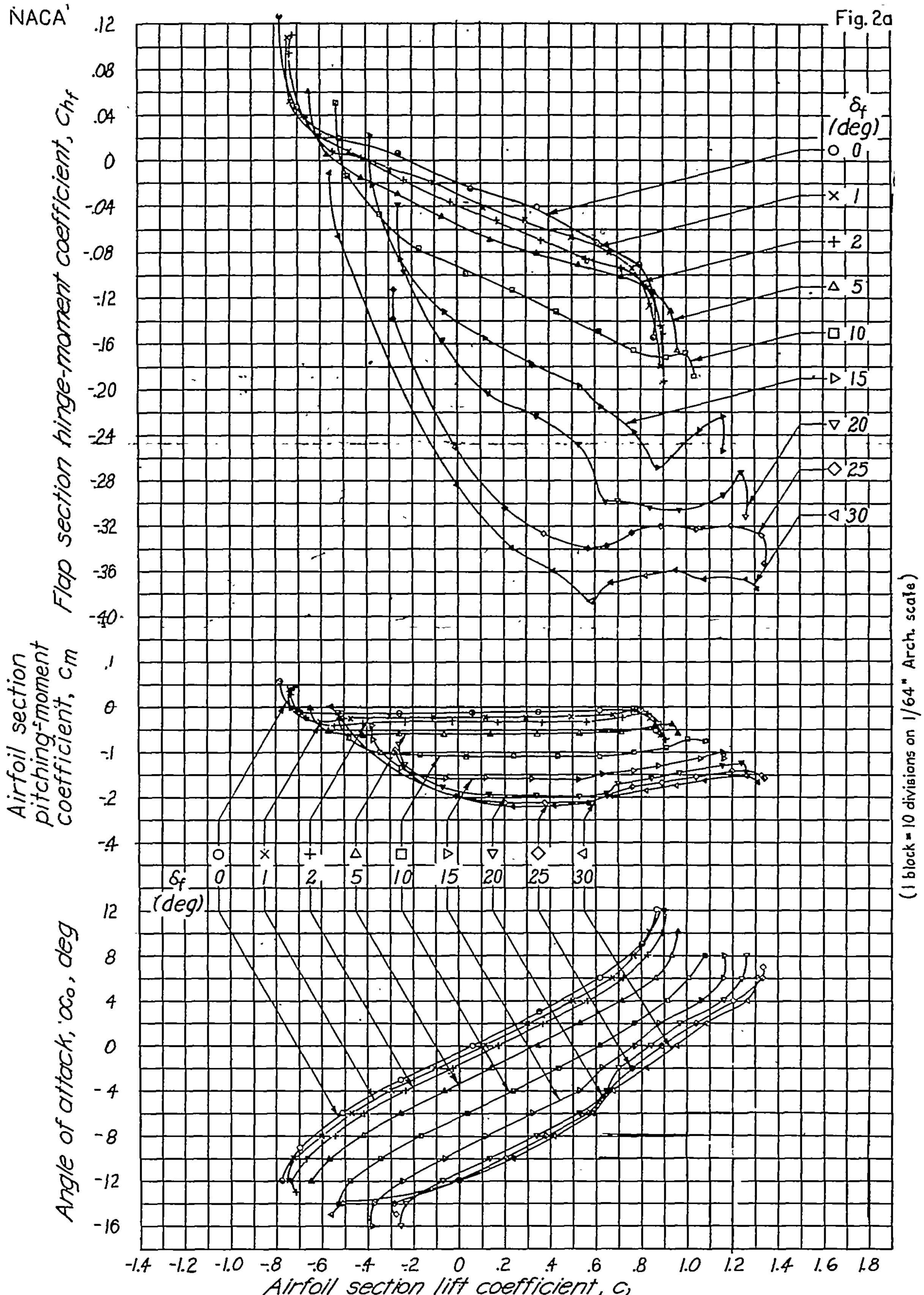


Figure 1.- Various overhangs for a 0.30c flap on an NACA 66-009 airfoil.

