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By F. M. Rogallo

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

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AERODYNAMIC CHARACTERISTICS OF A SLOT-LIP AILERON AND SLOTTED FLAP FOR DIVE BRAKES

By F. M. Rogallo

SUMMARY

Section aerodynamic characteristics of an NACA 23012 airfoil with a slot-lip aileron and slotted flap have been determined over a large range of flap and aileron deflections. The results, which are presented in charts, indicate that these devices may be combined so as to provide satisfactory dive control. Additional tests are recommended for determination of the buffeting effects.

INTRODUCTION

At the request of the Bureau of Aeronautics, the NACA has undertaken an extensive investigation for the purpose of developing devices suitable for limiting the diving speeds of airplanes. As a part of this investigation, a study is being made of test results obtained during the development of devices designed primarily for other purposes, such as high lift or lateral control, but which may also be used for dive control. The slot-lip aileron is one of these dual-purpose devices that shows considerable promise, particularly for airplanes incorporating full-span slotted flaps. Section data of a slot-lip aileron in conjunction with an NACA slotted flap on an NACA 23012 wing were determined during a previous investigation (see reference 1) but were not made available. Those results have been reanalyzed and are herein presented in a form that should make them convenient for design purposes.

APPARATUS AND TESTS

The apparatus and tests have been described in reference 1. Briefly, the 3- by 7-foot model (see fig. 1 for cross section) was mounted in the 7- by 10-foot closed-throat wind tunnel (described in reference 2) so as to completely span the test section. The flap installation was that designated as 2-h in reference 2 and the flap was operated along the recommended optimum path. The aileron hinge moments were determined by means of a torque rod balance. The tests were run at an air speed of about 80 miles per hour, corresponding to an average effective Reynolds number of 3,500,000.

RESULTS AND DISCUSSION

In the presentation of results, the following symbols are used:

c_l section lift coefficient, l/qc

c_{d_o} section profile-drag coefficient, d/qc

$c_{m_{(a.c.)_o}}$ section pitching-moment coefficient about aerodynamic center of airfoil with flap and aileron neutral, m/qc^2

$c_{h_{sl}}$ slot-lip aileron section hinge-moment coefficient, h_{sl}/qc_{sl}^2

where

l section lift

d section profile drag

m section pitching moment

h_{sl} slot-lip aileron section hinge moment about the aileron hinge

q dynamic pressure, $\frac{1}{2}\rho V^2$

c airfoil chord including flap

c_{sl} slot-lip aileron chord measured along the airfoil chord line from the hinge axis of the aileron to the trailing edge of the aileron

and

α_o section angle of attack

δ_{sl} slot-lip aileron deflection from neutral, positive when trailing edge moves down

δ_f slotted flap deflection from neutral, positive when trailing edge moves down

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The lift has been corrected for tunnel effects, as explained in reference 2. No drag corrections have been made except for turbulence. As explained in reference 2, the drag data may be as much as 10 percent high.

The section lift, drag, and pitching-moment coefficients of the complete wing and the section hinge-moment coefficient of the slot-lip aileron, over a wide range of deflection of the flap and of the aileron, are given in figures 2 to 7. Because the characteristics at and near zero lift were considered of particular interest to the dive-brake designer, the results for zero lift have been replotted in a more concise form for flap deflections less than 30°. (See fig. 8.) From this chart the flap and aileron deflections necessary for given section drag and moment coefficients, or drag and angle of attack, may be determined. Either the angle of zero lift or the pitching-moment coefficient may be held constant as the flaps are deflected; unfortunately, those two conditions cannot be satisfied simultaneously.

Although the tests were made with the flap and aileron deflected uniformly over the entire span of the model, it will often be desirable in a practical installation to vary the span of the aileron relative to that of the flap. The characteristics of such an arrangement may be estimated from the data presented.

The relationship between drag coefficient, wing loading, and indicated velocity for an airplane in a vertical dive is shown in figure 9. For other diving angles the velocity given by the chart should be multiplied by the square root of the sine of the diving angle, referred to the horizontal. With a wing loading of 25 pounds per square foot, the indicated terminal diving speed will be limited to 250 miles per hour by an airplane drag coefficient of 0.16. (See fig. 9.) It should be possible to attain this drag coefficient if the slot-lip aileron is given sufficient span and deflection. In laying out the design, the engineer should remember that the drag data presented may be about 10 percent high, as previously mentioned.

