NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

# WARTIME REPORT

ORIGINALLY ISSUED
September 1941 as
Advance Restricted Report

WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS

IV - A MEDIUM AERODYNAMIC BALANCE OF VARIOUS NOSE SHAPES

USED WITH A 30-PERCENT-CHORD FLAP ON AN NACA 0009 AIRFOIL

By Milton B. Ames, Jr., and Donald R. Eastman, Jr.

Langley Memorial Aeronautical Laboratory
Langley Field, Va.



NACA

WASHINGTON

NACA WARTIME REPORTS are reprints of papers originally issued to provide rapid distribution of advance research results to an authorized group requiring them for the war effort. They were previously held under a security status but are now unclassified. Some of these reports were not technically edited. All have been reproduced without change in order to expedite general distribution.

L - 355

# WIND-TUNNEL INVESTIGATION OF CONTROL-SURFACE CHARACTERISTICS

# IV - A MEDIUM AERODYNAMIC BALANCE OF VARIOUS NOSE SHAPES USED WITH A 30-PERCENT-CHORD FLAP ON AN NACA 0009 AIRFOIL

By Milton B. Ames, Jr., and Donald R. Eastman, Jr.

## SUMMARY

Tests have been made in the NACA 4- by 6-foot vertical wind tunnel of an NACA 0009 airfoil with a 30-percent-chord flap having a medium amount of aerodynamic overhanging balance. In the investigation the effects of the shape of the flap-nose overhang and the gap at the nose of the flap have been determined. A few tests were made to determine the effectiveness of a tab on the balanced surface. The aerodynamic section characteristics of the various arrangements tested are given. A partial analysis of the data has been made, and the results discussed.

The results indicate that, in general, the lift effectiveness of the aerodynamically balanced flap was increased slightly over that of a plain flap when a blunt or medium flap nose was used on the balanced flap. The balance effectiveness of the flap having the medium amount of aerodynamic balance showed an appreciable increase over that of a flap having a small aerodynamic balance. The flap with the blunt nose shape proved to be the most effective in reducing flap hinge moments. The adverse effect of an unsealed gap on the balance effectiveness of the flap with a medium amount of aerodynamic overhang appeared to be of smaller magnitude than for a plain flap or a flap having a small aerodynamic overhang. The medium nose on the flap gave the highest values of lift at positive angles of attack and flap deflection with the largest gap tested. The effectiveness of a tab as a balancing device for a flap having a medium amount of aerodynamic overhang was slightly less than for a plain flap. The minimum profile-drag coefficient of the airfoil with the most tapered nose shape was 0.0024 greater than for the airfoil with the blunt nose flap, while the medium nose flap on the airfoil resulted in an increase of 0.0014 in profile-drag coefficient over that for the airfoil with the blunt nose flap.

## INTRODUCTION

The problem of reducing the hinge moments on the controls of an airplane is becoming more acute with the increases of speed and size of modern airplanes. To copé with this problem the NACA has in progress an extensive investigation of the aerodynamic characteristics of control surfaces. The investigation has as its purpose the presentation of design data for the determination of the types of flap arrangement suitable for use as control surfaces. Because a conventional control surface is merely a flap on an airfoil, these two terms are used synonymously in this paper.

As part of this investigation, the effects of flap-nose shape, flap-nose gap, and balance on a typical horizontal tail of finite span were determined in the full-scale wind tunnel. (See reference 1.) The more detailed part of the investigation is, however, being made in two-dimensional flow.

The first part of the two-dimensional flow investigation was the determination of the section characteristics of airfoil-flap combinations with plain flaps of various sizes and with sealed gaps. (See references 2, 3, and 4.) The data presented in references 2, 3, and 4 have been analyzed, and parameters for determining the characteristics of a thin symmetrical airfoil with a plain flap of any chord and a sealed gap at the flap nose are given in reference 5. The results of force tests of a plain flap with various gaps at the flap nose are reported in reference 6. Tests to determine the effect of flap-nose shape on a 30-percent-chord flap having a 20-percent-flap-chord overhanging balance with various gaps at the flap nose were conducted in the NACA 4- by 6-foot wind tunnel, and the results are presented in reference 7.

The present investigation consisted of tests of an airfoil having a 30-percent-chord flap with a 35-percent-flap-chord overhanging balance of several nose shapes and with various amounts of gap at the flap nose. To expedite the publication of the data, only a very limited analysis of the results has been made.

## APPARATUS AND MODEL

The tests were made in the NACA 4- by 6-foot vertical wind tunnel (reference 8), modified as described in reference 2 for force tests in two-dimensional flow. A three-component balance system has been installed in the tunnel. On this balance, the aerodynamic forces of lift, drag, and the pitching moments are measured independently and simultaneously. The hinge moments of the flap and the tab are measured with special torque rod balances built into the model.

The 2-foot-chord by 4-foot-span model was the same model used for the investigations reported in references 6 and 7, but with modifications so that tests could be made with a medium overhanging balance on the flap. (See fig. 1.) The model was made of laminated mahogany to the NACA 0009 profile, the stations and ordinates of which are given in table I. The flap chord, measured from the flap hinge axis to the trailing edge, is 30 percent of the airfoil chord. The overhanging balance ahead of the flap hinge axis is 35 percent of the flap chord. The flap-nose shape and the gap between the airfoil and the flap were varied by detachable flap nose blocks and airfoil tail blocks ahead of the flap nose. In accordance with the results of the flap-nose-shape investigation in reference 7, three flap nose shapes similar to those previously investigated were tested. The nose shapes are shown in figure 1, and are designated blunt, medium, and sharp. The tab was made of brass, and the nose radius is approximately one-half the airfoil thickness at the tab hinge axis. The gap between the flap and the tab was fixed at 0.1 of 1 percent of the airfoil chord.

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 can be determined. The model was attached to the balance frame by torque tubes, which extended through the sides of the tunnel. (See reference 2.) 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 and were held by friction clamps on the torque rods which 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 an air velocity of about 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-ft vertical tunnel is 1.93.)

Tests were made on the airfoil with the blunt, medium, and sharp nose flaps to determine the effects of sealed gap and 0.001c, 0.005c, and 0.010c size gaps at the flap nose. Flap deflections were set from 0° to 18° or 20° for the tests with sealed gap and from 0° to 25° in 5° increments for the tests of the various unsealed gaps. The flaps with the sharp and medium noses were tested at a flap deflection of 18° instead of at 20° because 18° was the maximum deflection at which these flap-nose shapes could be tested with the gap grease-sealed.

Tab tests were made using the medium flap nose only. Deflections of the tab of 0° and ±15° were tested at flap deflections of 0° and 10°. The gap at the flap nose was sealed for all tab tests.

Throughout all the tests, lift, drag, and pitching moments of the airfoil and the hinge moments of the flap and the tab were measured. For each flap or tab setting, force tests were made throughout the entire angle-of-attack range from negative stall to positive stall at 2° increments of angle of attack. Near the airfoil stall, however, the results at increments of 1° were recorded.

## RESULTS

### Symbols

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

$c_l$ airfoil section lift coefficient $\left(\frac{l}{qc}\right)$

$c_{d_o}$ airfoil section profile-drag coefficient $\left(\frac{d_o}{qc}\right)$

$c_m$ airfoil section pitching-moment coefficient about the quarter-chord point of the airfoil $\left(\frac{m}{qc^2}\right)$

$c_{h_f}$ flap section hinge-moment coefficient $\left(\frac{h_f}{qc_f^2}\right)$

$c_{h_t}$ tab section hinge-moment coefficient $\left(\frac{h_t}{qc_t^2}\right)$

where

$l$ airfoil section lift

$d_o$ airfoil profile drag

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

$h_f$ flap section hinge moment

$h_t$ tab section hinge moment

$c$ chord of airfoil with flap and tab neutral

$c_f$ flap chord (measured from flap hinge axis to trailing edge, tab neutral)

$c_t$ tab chord

$q$ dynamic pressure $(1/2\rho V^2)$

and

$\alpha_o$ angle of attack for airfoil of infinite aspect ratio

$\delta_f$ flap deflection with respect to airfoil

$\delta_t$ tab deflection with respect to flap

## Precision

The accuracy of the data is indicated by the deviation from zero of the lift and moment coefficients at zero angle of attack and flap deflection. The maximum error in effective angle of attack at zero lift appears to be about $\pm 0.2^\circ$.

Tunnel corrections, experimentally determined in the 4- by 6-foot vertical tunnel, were applied to the lift coefficients only. The hinge-moment coefficients, therefore, are probably higher than would be obtained in free flight; hence the values presented are considered to be conservative. The increments of airfoil profile-drag coefficient should be reasonably independent of tunnel effect although the absolute values of the drag coefficient are subject to an undetermined correction.

Inaccuracies in the airfoil, flap, and tab-section data are thought to be negligible relative to the inaccuracies that will be incurred in the application of the data to practical installations.

## Aerodynamic Section Characteristics

The results of the tests to determine the section characteristics of the airfoil and the flap having a $0.35c_f$ overhang and blunt nose are given in figure 2(a) for the sealed-gap condition, in figure 2(b) for a 0.001c gap, in figure 2(c) for a 0.005c gap, and in figure 2(d) for a 0.010c gap. In figures 3(a), 3(b), 3(c), and 3(d) and 4(a), 4(b), 4(c), and 4(d) the results of tests of the various gap conditions for the airfoil with the flap having the medium and sharp nose, respectively, are presented.

# DISCUSSION

## Lift

The slope of the lift-coefficient curve $\left(\frac{\partial c_l}{\partial \alpha_0}\right)_{\delta_f}$, in agreement with the results of references 6 and 7, was approximately 0.097 for the condition of sealed gaps, regardless of the flap-nose shape. In general, increases in the size of the gap at the flap nose caused the value of $\left(\frac{\partial c_l}{\partial \alpha_0}\right)_{\delta_f}$ to decrease. The lift-coefficient curves for the conditions of unsealed gaps became increasingly nonlinear as the angle of attack, flap deflection, or the taper of the flap nose increased. The flap lift effectiveness, $\left(\frac{\partial \alpha_0}{\partial \delta_f}\right)_{c_l}$ was also greatly affected by the presence of a gap at the flap nose. In general, increases in the gap size gave decreases in the value of $\left(\frac{\partial \alpha_0}{\partial \delta_f}\right)_{c_l}$, and the magnitude of these decreases were the greatest at the high values of $c_l$. Exceptions to the foregoing statement were noted in the case of the flap with the medium nose and with gap of 0.005c and 0.010c. (See figs. 3(c) and 3(d).) At positive values of $c_l$ and flap deflections between 10° and 15° an increase in $\left(\frac{\partial \alpha_0}{\partial \delta_f}\right)_{c_l}$ was observed, and the magnitude of the increases was greater with the larger gap. The condition is probably caused by a radical flow phenomenon and was also observed in the results of reference 7, but to a lesser degree.

## Pitching Moments

With the blunt nose flap neutral and the gap sealed, the rate of change of pitching-moment coefficient with lift coefficient $\left(\frac{\partial c_m}{\partial c_l}\right)_{\delta_f}$ was about 0.010, which is in agreement with the values given in references 6 and 7. The greatest effect of increasing the gap on $c_m$ was the reduction in $\left(\frac{\partial c_m}{\partial \delta_f}\right)_{c_l}$, which was observed at high values of $c_l$. This result is indicated by the steepening of the $c_m$ curves for the various values of $\delta_f$. With the gap unsealed, the value of $\left(\frac{\partial c_m}{\partial \delta_f}\right)_{c_l}$ also decreased with increase in taper of the flap-nose shape. (See figs. 2(c) and 2(d), 3(c) and 3(d), and 4(c) and 4(d).)