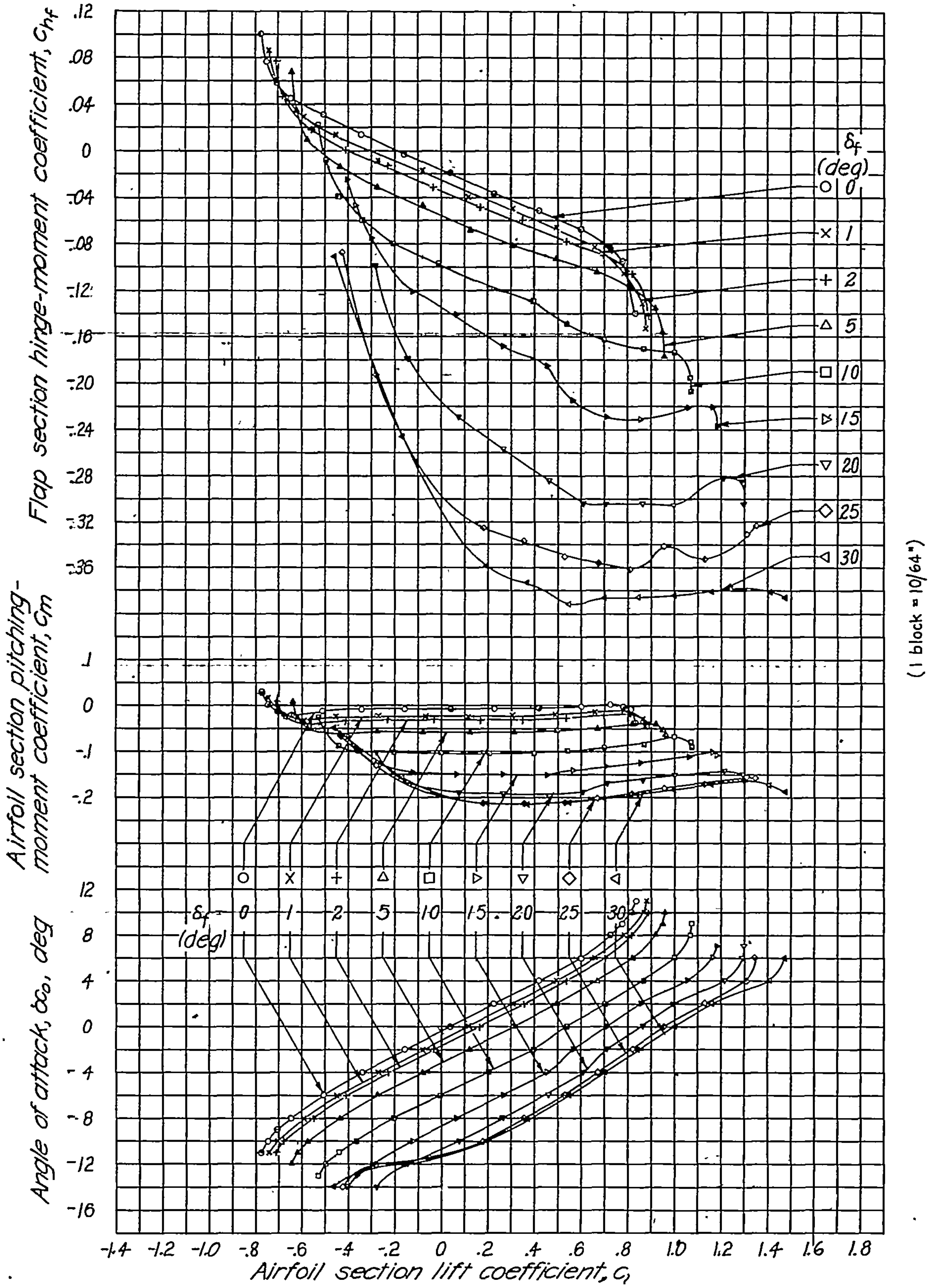
L - 314



(a) Sealed gap.

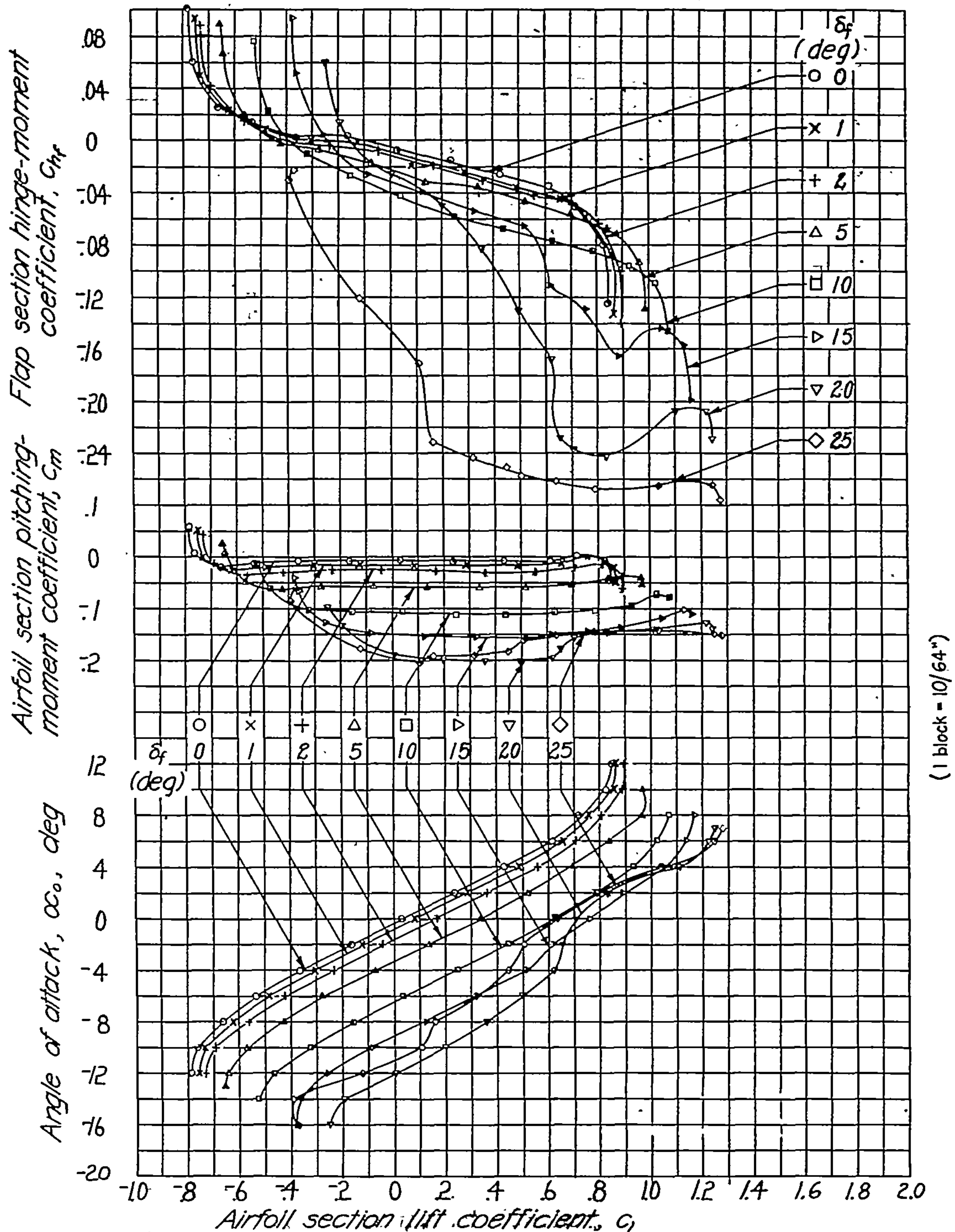
Fig. 2(a,b).-Section aerodynamic characteristics of an NACA 66-009 airfoil with a 0.30c plain flap.

L-314



(b) 0.005c gap.
Figure 2-Concluded.