The maximum section lift coefficient was greater than 1.1 for any of the arrangements tested. (See figs. 2 to 7.) It is presumed that this lift coefficient will be adequate for the pull-out.

The computation of lateral-control characteristics from the section data by the method employed in reference 1 is not recommended for this type of device. A recent investigation (see reference 3) indicates that the method is not directly applicable.

CONCLUDING REMARKS

The data presented indicate that slot-lip ailerons and slotted flaps may be combined so as to provide satisfactory dive control. These data, however, give no indication of the tendency of the arrangement to induce flutter or buffeting, a tendency known to exist in many proposed dive-control devices. Before application to a production model is considered, additional flight or wind-tunnel test should be made to determine the buffeting effects.

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

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2. Wenzinger, Carl J., and Harris, Thomas A.: Wind-Tunnel Investigation of an N.A.C.A. 23012 Airfoil with Various Arrangements of Slotted Flaps. NACA Rep. No. 664, 1939.

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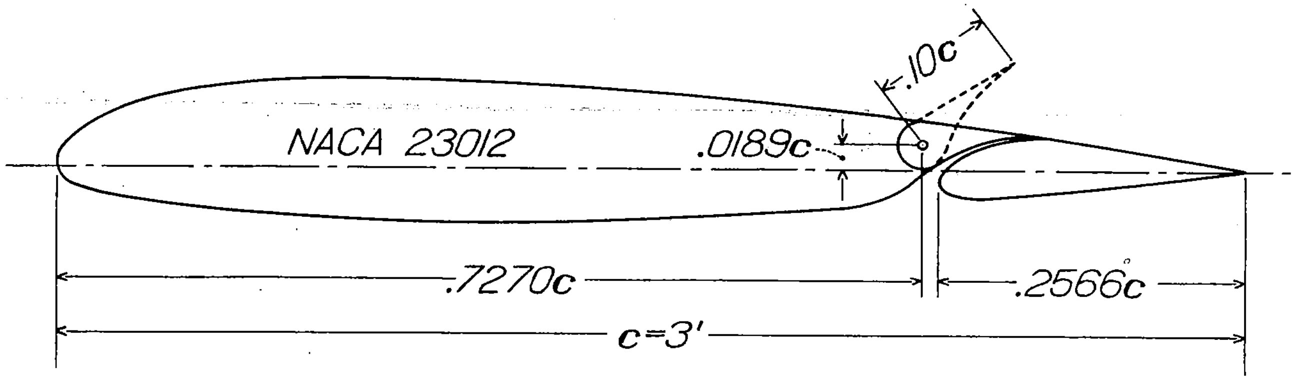

Figure 1.- Slot-lip aileron on wing with slotted flap.