## Hinge Moments of the Flap

The effect of the presence of a gap, gap size, and flap-nose shape on the variation of the flap hinge-moment coefficient with lift coefficient $\left(\frac{\partial c_{h_f}}{\partial c_l}\right)_{\delta_f}$, as shown by the data in figures 2, 3, and 4, was negligible. For the flap with the medium and sharp nose shapes, at a given value of $c_l$, however, the value of $\left(\frac{\partial c_{h_f}}{\partial \delta_f}\right)_{c_l}$ increased very slightly as the gap was increased. The lowest value of $\left(\frac{\partial c_{h_f}}{\partial \delta_f}\right)_{c_l}$ was obtained with the blunt nose flap; and the value of the parameter increased with increase in taper of the flap nose.

## Criterion of Balance Effectiveness

A criterion of balance effectiveness is the increment in flap hinge-moment coefficient $\Delta c_{h_f}$ for a given increment in lift coefficient $\Delta c_l$. Figure 5 shows this characteristic of the flap with the blunt nose at angles of attack of $-8^\circ$, $0^\circ$, $8^\circ$ and the various gap arrangements tested. Similar plots are presented in figure 6 for the flap with the medium nose, and in figure 7 for the flap with the sharp nose.

Effect of gaps.- In general, the results indicate that for the medium and sharp nose flaps, as the gap size increased, the $\Delta c_{h_f}$ for a given $\Delta c_l$ increased slightly at angles of attack of $-8^\circ$ and $0^\circ$. The maximum value of $\Delta c_l$ at an angle of attack of $0^\circ$ was, however, obtained with the medium nose flap and the largest gap. For the high positive angle-of-attack condition the sealed gap was best for the sharp nose flap. The medium nose flap was best at the high angle-of-attack condition with the gap sealed for flap deflections up to $10^\circ$, while for flap deflections greater than $10^\circ$ the largest gap gave the highest values of $\Delta c_l$. In contrast to the results obtained in reference 7, the blunt nose flap appeared to have the most balance effectiveness with the largest gap for all angles of attack investigated. For the flaps with the $0.35c_f$ overhang, however, the effect of the presence of gap or gap size was slight, except at the high positive angle of attack.

Effect of flap nose shape.- In agreement with the

L-355

results of reference 7, the blunt nose flap gave the smallest values of $\Delta c_{h_f}$ for a given $\Delta c_l$. The medium nose flap, however, maintained lift and balance effectiveness at higher flap deflections for all angles of attack than did the blunt nose flap, and, hence, gave the larger values of $\Delta c_l$. The balance effectiveness of the sharp nose flap was less than for either the blunt or medium nose flap. The values of $\Delta c_{h_f}$ for a given value of $\Delta c_l$ are much less for the flap having the $0.35c_f$ overhang than for the flap having the $0.20c_f$ overhang reported in reference 7.

## Tab Characteristics

In accordance with the conclusion of reference 7 that tab characteristics were generally independent of flap-nose shape, only a very limited investigation of tab characteristics on the flap having a $0.35c_f$ overhang was conducted. The aerodynamic section characteristics of the airfoil with the medium nose flap neutral and deflected 10° for tab deflections of 0° and ±15° are presented in figure 8 and exhibit no unusual characteristics. The values of $\Delta c_l$ and $\Delta c_{h_f}$ caused by tab deflections for the flap neutral and deflected 10° are plotted for angles of attack of -8°, 0°, and 8° in figure 9. The results indicate that when the flap was neutral or deflected 10° the values of $\Delta c_l$ caused by tab deflection were generally about the same as those for the plain flap reported in reference 6 and the flap having a $0.20c_f$ overhang reported in reference 7. The values of $\Delta c_{h_f}$ caused by tab deflections were generally slightly less than those obtained with the tab on a plain flap. This result would indicate the balance effectiveness of a tab on a flap having a medium amount of overhanging balance is slightly less than for a plain flap and tab combination.

## Profile Drag

Because generally the drag coefficient of a tail surface is considered only for a high-speed or cruising-speed condition, the profile-drag coefficients for all test conditions have not been presented. The profile-drag coefficients are plotted in figure 10 against the airfoil section lift coefficients for the airfoil with the flap neutral and for each flap-nose shape and gap arrangement tested. With each flap-nose shape the drag increased with increasing gap and the increments caused by gap became greater as the lift coefficient varied from zero. The minimum profile-drag coefficient was obtained with the blunt nose flap having the gap sealed, and was 0.0098. With the blunt nose flap and sealed-gap condition as a basis, the increment of profile-drag coefficient with the medium flap nose shape and gap sealed was 0.0014, while with the sharp nose shape and gap sealed the increment in profile-drag coefficient was 0.0024. Because of a relatively large unknown tunnel correction, the drag coefficients cannot be considered absolute; however, the relative values should be independent of tunnel effects.

<u>Parameters</u>.- The use of aerodynamic parameters is a direct means by which the characteristics of the different flap-nose shapes and the various amounts of aerodynamic overhang may be compared. (See reference 5.) It is not within the scope of this paper to make a complete analysis by this method, but it is important that, in general, the effect on the parameters of the aerodynamic overhang, flap-nose shape, and gap be treated.

In agreement with the results of references 6 and 7, the value of $\left(\frac{\partial c_l}{\partial \alpha_0}\right)_{\delta_f}$ for the blunt nose flap neutral and the gap sealed was 0.097. As already discussed, the value of this parameter decreased as the gap size increased, the magnitude of these decreases being largest for the sharp nose flap. The flap lift effectiveness $-\left(\frac{\partial \alpha_0}{\partial \delta_f}\right)_{c_l}$ for the blunt and medium nose flaps with the gaps sealed was about -0.60. The value of the flap lift effectiveness for the blunt nose and medium-nose 0.30c flaps having a $0.35c_f$ overhang was therefore slightly higher than the flap effectiveness of -0.57 for the 0.30c plain flap and 0.30c flap having a $0.20c_f$ overhang as reported in references 6 and 7. The reductions in $\left(\frac{\partial \alpha_0}{\partial \delta_f}\right)_{c_l}$ caused by the presence of a gap at the flap nose were greatest at the high values of $c_l$. The lift effectiveness of the sharp nose flap was generally less than for the medium and blunt nose flaps for all test conditions.

L-355

Two parameters of major concern to the designer of a control surface are the flap hinge-moment parameters, $\left(\frac{\partial c_{h_f}}{\partial \alpha_o}\right)_{\delta_f}$ and $\left(\frac{\partial c_{h_f}}{\partial \delta_f}\right)_{\alpha_o}$. The flap with the $0.35c_f$ overhang had a value for $\left(\frac{\partial c_{h_f}}{\partial \alpha_o}\right)_{\delta_f}$ of about -0.0035 for all nose shapes with gaps sealed, and this value was reduced slightly with gap. The value of $\left(\frac{\partial c_{h_f}}{\partial \alpha_o}\right)_{\delta_f}$ obtained with the flap having a small overhang in reference 7 was about -0.0060, which indicates that the $0.35c_f$ overhang on the flap resulted in an appreciable reduction in the value of this parameter. The value of $\left(\frac{\partial c_{h_f}}{\partial \delta_f}\right)_{\alpha_o}$ varied with nose shape. With the blunt nose shape and sealed gap the value was -0.0033, which was the lowest value obtained with the $0.35c_f$ overhang on the flap. The values of $\left(\frac{\partial c_{h_f}}{\partial \delta_f}\right)_{\alpha_o}$ for the medium and sharp nose flaps were about -0.0055 and -0.0076, respectively. The smallest value of $\left(\frac{\partial c_{h_f}}{\partial \delta_f}\right)_{\alpha_o}$ for the flap with the $0.20c_f$ overhang (reference 7) was obtained with the blunt nose flap and was -0.0088. The values of $\left(\frac{\partial c_{h_f}}{\partial \delta_f}\right)_{\alpha_o}$ were generally reduced by the presence of a gap. From this discussion, it would follow that the parameter for free-control effectiveness $\left(\frac{\partial \delta_f}{\partial \alpha_o}\right)_{c_{h_f} = 0}$ will be the highest for the blunt nose flap.

Because the effect of gap on certain parameters is quite marked, it is essential that some additional consideration be given to this phenomenon. The changes in the parameters caused by gap increase in magnitude as the angle of attack, flap deflection, or lift coefficient increases positively from zero. These changes in the values of the parameters indicate a trend toward a nonlinear variation of the aerodynamic coefficients; and when the nonlinear variation is large, the parameters cannot be used accurately to determine the aerodynamic characteristics of a control surface.

## CONCLUSIONS

The results of the tests of a 0.30c flap having a $0.35c_f$ aerodynamic overhang indicate that the largest reduction in the flap section hinge-moment coefficient was obtained with the blunt nose flap. The lift effectiveness of the flap with either a blunt or medium nose shape and a $0.35c_f$ overhang was slightly greater than that obtained with a plain flap or a flap having a small aerodynamic overhang. The adverse effect of a gap at the flap nose on the balance effectiveness of a flap having a $0.35c_f$ overhang generally was less than for a plain flap or a flap having a small aerodynamic balance. When the angle of attack and the flap deflection were both positive, the test data indicate that with a blunt or medium nose flap, the largest gap gave the highest values of airfoil section lift coefficient and the most balance effectiveness at large flap deflections.

The effect of tab deflection on the hinge-moment coefficient of a flap with $0.35c_f$ aerodynamic overhang was less than for the same size tab on a plain flap, but this reduction in balance effectiveness of the tab was very slight.

The minimum profile-drag coefficient was obtained with the blunt nose flap neutral and with the gap sealed. The medium and sharp nose flaps gave increments in minimum profile-drag coefficients of 0.0014 and 0.0024, respectively, over that obtained with the blunt nose flap.

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

L-355

## REFERENCES

1. Goett, Harry J., and Reeder, J. P.: Effects of Elevator Nose Shape, Gap, Balance, and Tabs on the Aerodynamic Characteristics of a Horizontal Tail Surface. Rep. No. 675, NACA, 1939.

2. Ames, Milton B., Jr., and Sears, Richard I.: Pressure-Distribution Investigation of an N.A.C.A. 0009 Airfoil with a 30-Percent-Chord Plain Flap and Three Tabs. T.N. No. 759, NACA, 1940.

3. Street, William G., and Ames, Milton B., Jr.: Pressure-Distribution Investigation of an N.A.C.A. 0009 Airfoil with a 50-Percent-Chord Plain Flap and Three Tabs. T.N. No. 734, NACA, 1939.

4. Ames, Milton B., Jr., and Sears, Richard I.: Pressure-Distribution Investigation of an N.A.C.A. 0009 Airfoil with 80-Percent-Chord Plain Flap and Three Tabs. T.N. No. 761, NACA, 1940.

5. Ames, Milton B., Jr., and Sears, Richard I.: Determination of Control-Surface Characteristics from NACA Plain-Flap and Tab Data. T.N. No. 796, NACA, 1941.

6. Sears, Richard I.: Wind-Tunnel Investigation of Control-Surface Characteristics. I - Effect of Gap on the Aerodynamic Characteristics of an NACA 0009 Airfoil with a 30-Percent-Chord Plain Flap. NACA ARR, June 1941.

7. Ames, Milton B., Jr.: Wind-Tunnel Investigation of Control-Surface Characteristics. III - A Small Aerodynamic Balance of Various Nose Shapes Used with a 30-Percent-Chord Flap on an NACA 0009 Airfoil. NACA ARR, Aug. 1941.

8. Wenzinger, Carl., and Harris, Thomas A.: The Vertical Wind Tunnel of the National Advisory Committee for Aeronautics. Rep. No. 387, NACA, 1931.