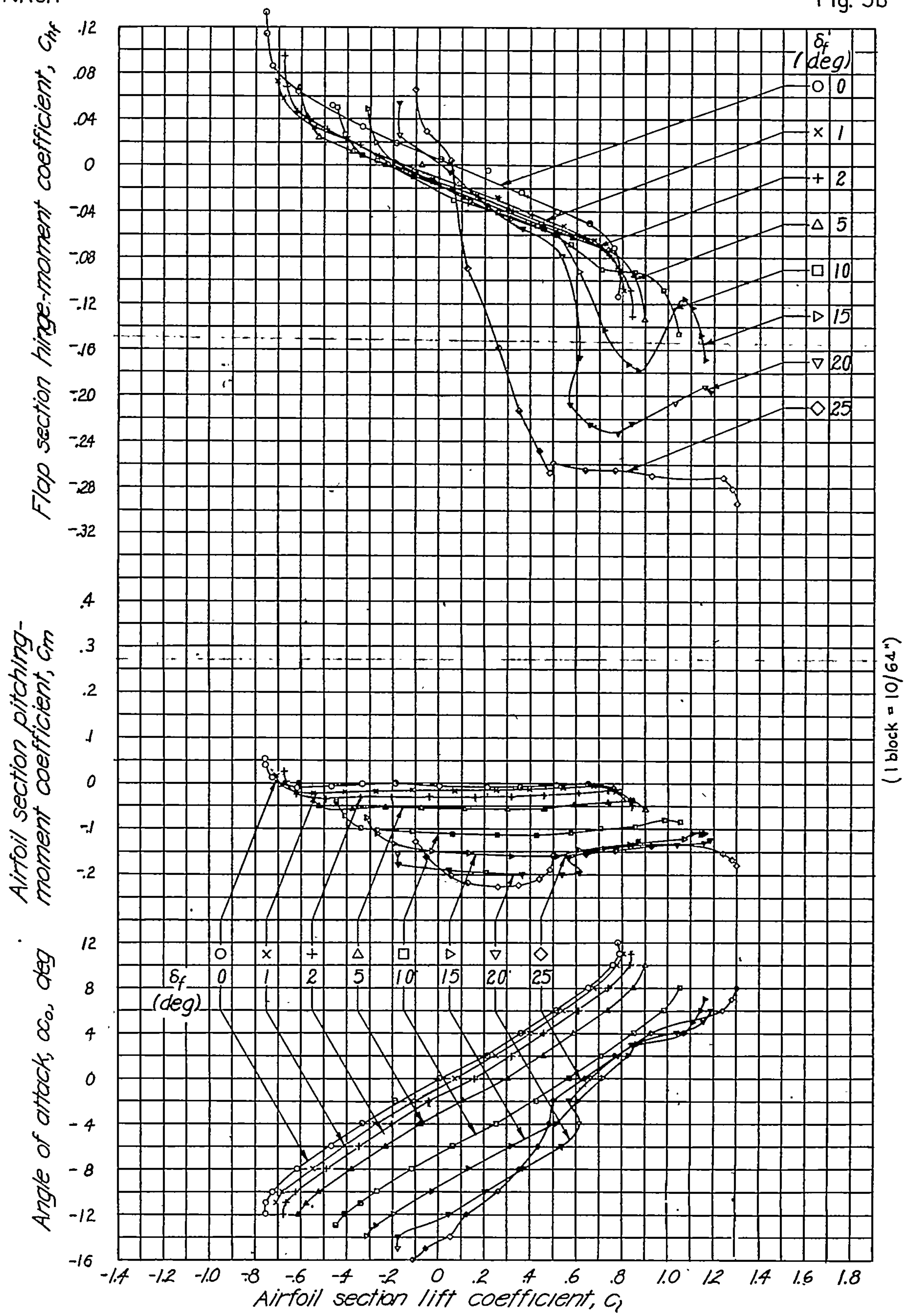
L - 314



(a) Sealed gap.

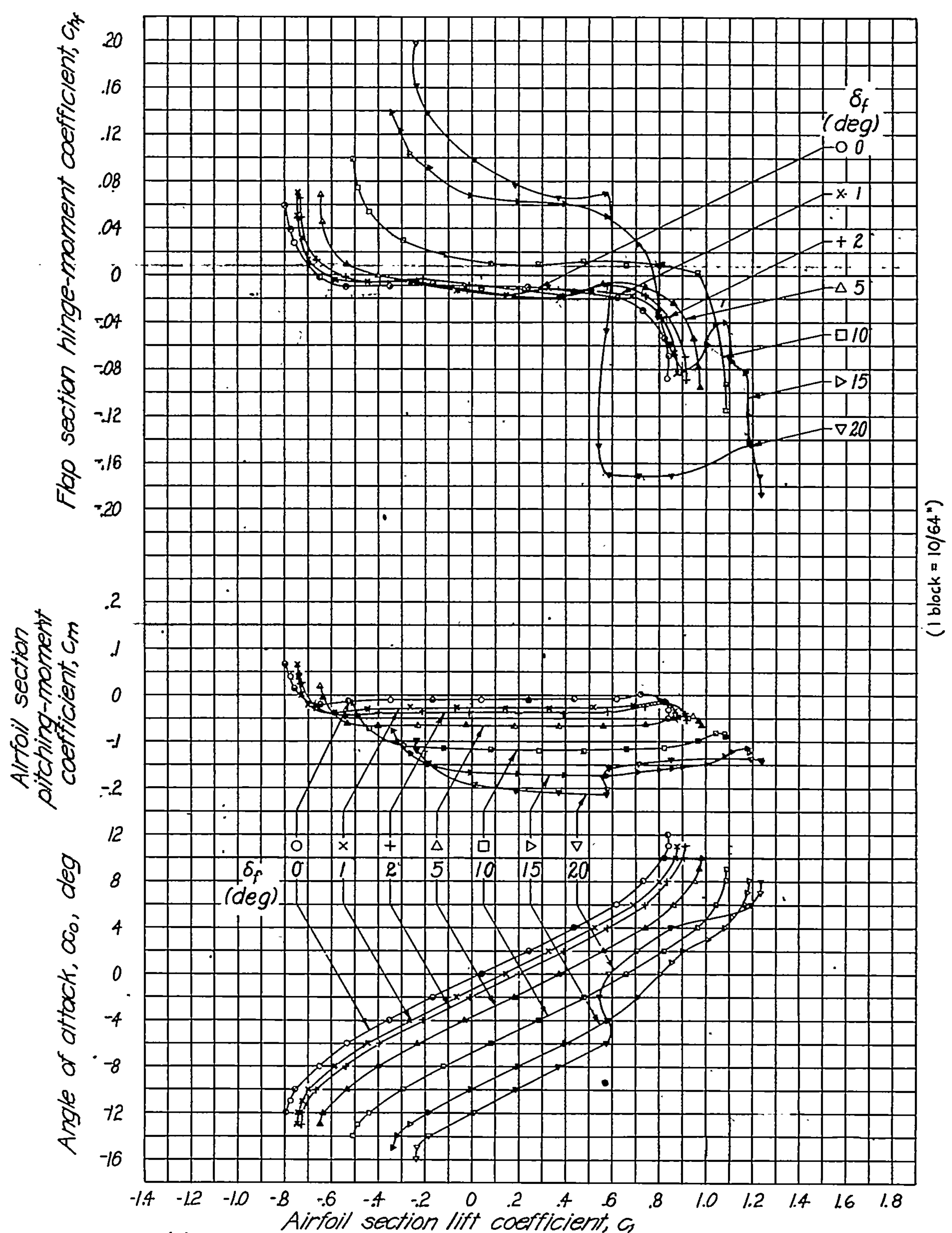
Fig. 3(a,b).-Section aerodynamic characteristics of an NACA 66,-009 airfoil with a 0.30c flap. Blunt-nose 0.35c_f overhang.