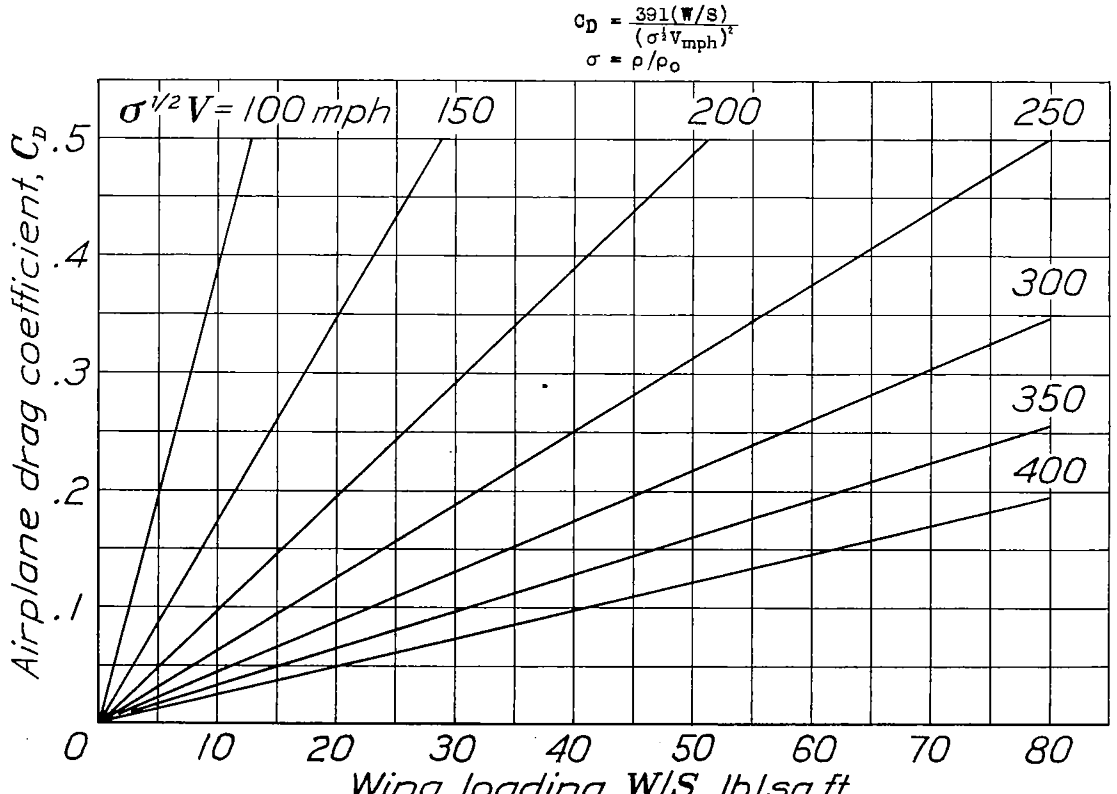

Figure 9.- Indicated terminal diving speeds of airplanes with various wing loadings and drag coefficients.

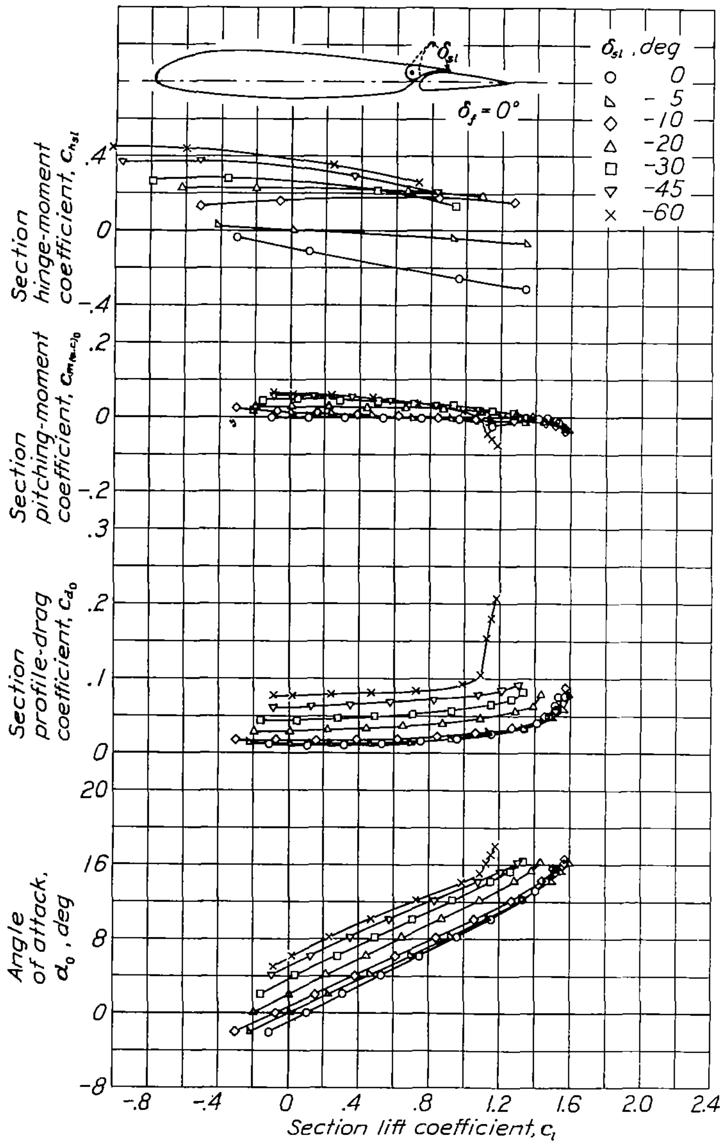

Figure 2.- Section aerodynamic characteristics of NACA 23012 airfoil with slotted-flap and slot-lip aileron; δ_f, 0°.