TABLE I

NACA 0009 airfoil

[All dimensions in percent chord]

| Station | Ordinates | |
|---|---|---|
| | Upper | Lower |
| 0 | 0 | 0 |
| 1.25 | 1.42 | -1.42 |
| 2.5 | 1.96 | -1.96 |
| 5.0 | 2.67 | -2.67 |
| 7.5 | 3.15 | -3.15 |
| 10 | 3.51 | -3.51 |
| 15 | 4.01 | -4.01 |
| 20 | 4.30 | -4.30 |
| 25 | 4.46 | -4.46 |
| 30 | 4.50 | -4.50 |
| 40 | 4.35 | -4.35 |
| 50 | 3.97 | -3.97 |
| 60 | 3.42 | -3.42 |
| 70 | 2.75 | -2.75 |
| 80 | 1.97 | -1.97 |
| 90 | 1.09 | -1.09 |
| 95 | .60 | -.60 |
| 100 | ( .10) | (-.10) |
| 100 | 0 | 0 |
| Leading edge radius: 0.89 | | |

Medium nose profile

[Stations measured from flap nose, and ordinates from chord line.]

| Station | Ordinate |
|---|---|
| 0 | 0 |
| .15 | .54 |
| .50 | .97 |
| 1.00 | 1.33 |
| 2.00 | 1.79 |
| 3.00 | 2.09 |
| 4.00 | 2.30 |
| 5.00 | 2.45 |
| 7.00 | 2.64 |
| 9.00 | 2.71 |
| 11.00 | 2.67 |
| 13.00 | 2.56 |
| 14.90 | 2.41 |

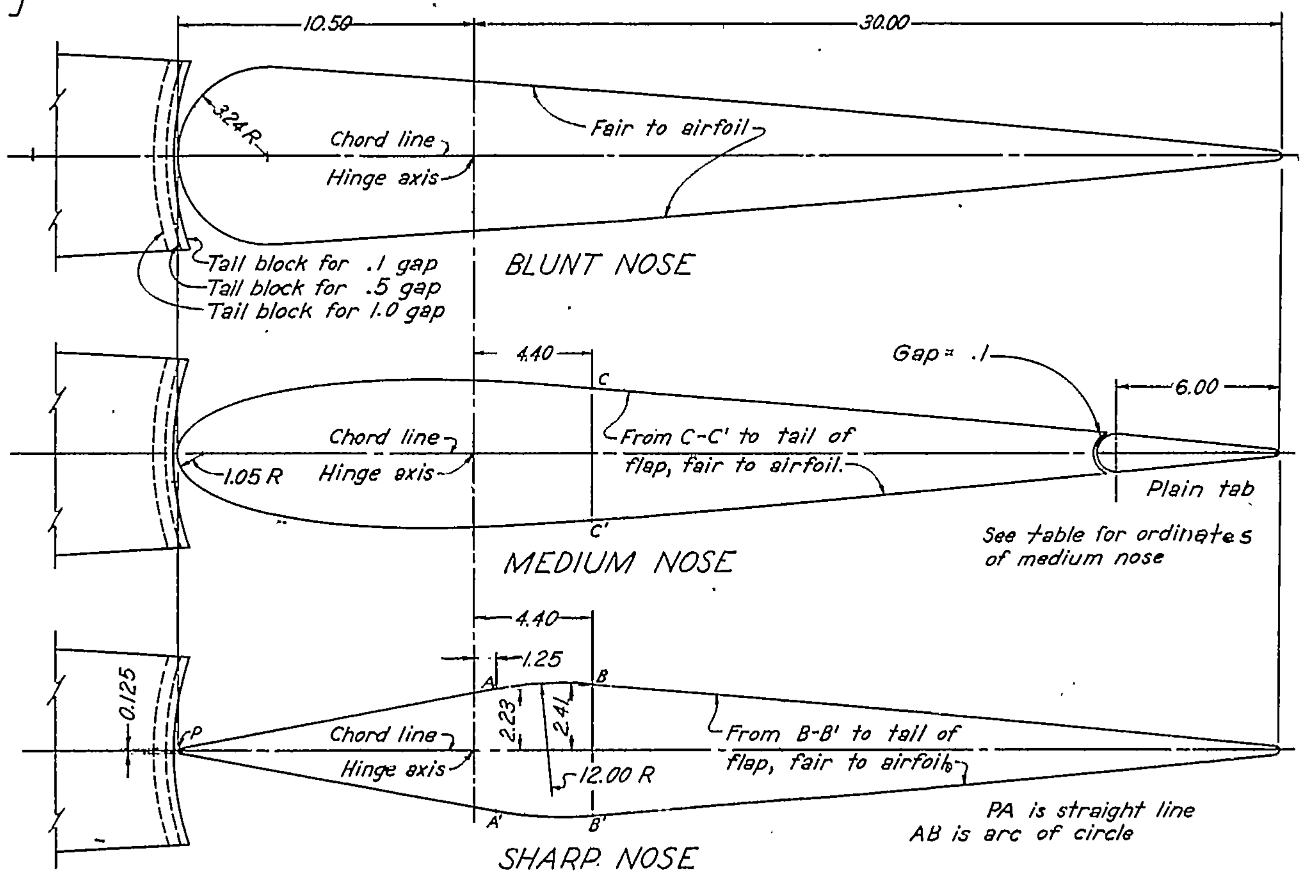
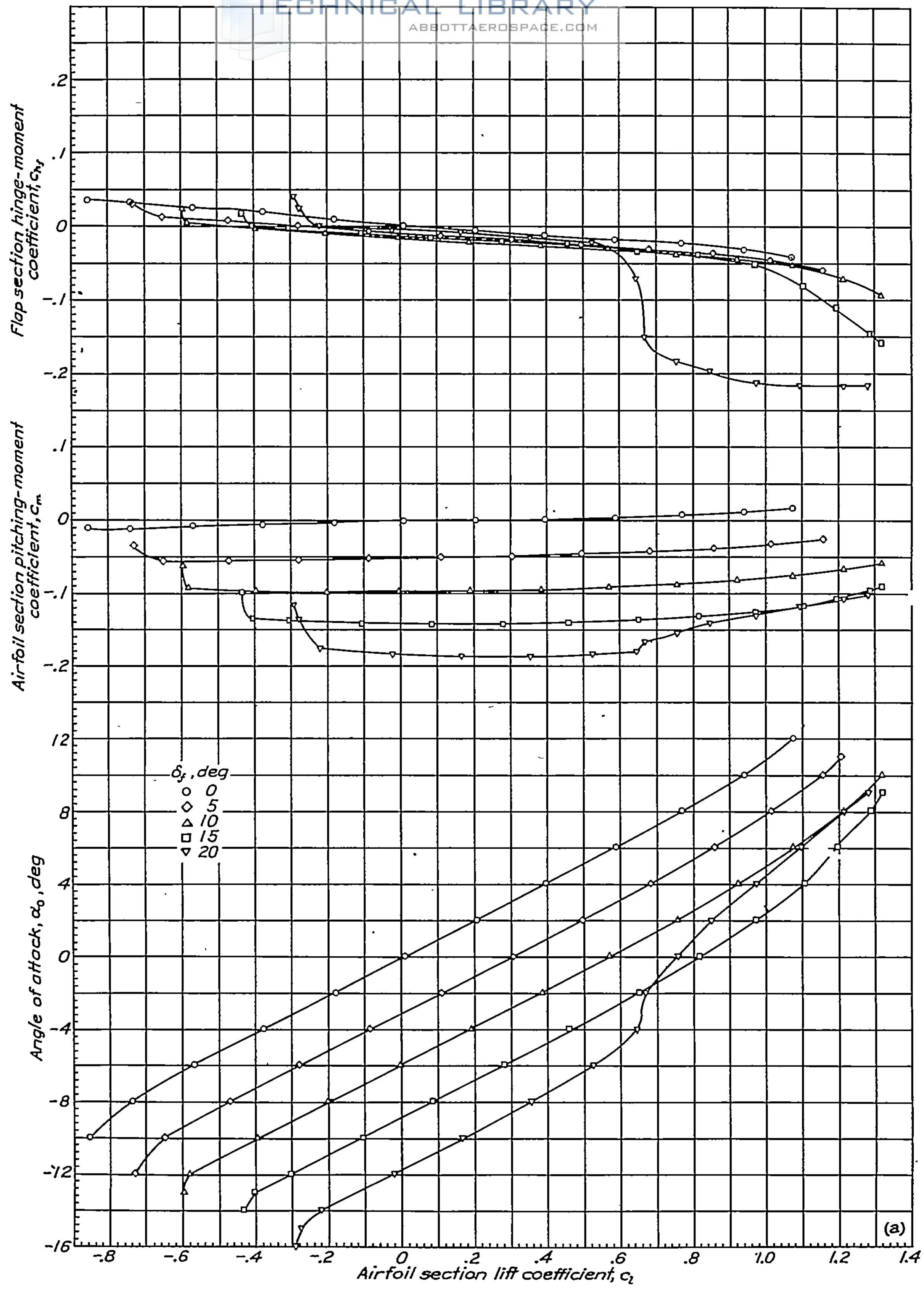


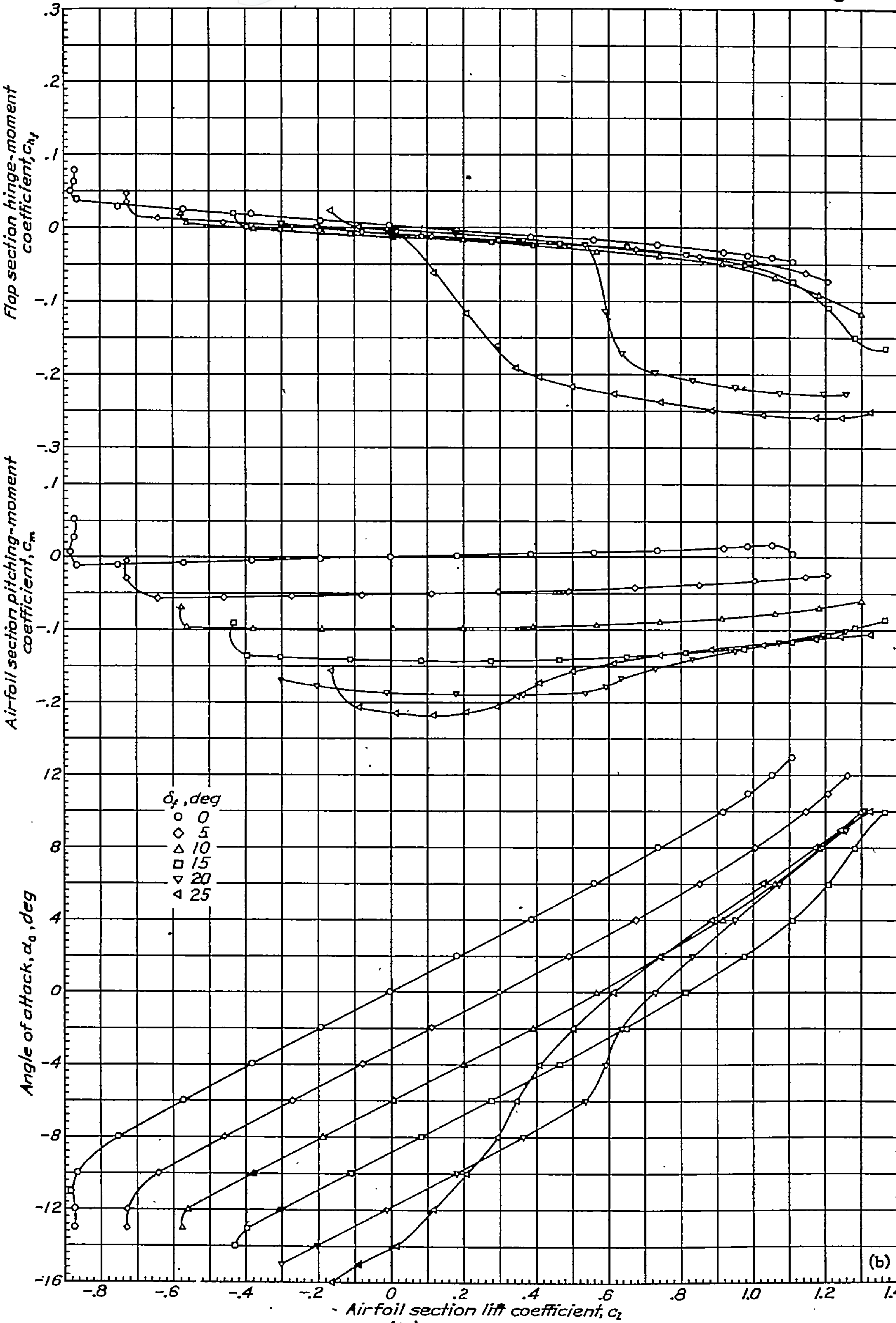

Figure 1.—Flap section of NACA 0009 airfoil showing variations of flap-nose shapes and gaps. All dimensions given in percent of airfoil chord. All flaps are symmetrical about chord line. All sealed gaps use minimum-gap tail block and grease seal.