L - 314



(b) 0.005 c gap.
Figure 3.-Concluded.

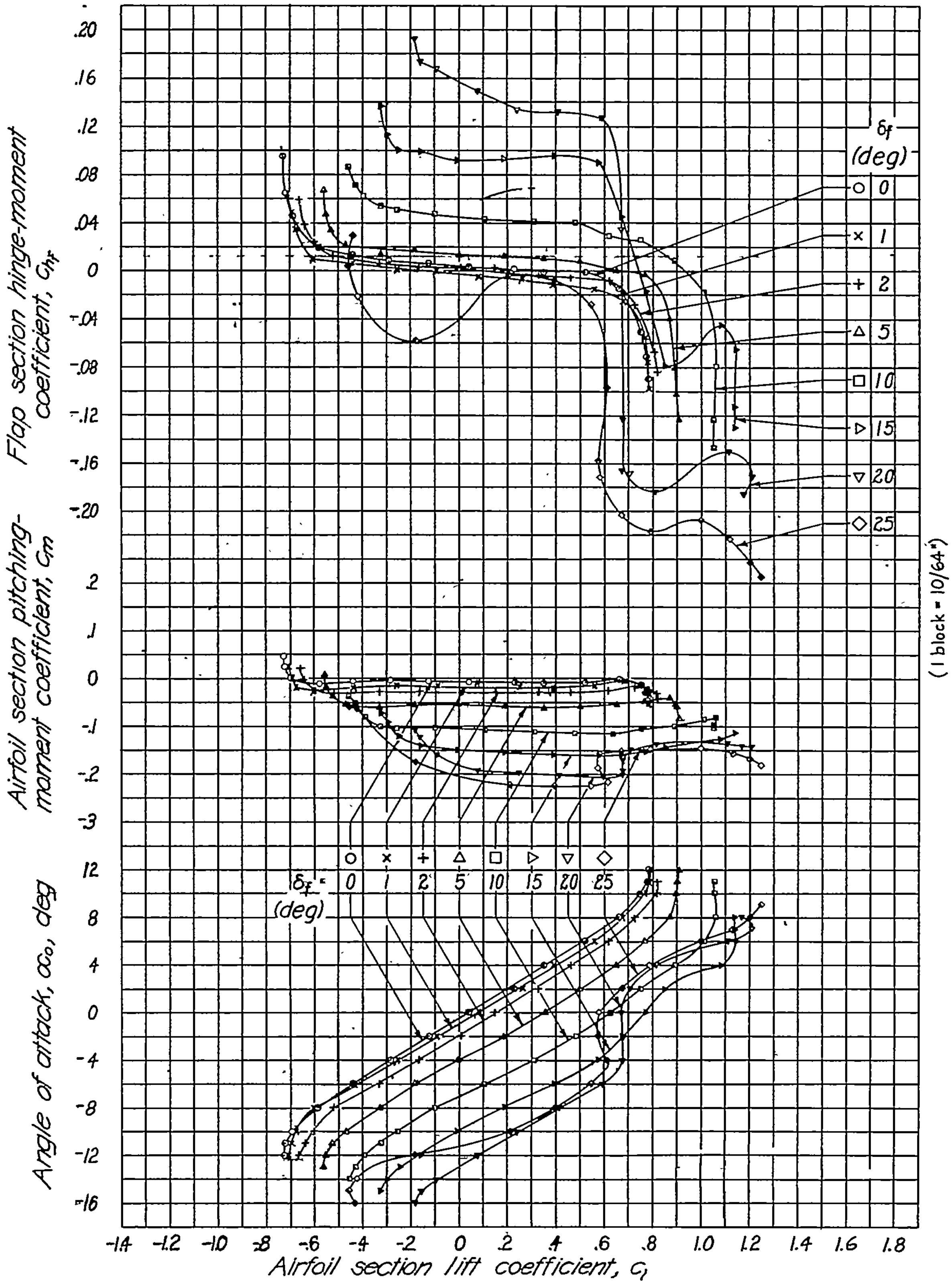
L - 314



(a) Sealed gap.