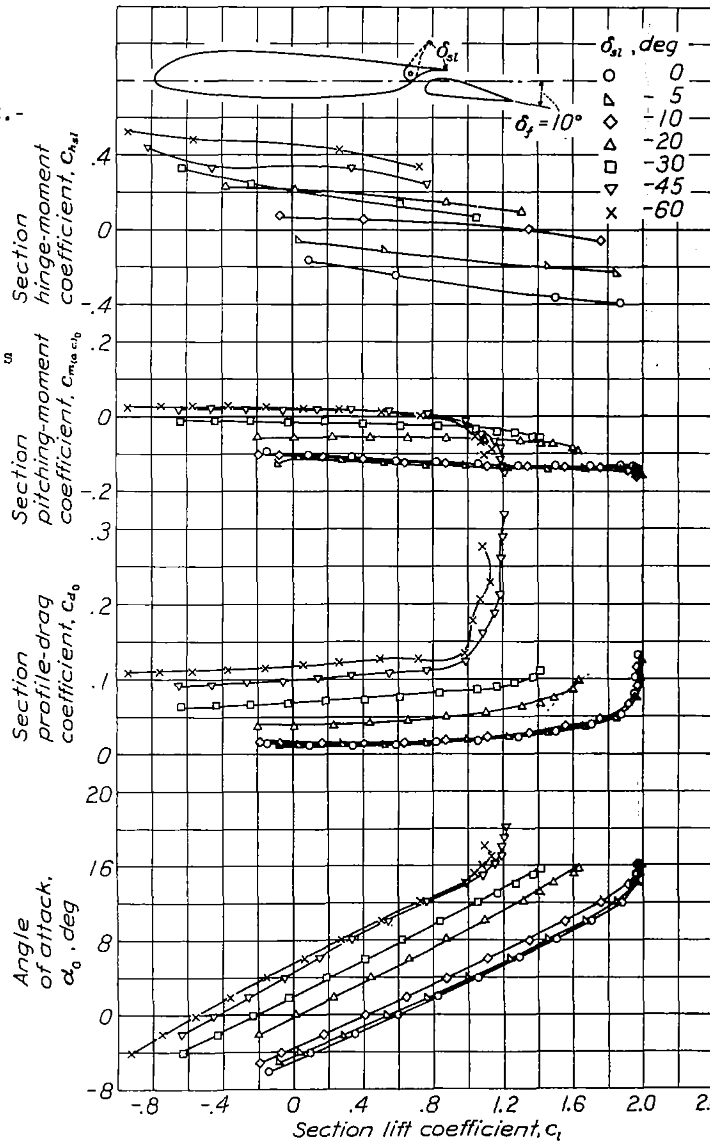

Figure 3.- Section aerodynamic characteristics of NACA 23012 airfoil with slotted-flap and slot-lip aileron; δ_f, 10°.