L - 355



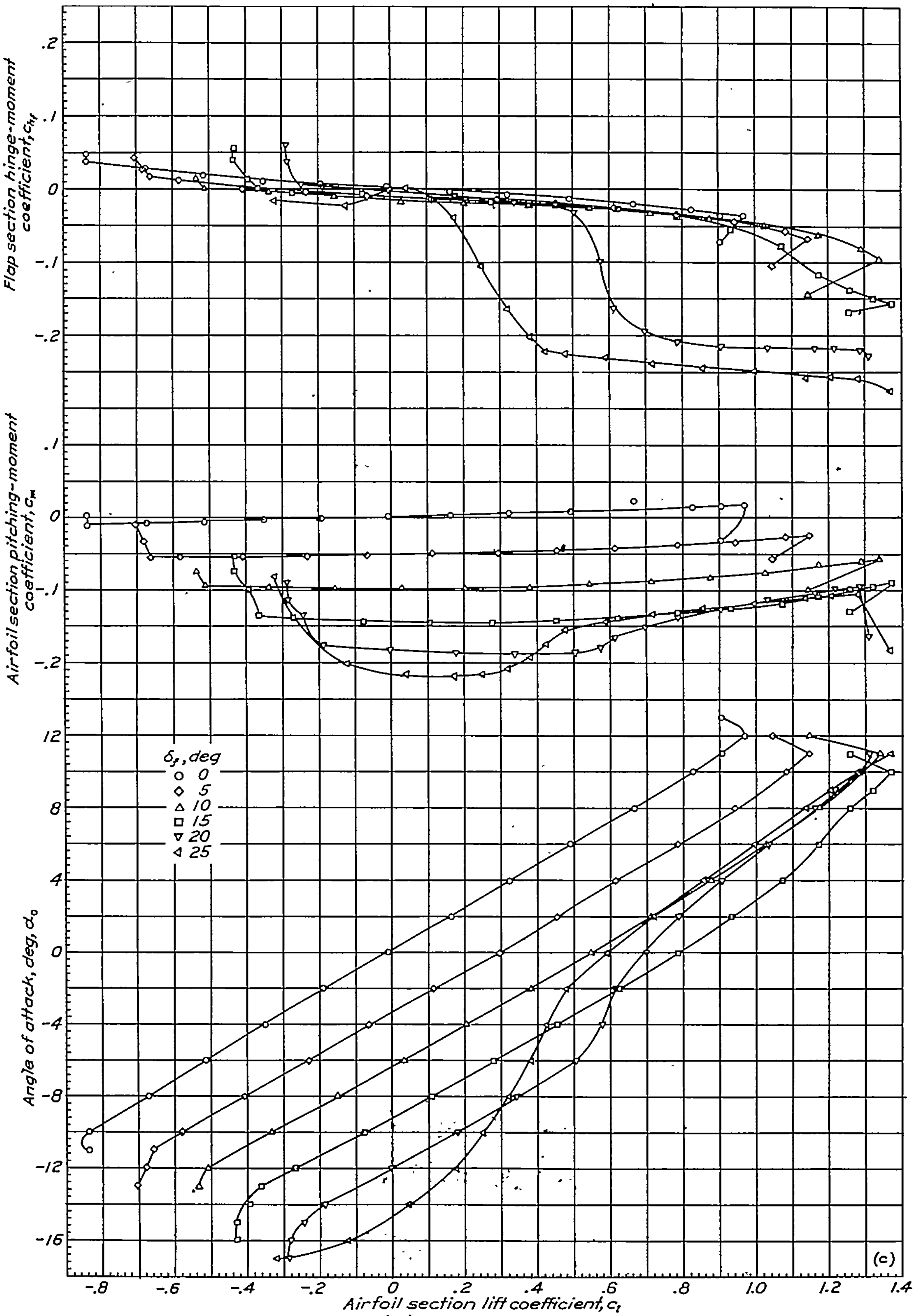

(a) Gap sealed.

Figure 2a to d.- Aerodynamic section characteristics of an NACA 0009 airfoil with 0.30c flap and $0.35c_f$ overhang. Blunt-nose flap.




(b) 0.001c gap.

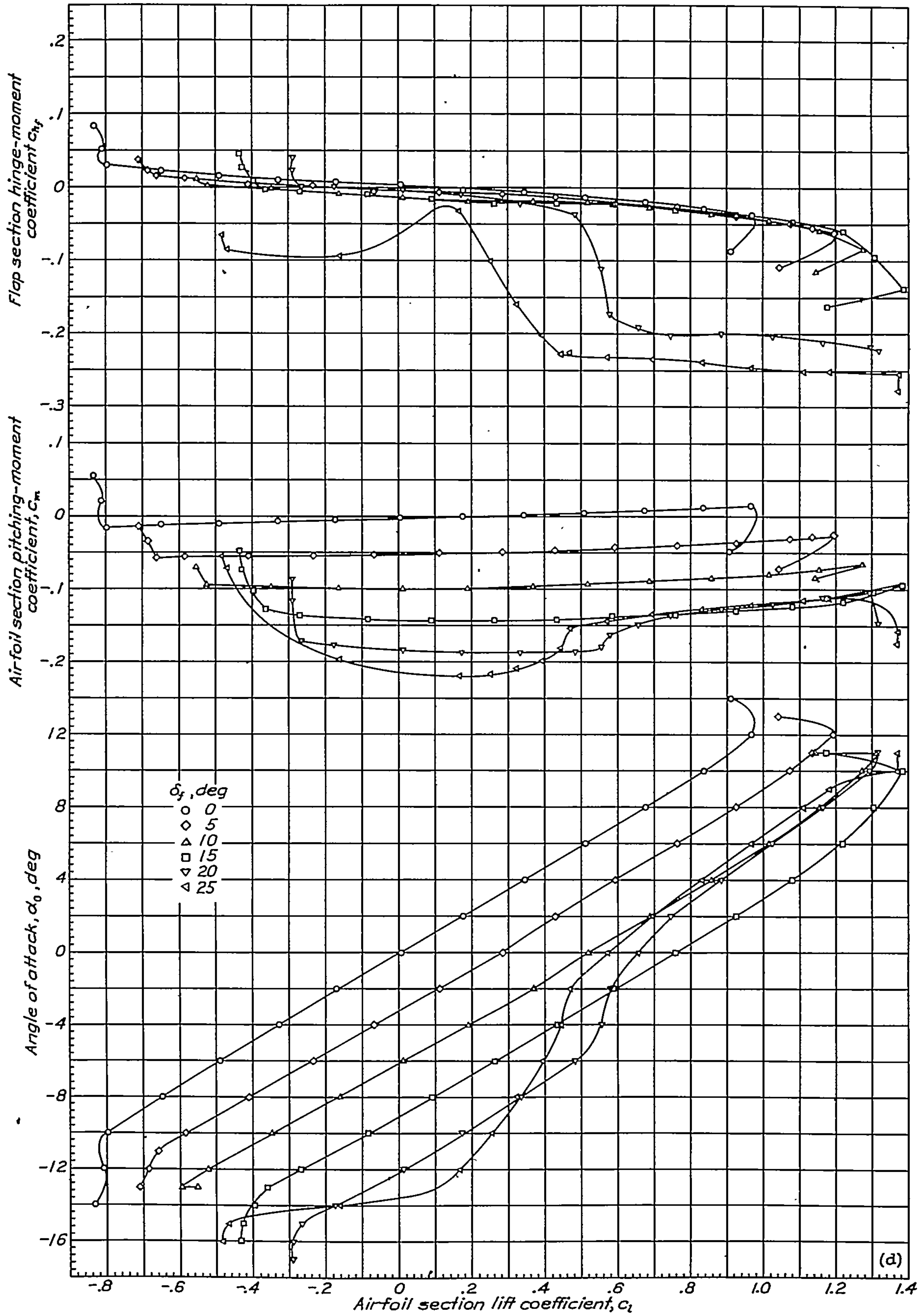
Figure 2.- Continued.




(c) 0.005c gap.

Figure 2.- Continued.

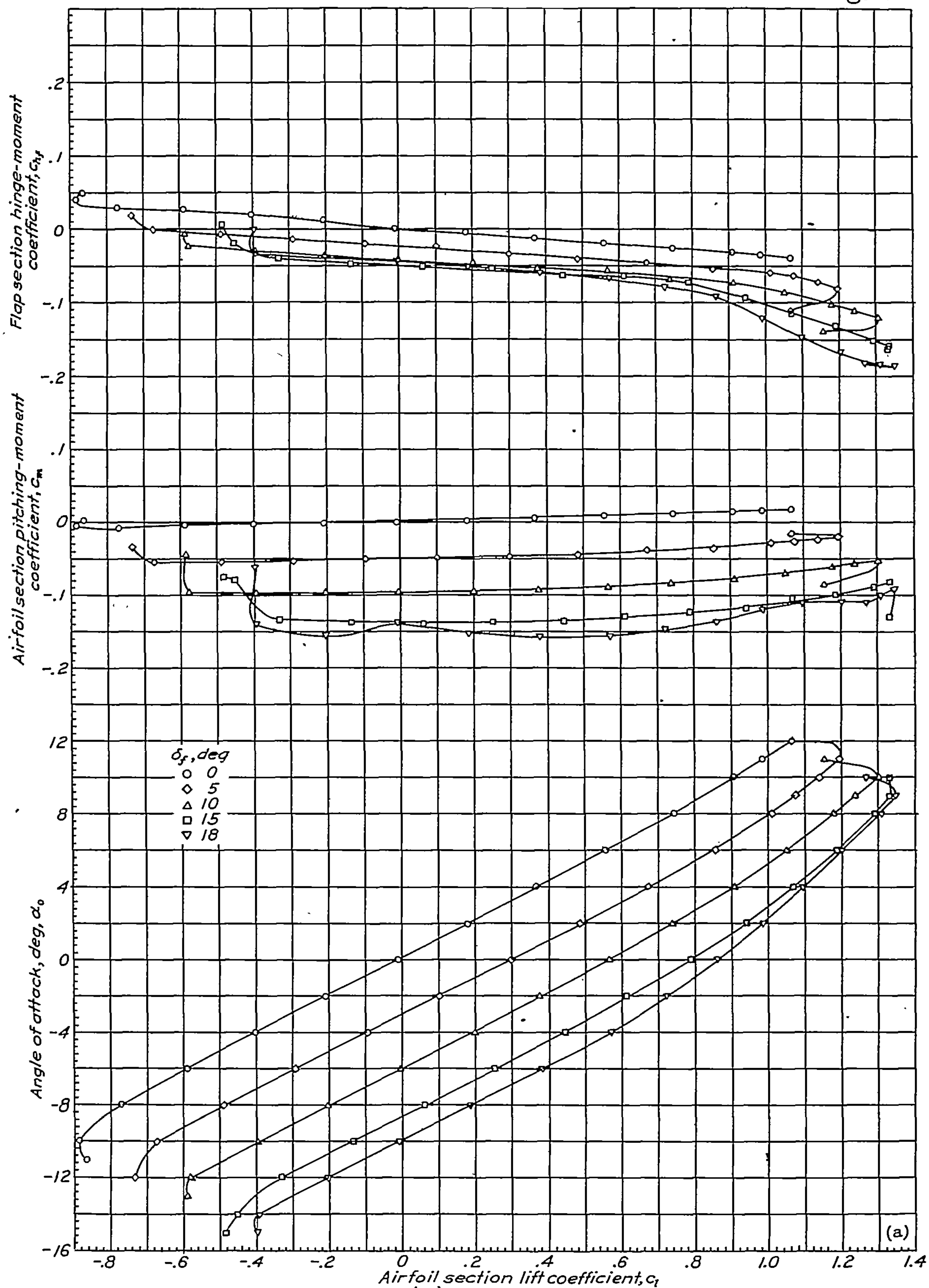
L - 332




(d) 0.010c gap.