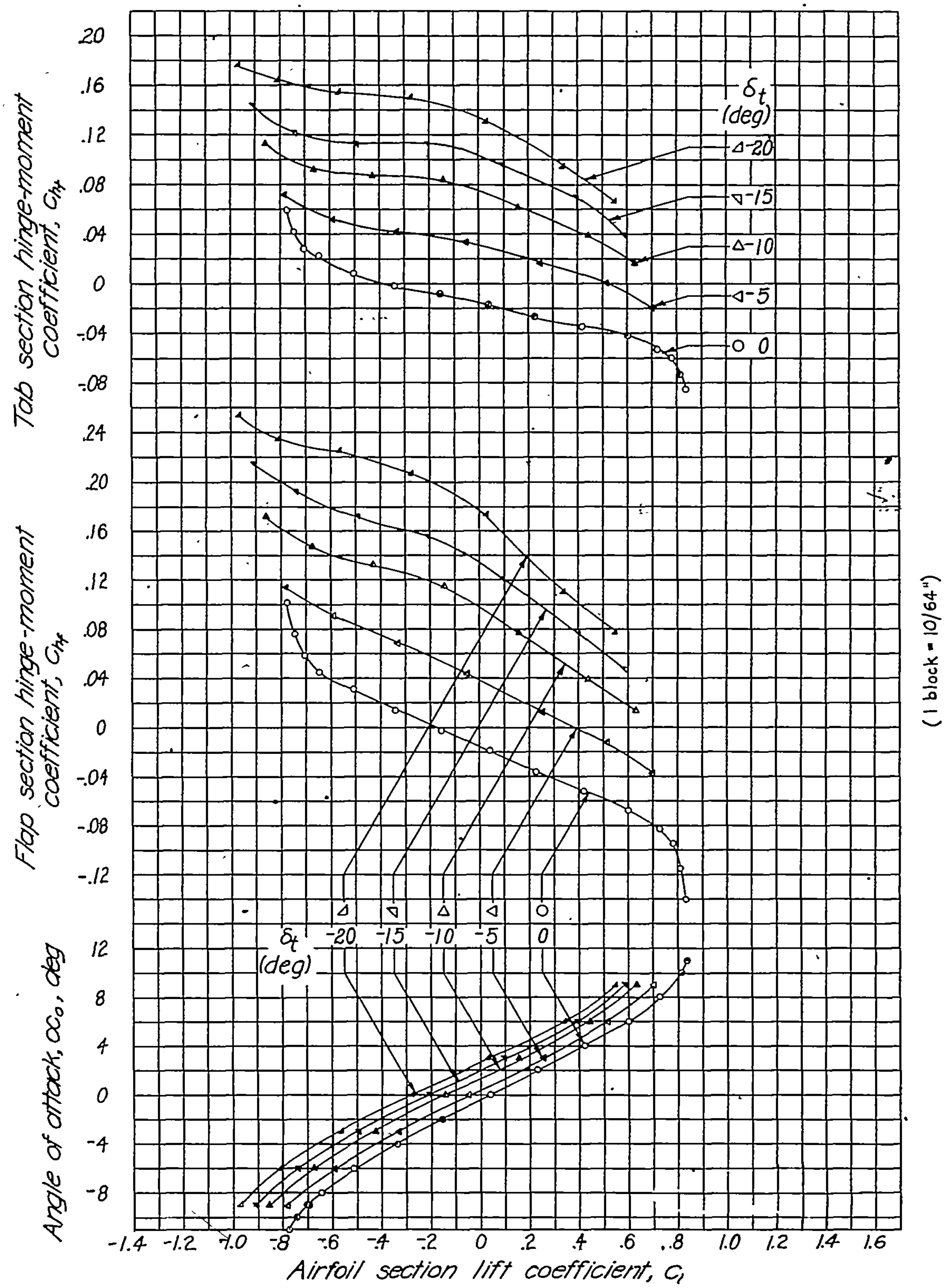
Fig. 4 (a,b).-Section aerodynamic characteristics of an NACA 66-009 airfoil with a 0.30c flap. Blunt-nose 0.50c_f overhang.

L - 314



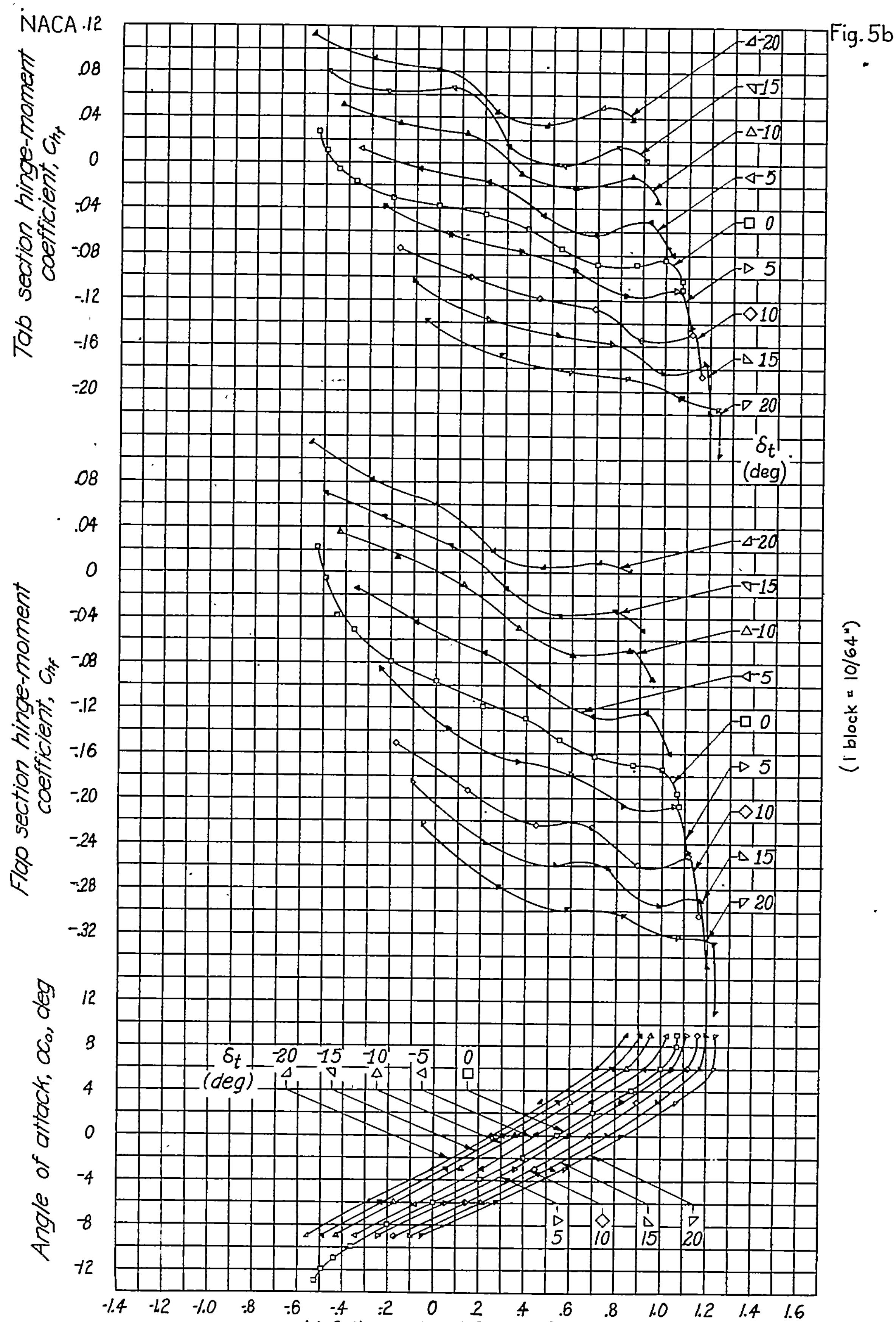
(b) 0.005 c gap.
Figure 4.-Concluded.