Figure 2.- Concluded.

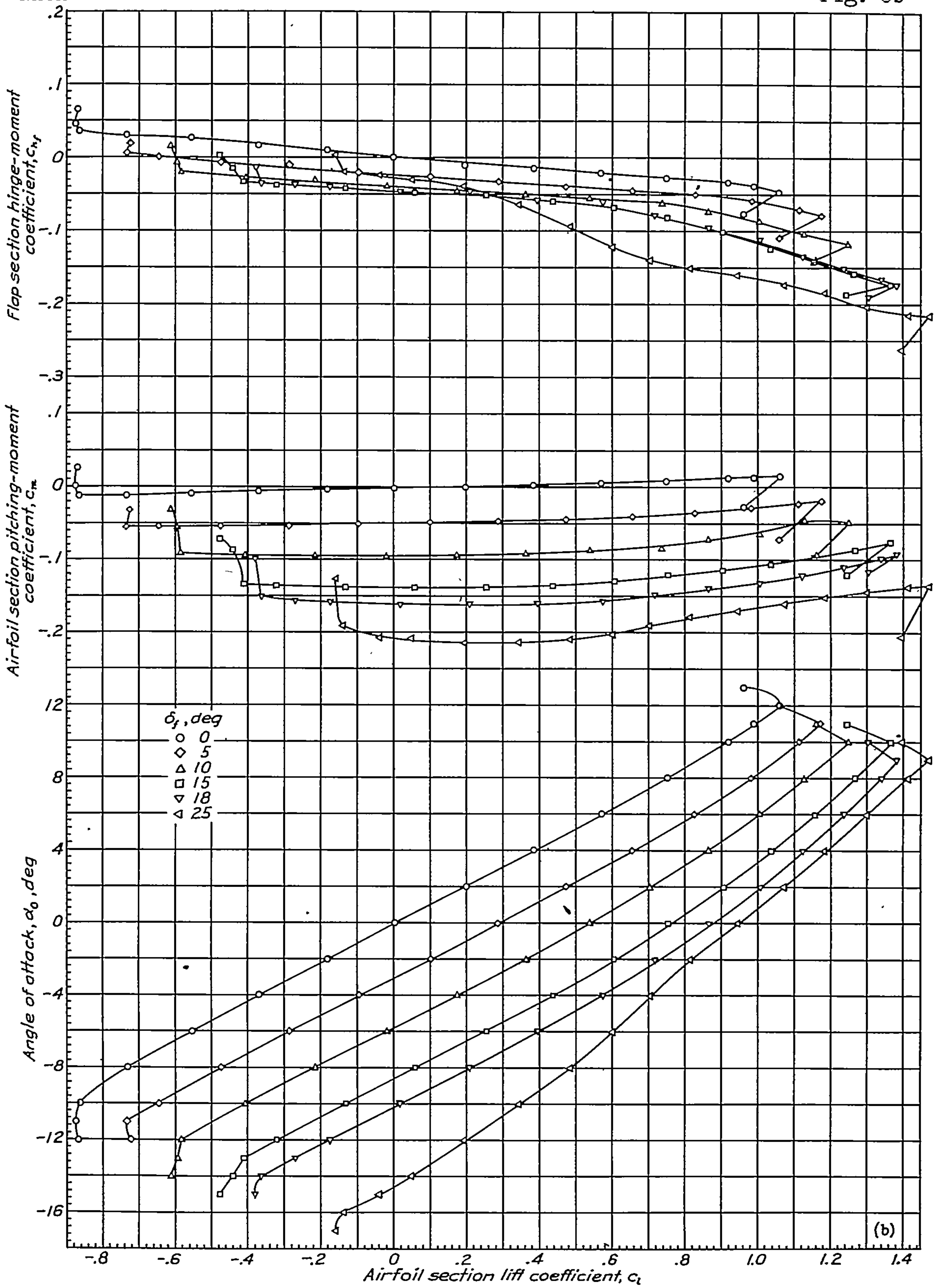
L - 355




(a) Gap sealed.

Figures 3a to d.- Aerodynamic section characteristics of an NACA 0009 airfoil with 0.30c flap and 0.35$c_f$ overhang. Medium-nose flap; $\delta_t = 0^o$.

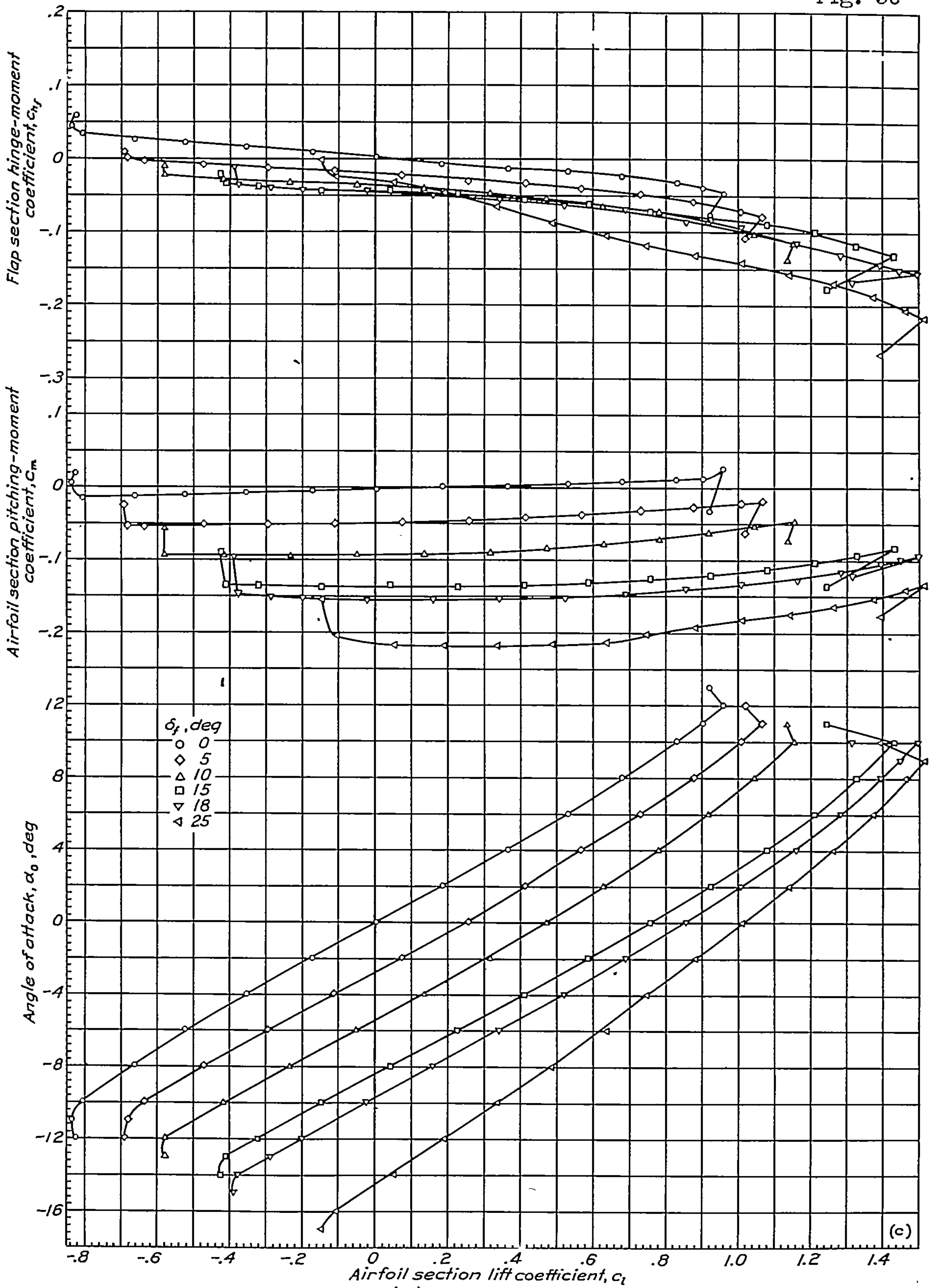
L - 355




(b) 0.001c gap.

Figure 3.- Continued.

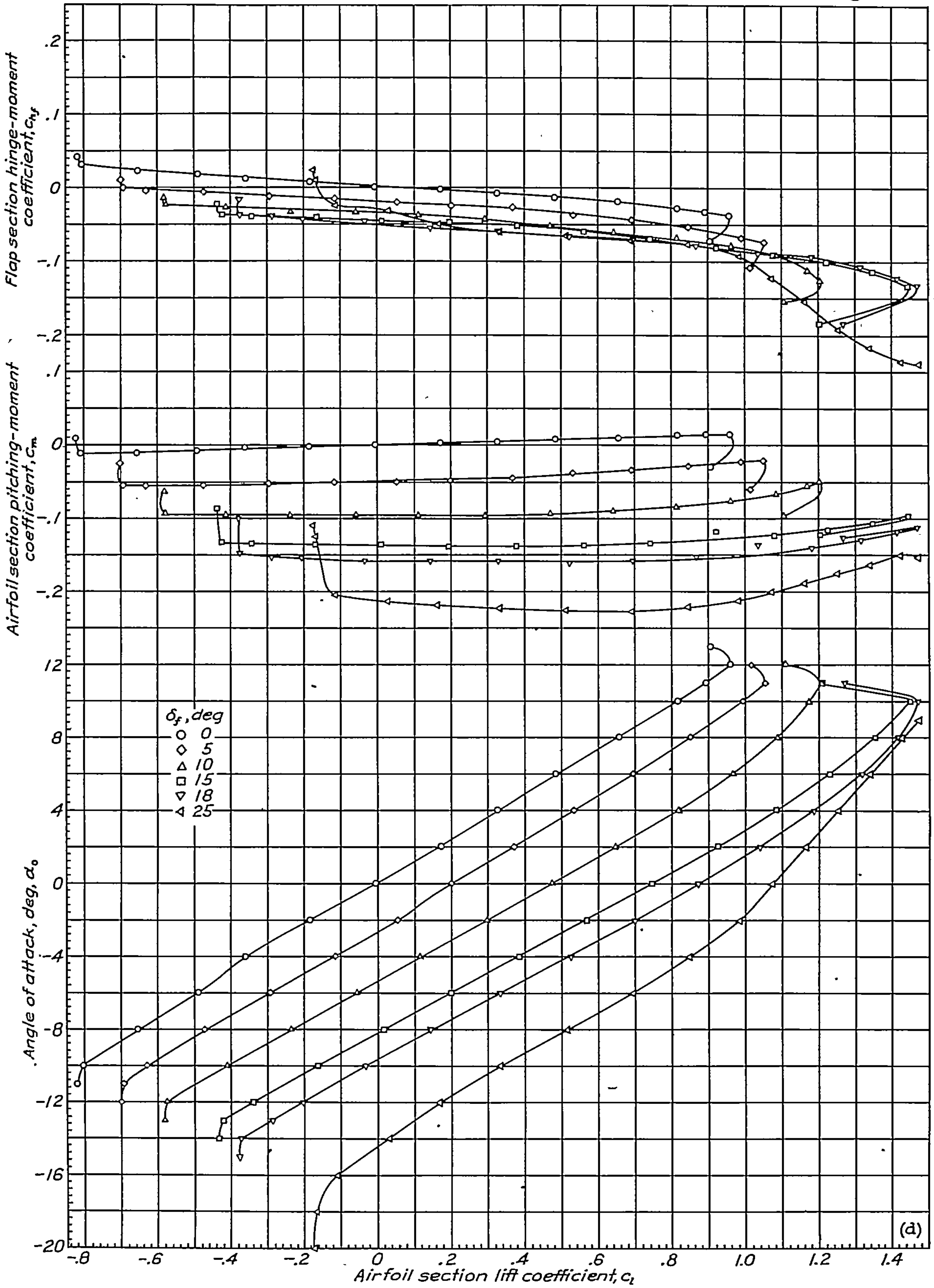
L - 355




(c) 0.005c gap.