L - 314



(a) $\delta_f = 0°$.

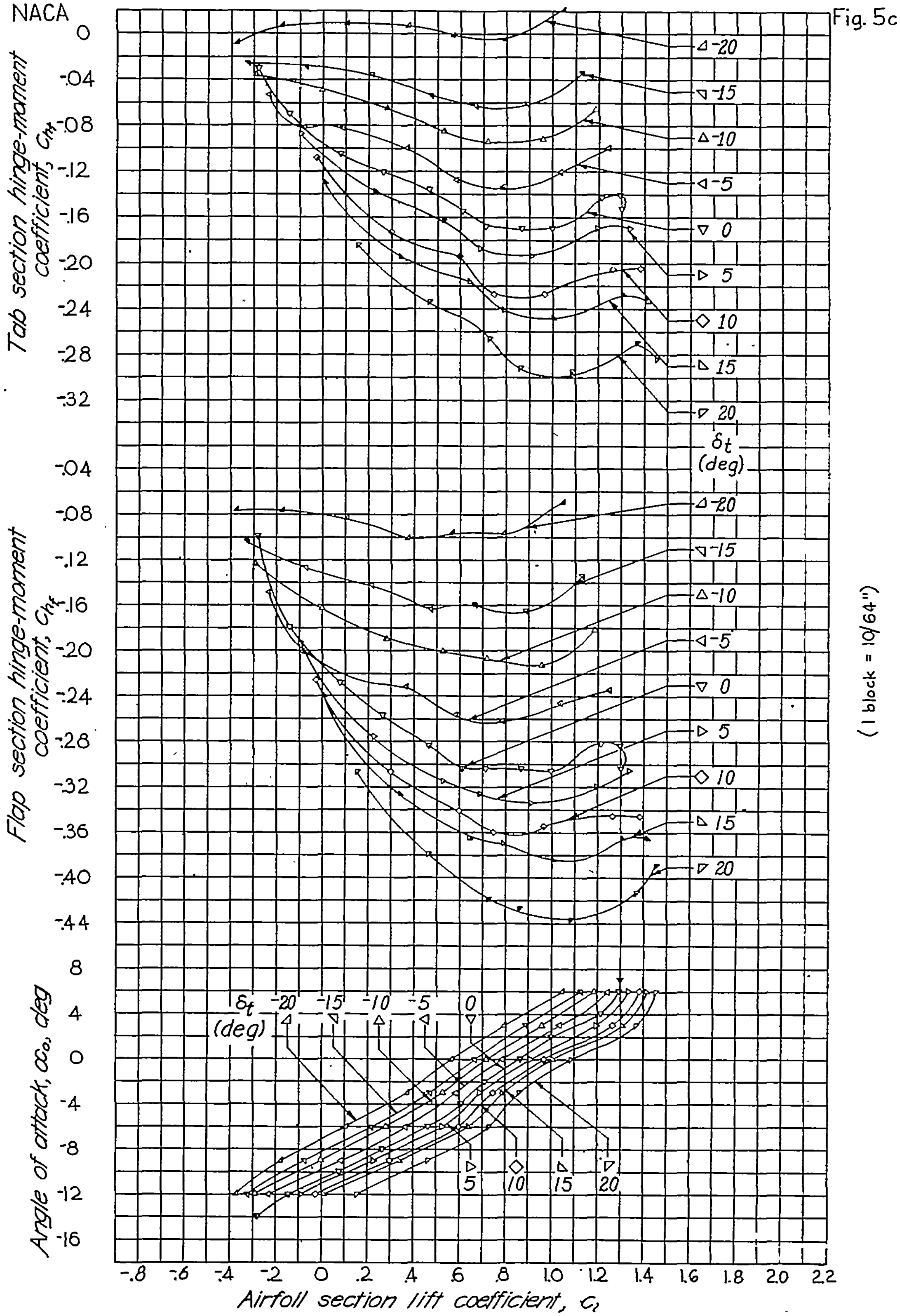
Fig. 5 (a to c) - Section aerodynamic characteristics of an NACA 66-009 airfoil with a 0.30c plain flap and a 0.20 c_f plain tab. Flap gap = 0.005c; tab gap = 0.001c.



(b) $\delta_f = 10°$

Figure 5.- Continued.

L - 314



(c) $\delta_f = 20°$
Figure 5.-Concluded.

L - 314

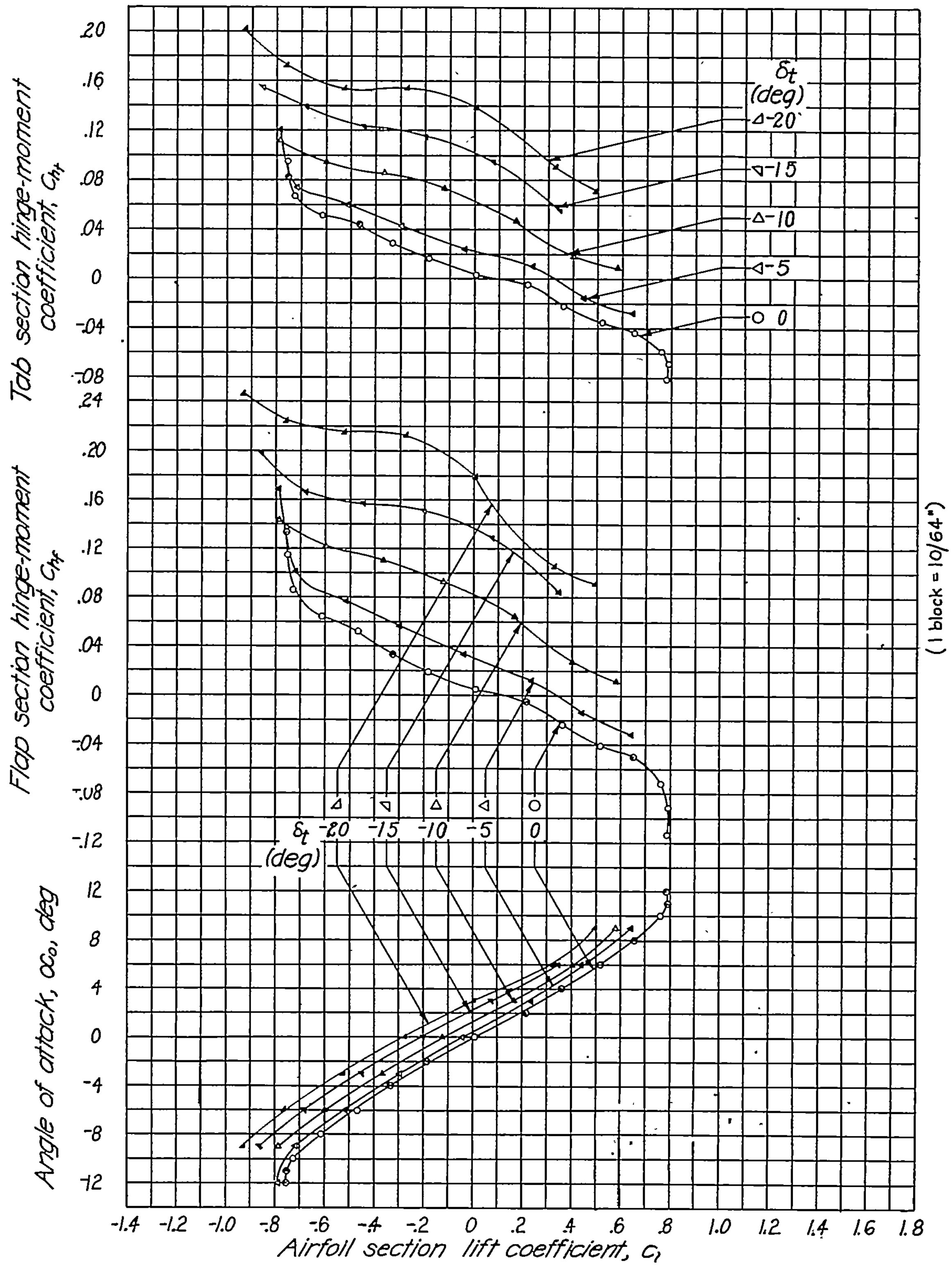


Figure 6.-Section aerodynamic characteristics of an NACA 66-009 airfoil with a 0.30c flap and a 0.20 c_f plain tab. Blunt-nose 0.35c_f overhang; flap gap=0.005c; tab gap=0.001c; δ_f=0°.