Figure 3.- Continued.

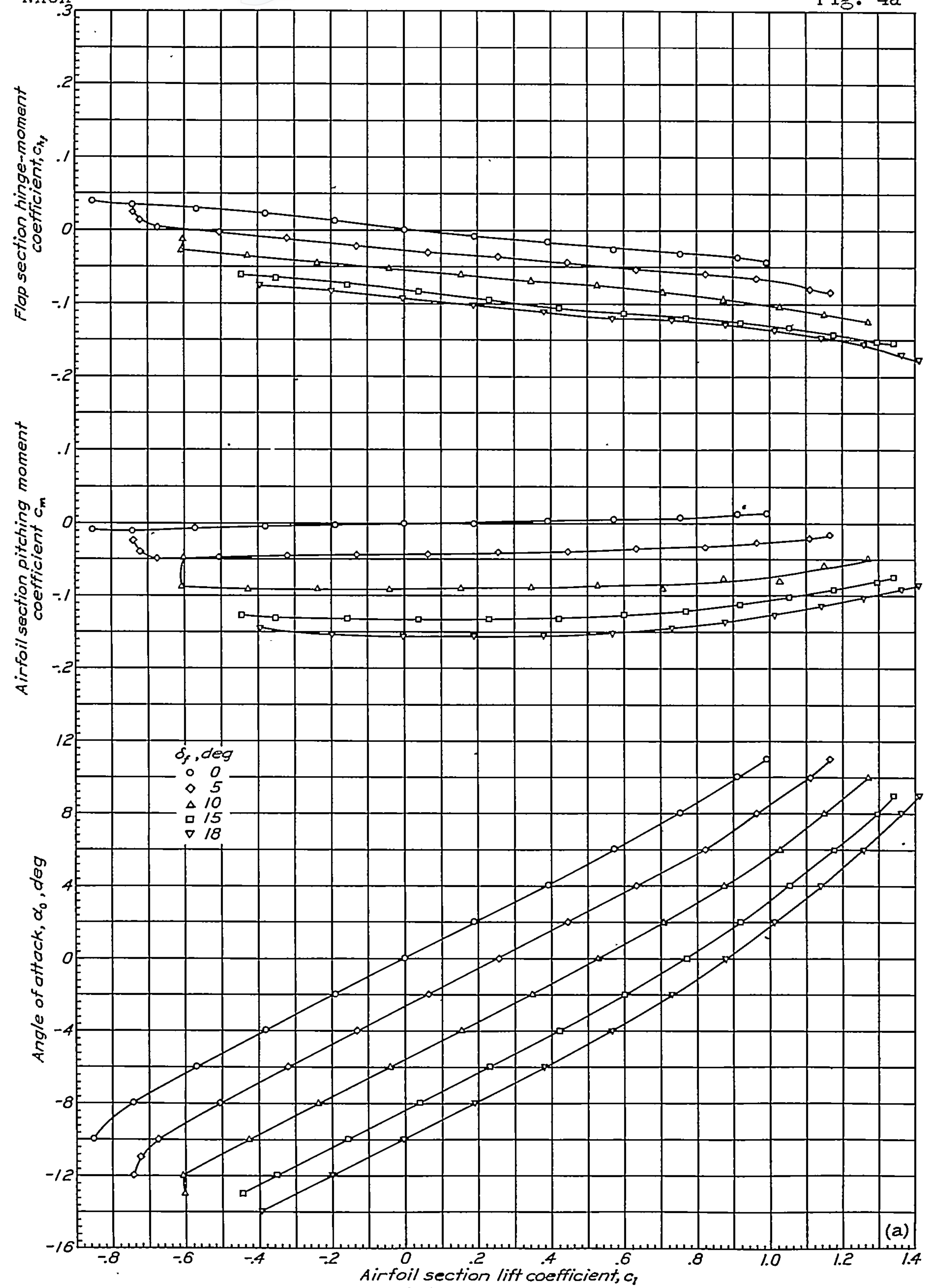
L-355




(d) 0.010c gap.

Figure 3.- Concluded.

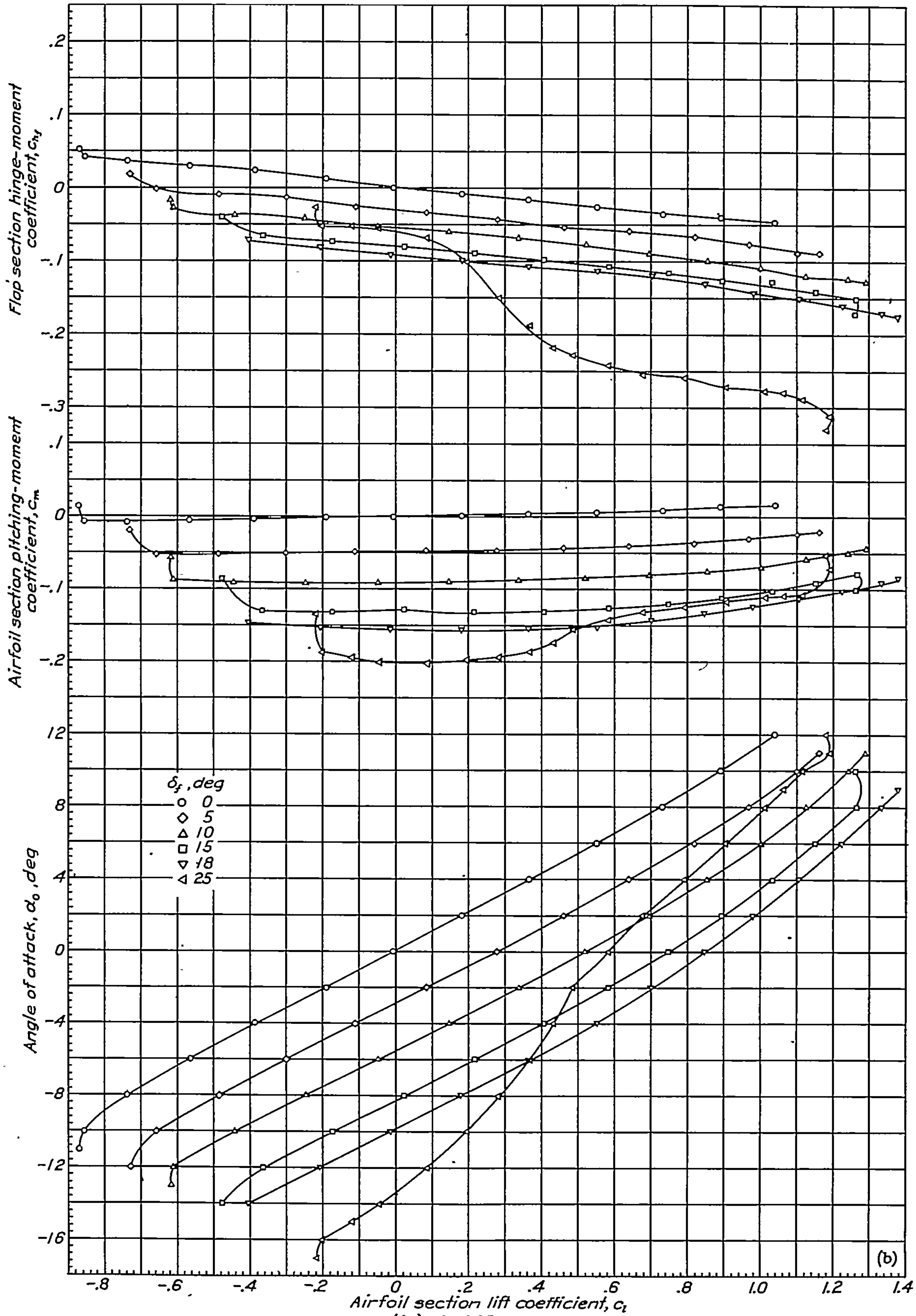
L-355




(a) Gap sealed.

Figure 4a to d.- Aerodynamic section characteristics of an NACA 0009 airfoil with 0.30c flap and 0.35$c_f$ overhang. Sharp-nose flap.

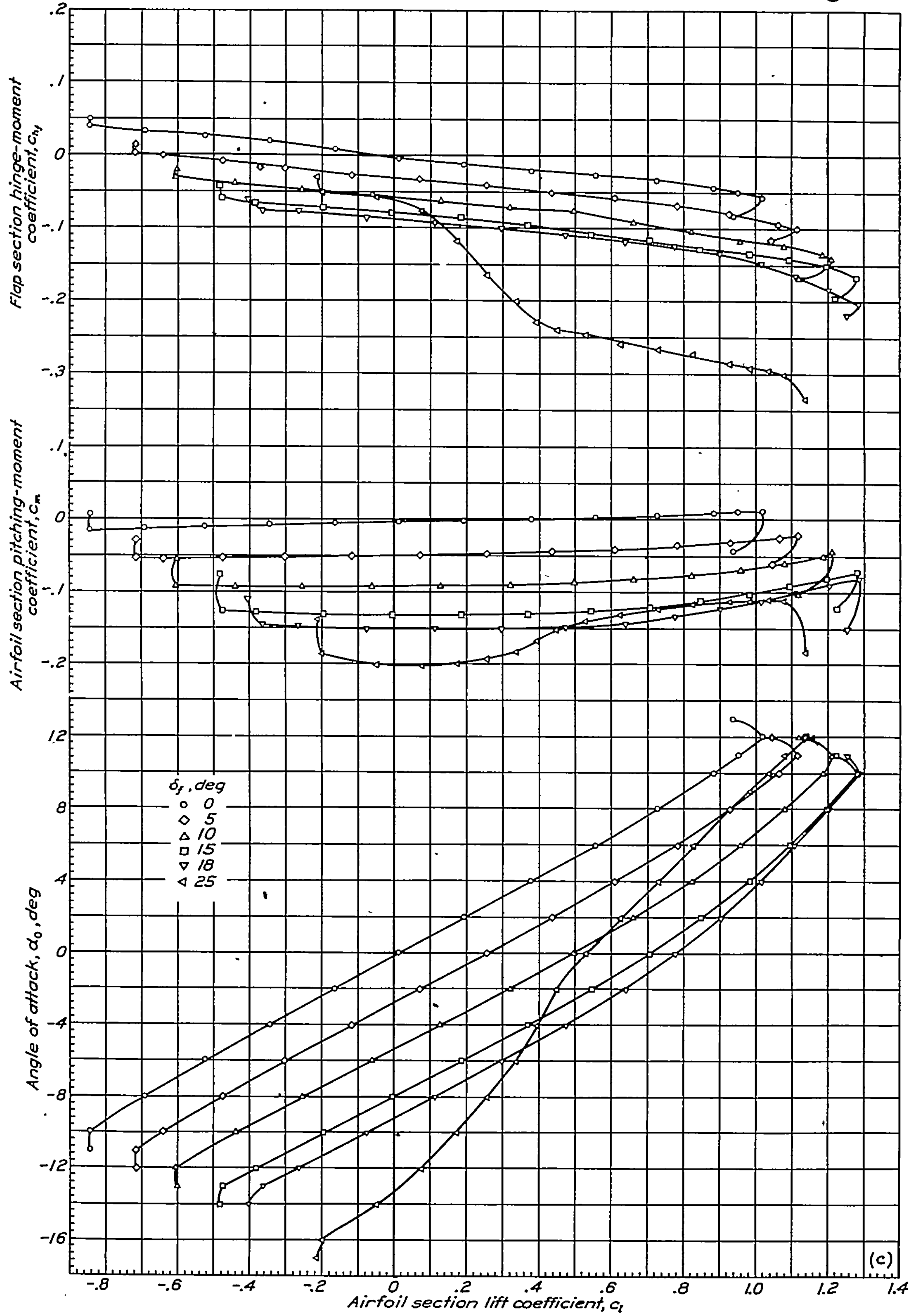
L-355




(b) 0.001c gap.