L - 314

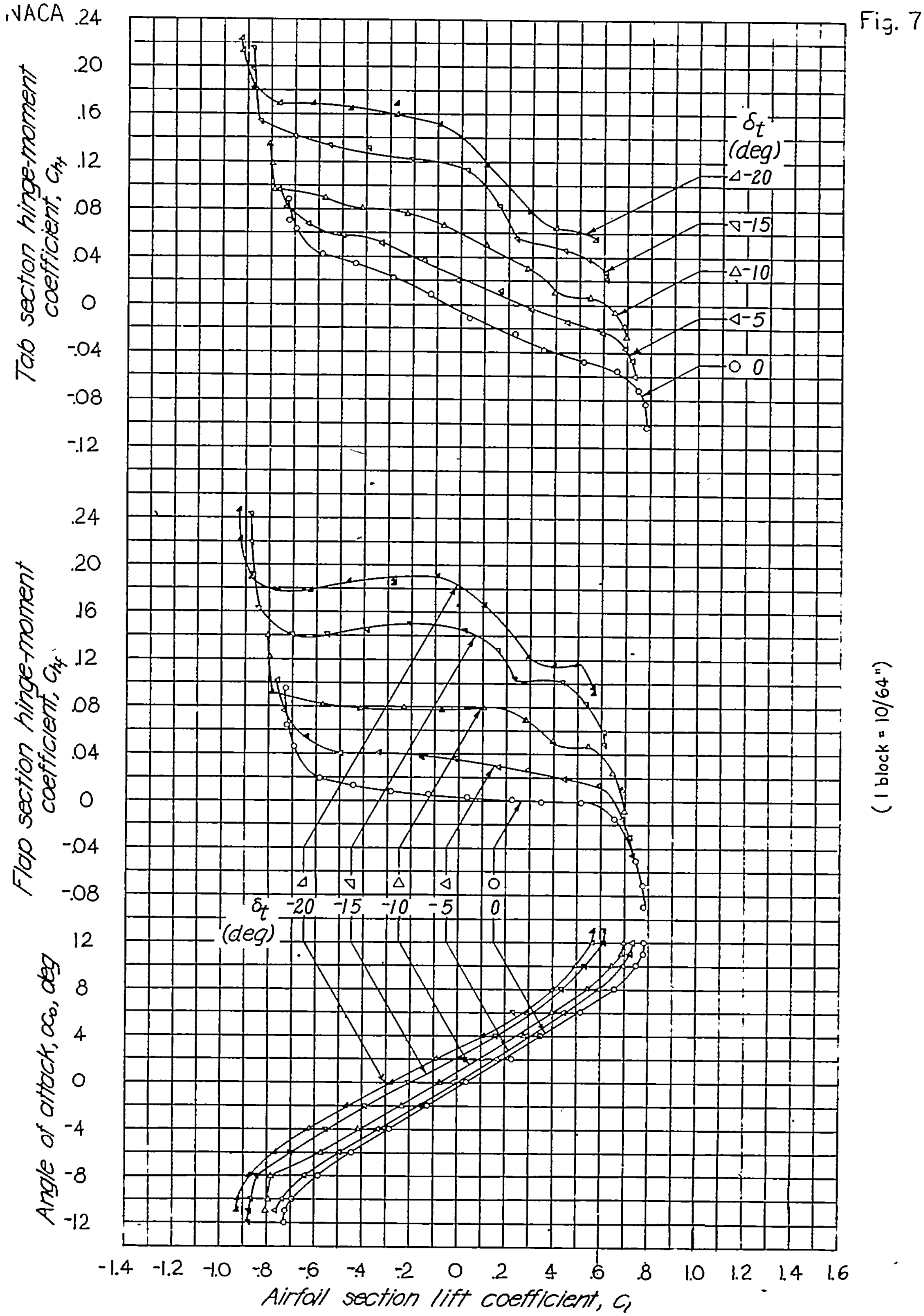


Figure 7.-Section aerodynamic characteristics of an NACA 66-009 airfoil with a 0.30c flap and a 0.20 c_f plain tab. Blunt-nose 0.50 c_f overhang; flap gap-0.005c ; tab gap-0.001c ; δ_f=0°.

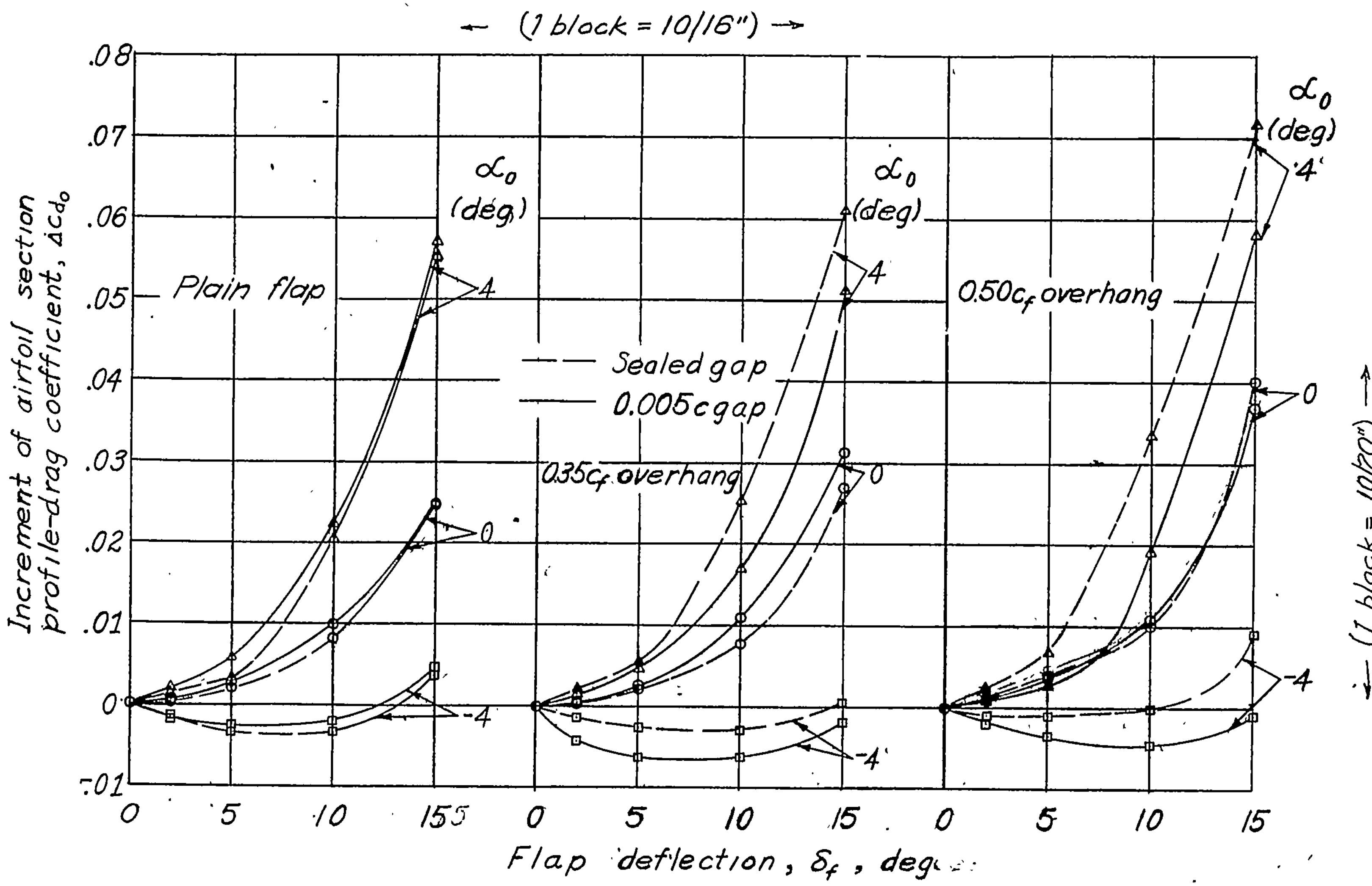


Figure 8. -Increment of airfoil section profile-drag coefficient caused by deflection of a 0.30c flap with blunt nose and three overhangs and with sealed and 0.005c gap.