Figure 4.- Continued.

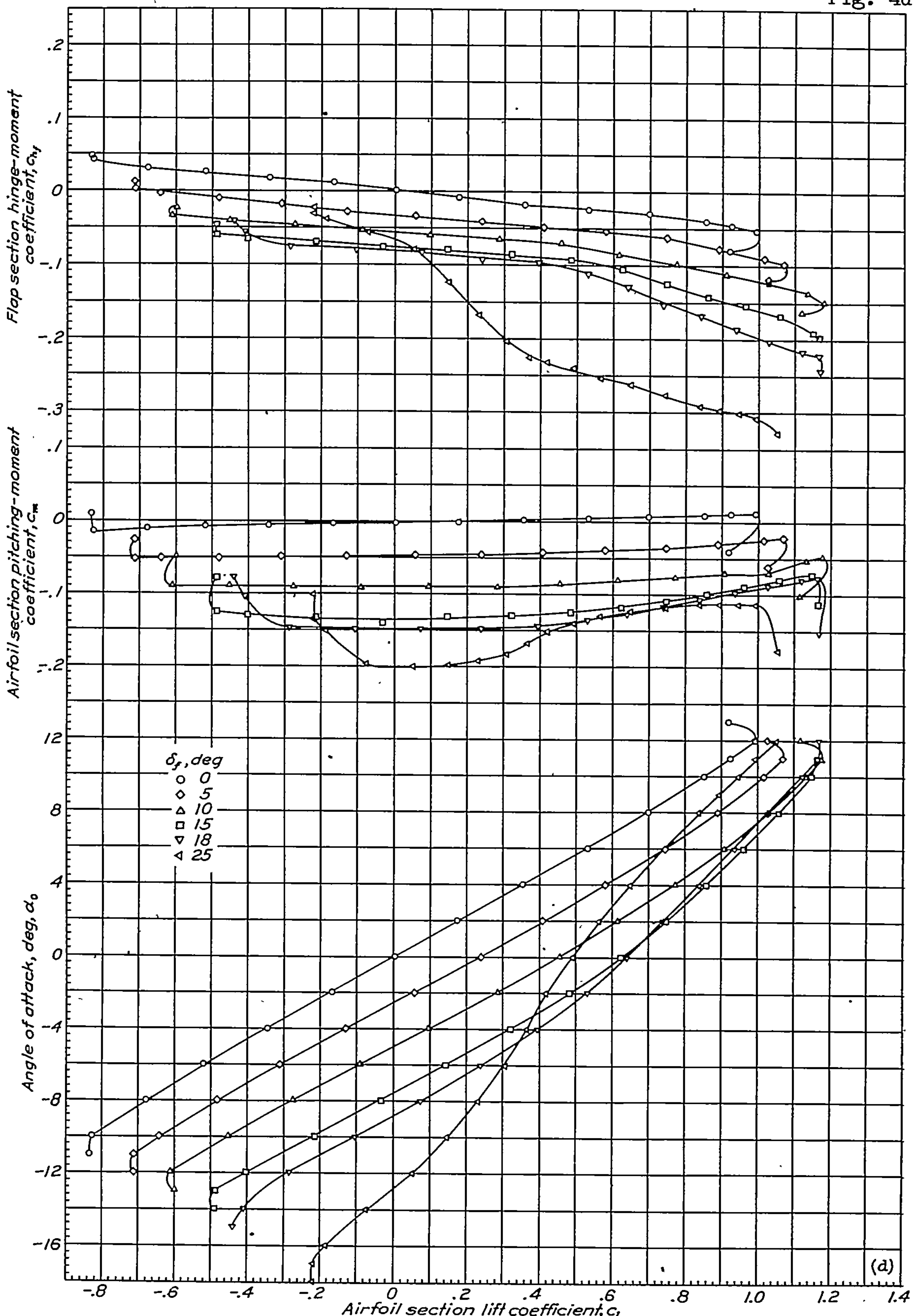
L-355




(c) 0.005c gap.

Figure 4.- Continued.

L-355




(d) 0.010c gap.

Figure 4.- Concluded.

L-355

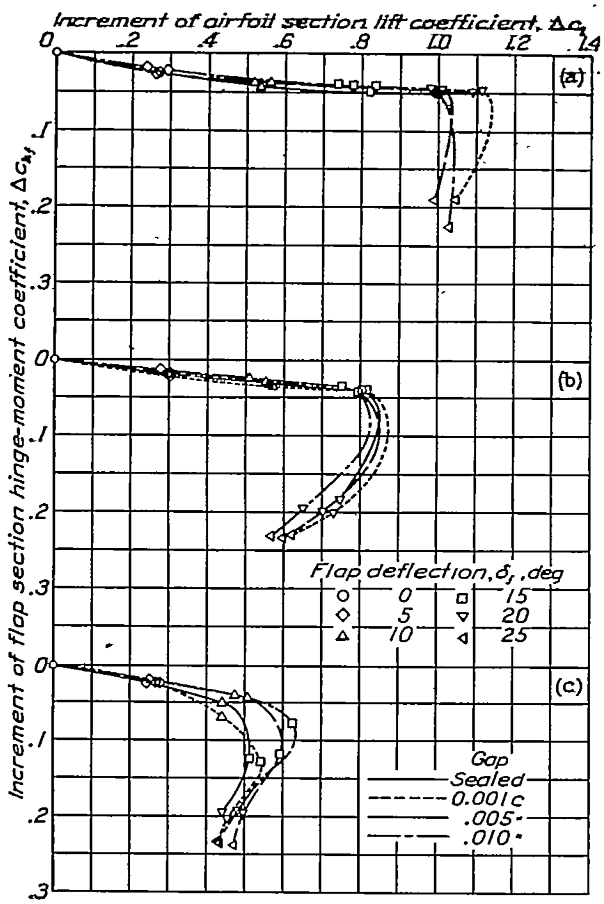



Figure 5.- Blunt-nose flap.

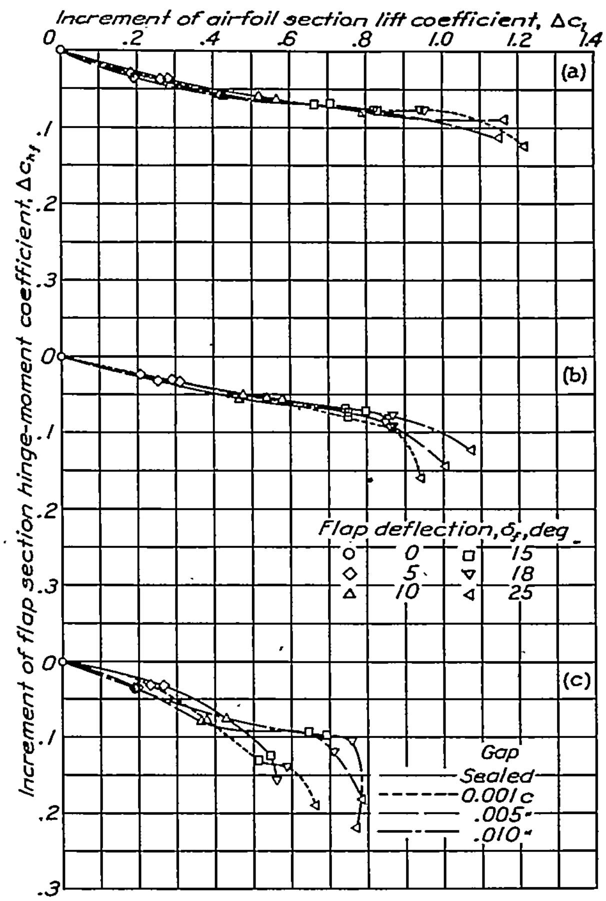



Figure 6.- Medium-nose flap.

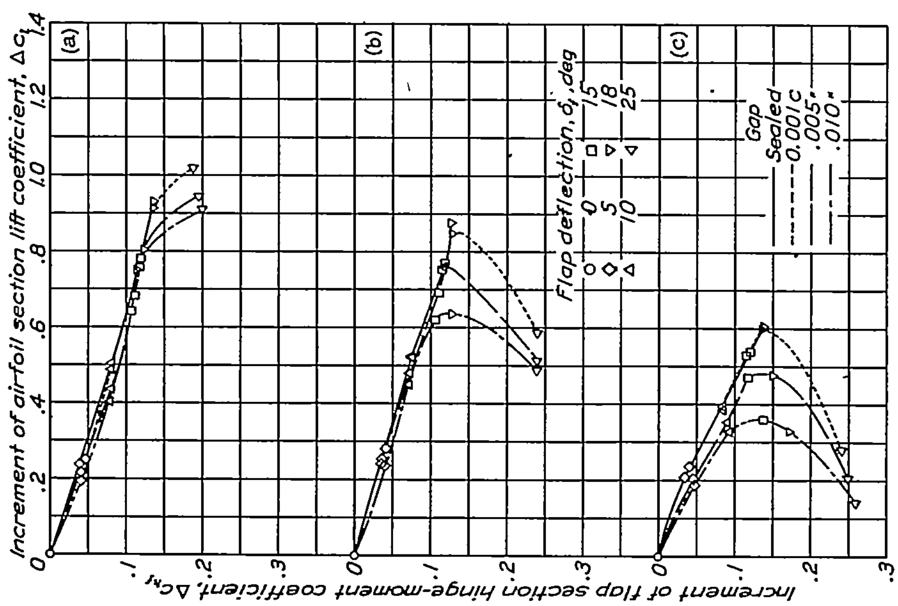



Figure 7.- Sharp-nose flap.

(a) $\alpha_0 = -8^\circ$
(b) $\alpha_0 = 0^\circ$
(c) $\alpha_0 = 8^\circ$

Figures 5,6,7.- Variation of $\Delta c_{h_f}$ with $\Delta c_l$ for various flaps and gaps.

L - 355

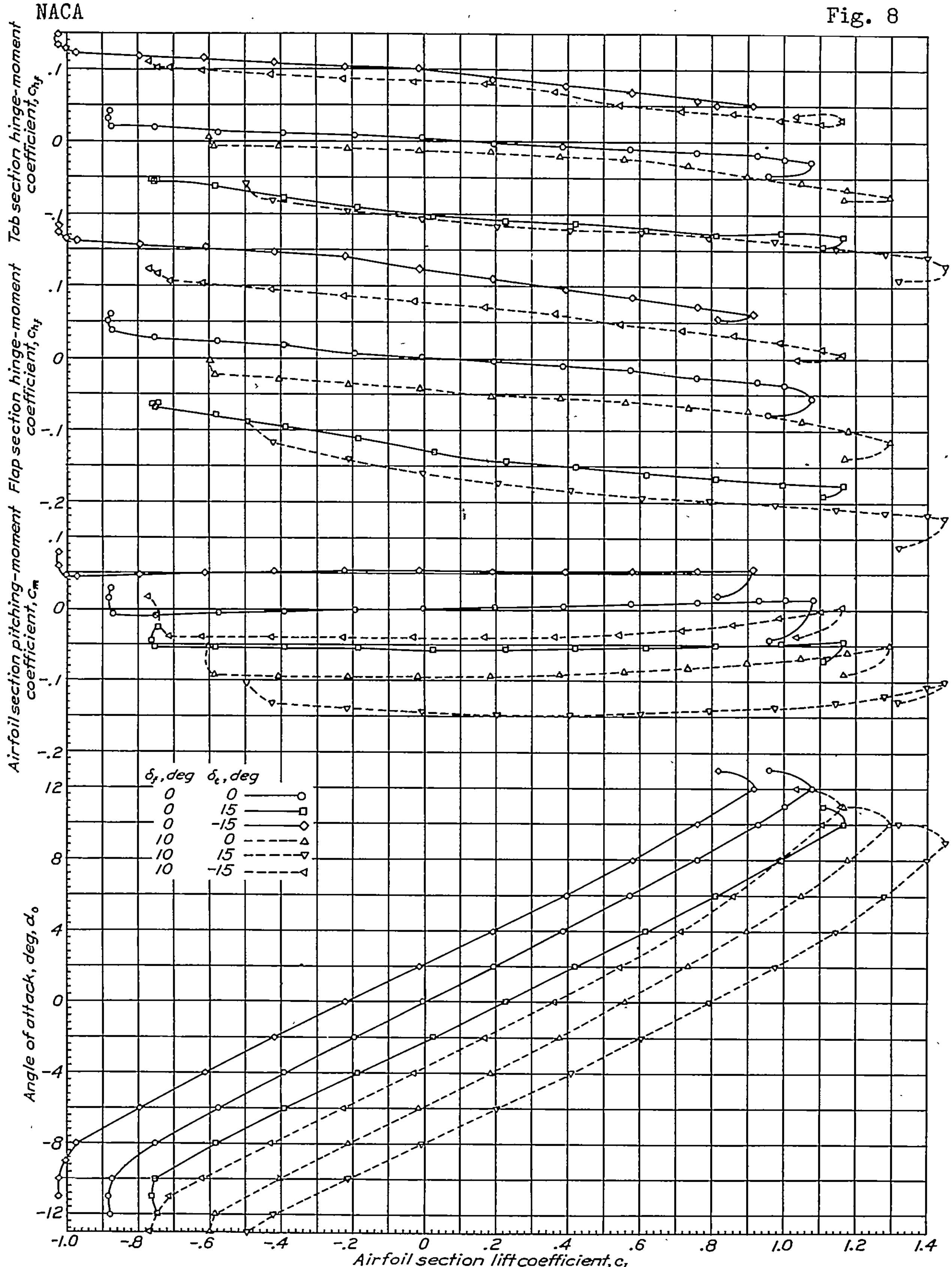
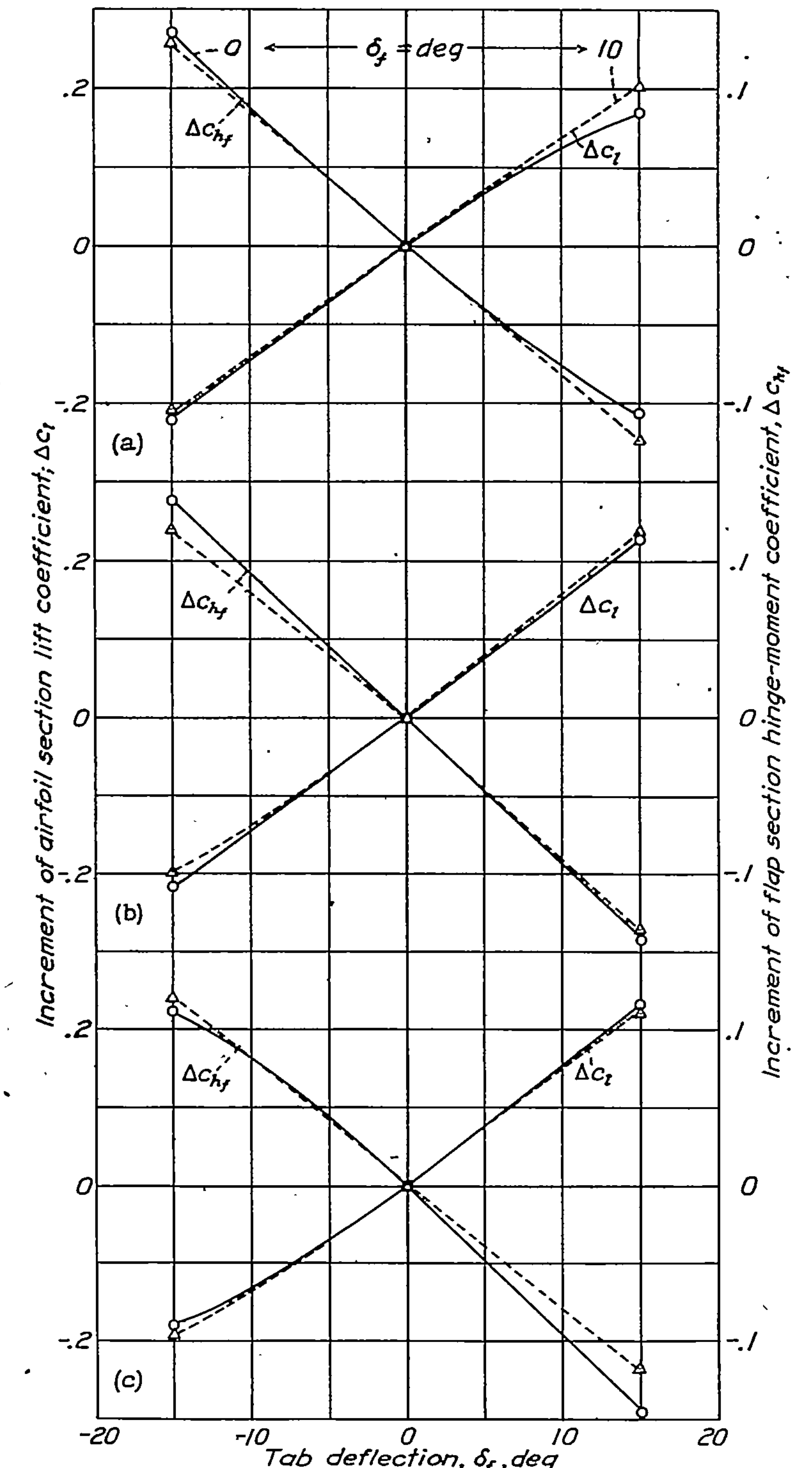



Figure 8.- Aerodynamic section characteristics of an NACA 0009 airfoil with 0.30c flap and 0.35$c_f$ overhang and 0.20$c_f$ tab. Medium-nose flap; gap sealed.

L - 355




(a) $\alpha_0 = -8^\circ$ (b) $\alpha_0 = 0^\circ$ (c) $\alpha_0 = 8^\circ$

**Figure 9.- Variation of $\Delta c_l$ and $\Delta c_{h_f}$ with $\delta_t$. Medium-flap nose on $0.35c_f$ flap overhang; gap sealed.**

L - 355

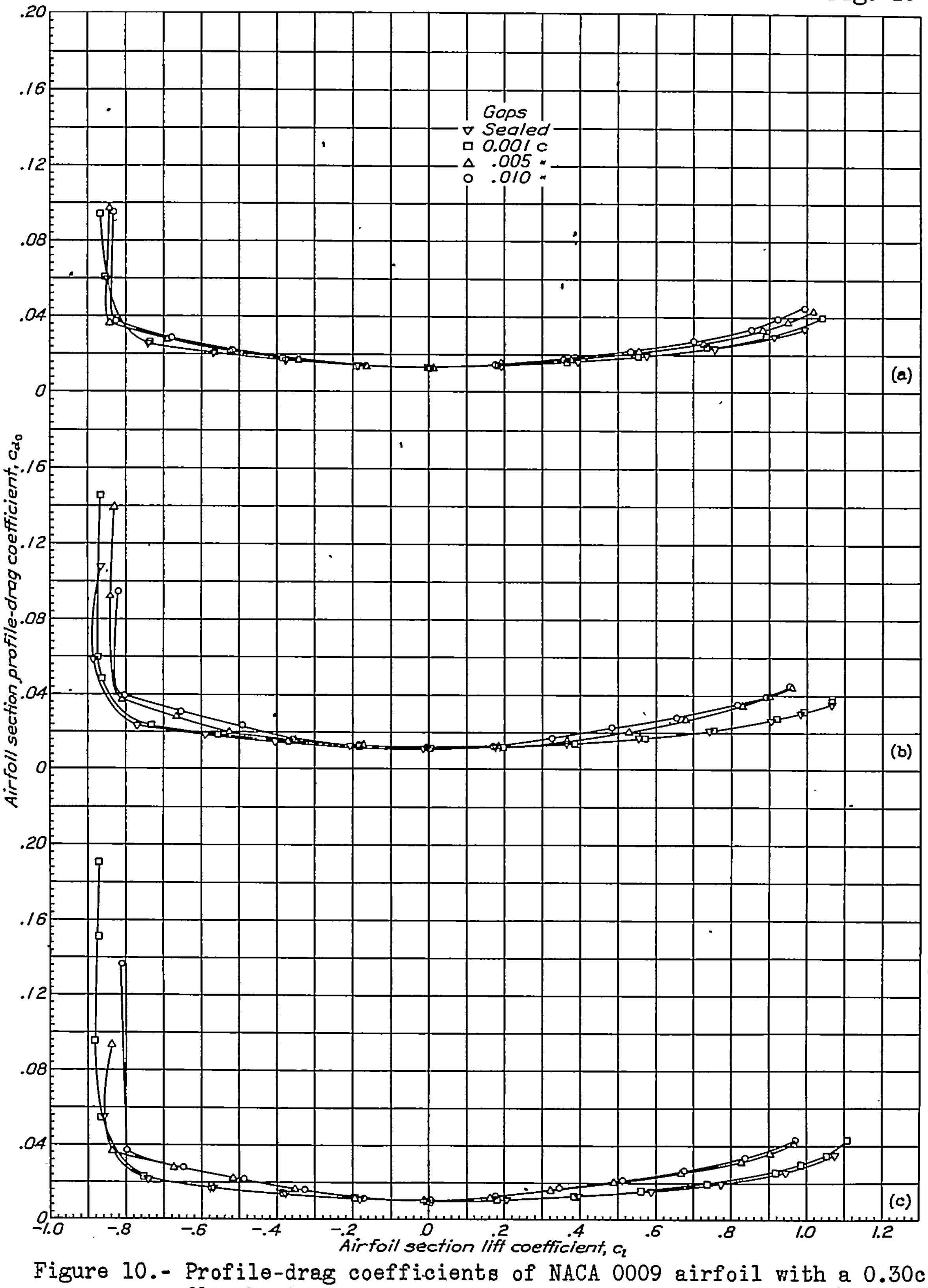



Figure 10.- Profile-drag coefficients of NACA 0009 airfoil with a 0.30c flap having a 0.35$c_f$ overhang. $\delta_f$, 0°
(a) Sharp-nose flap. (b) Medium-nose flap. (c) Blunt nose.