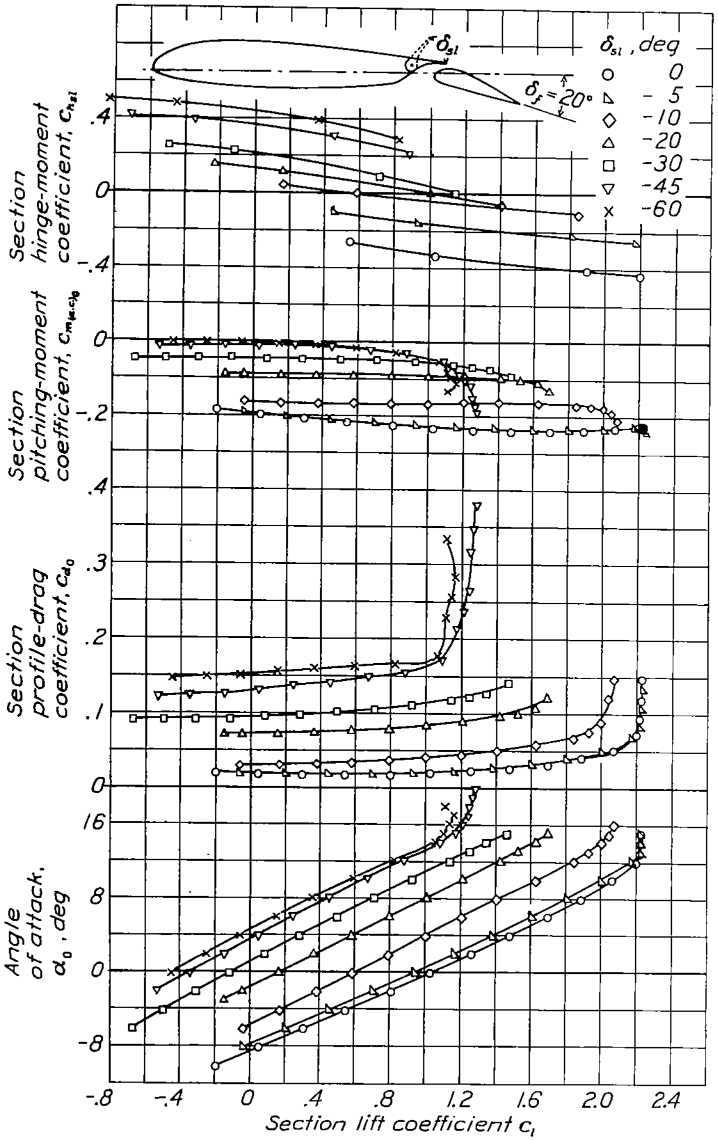

Figure 4.- Section aerodynamic characteristics of NACA 23012 airfoil with slotted-flap and slot-lip aileron; δ_f, 20°.

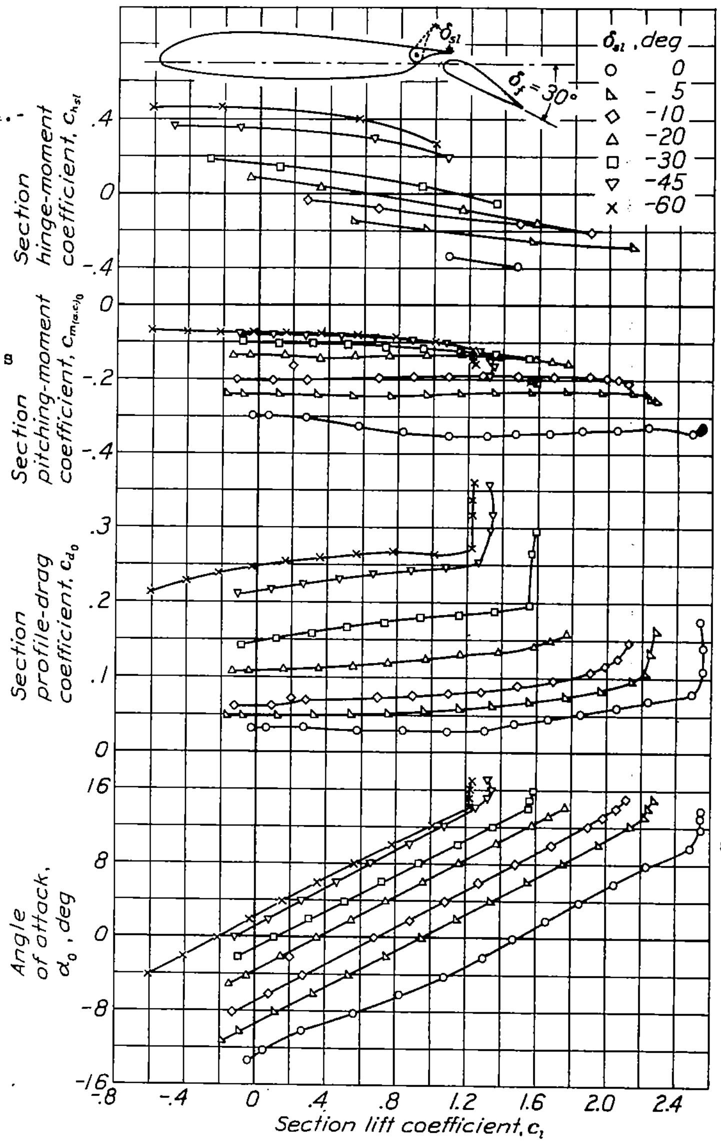

Figure 5.- Section aerodynamic characteristics of NACA 23012 airfoil with slotted-flap and slot-lip aileron; δ_f, 30°.

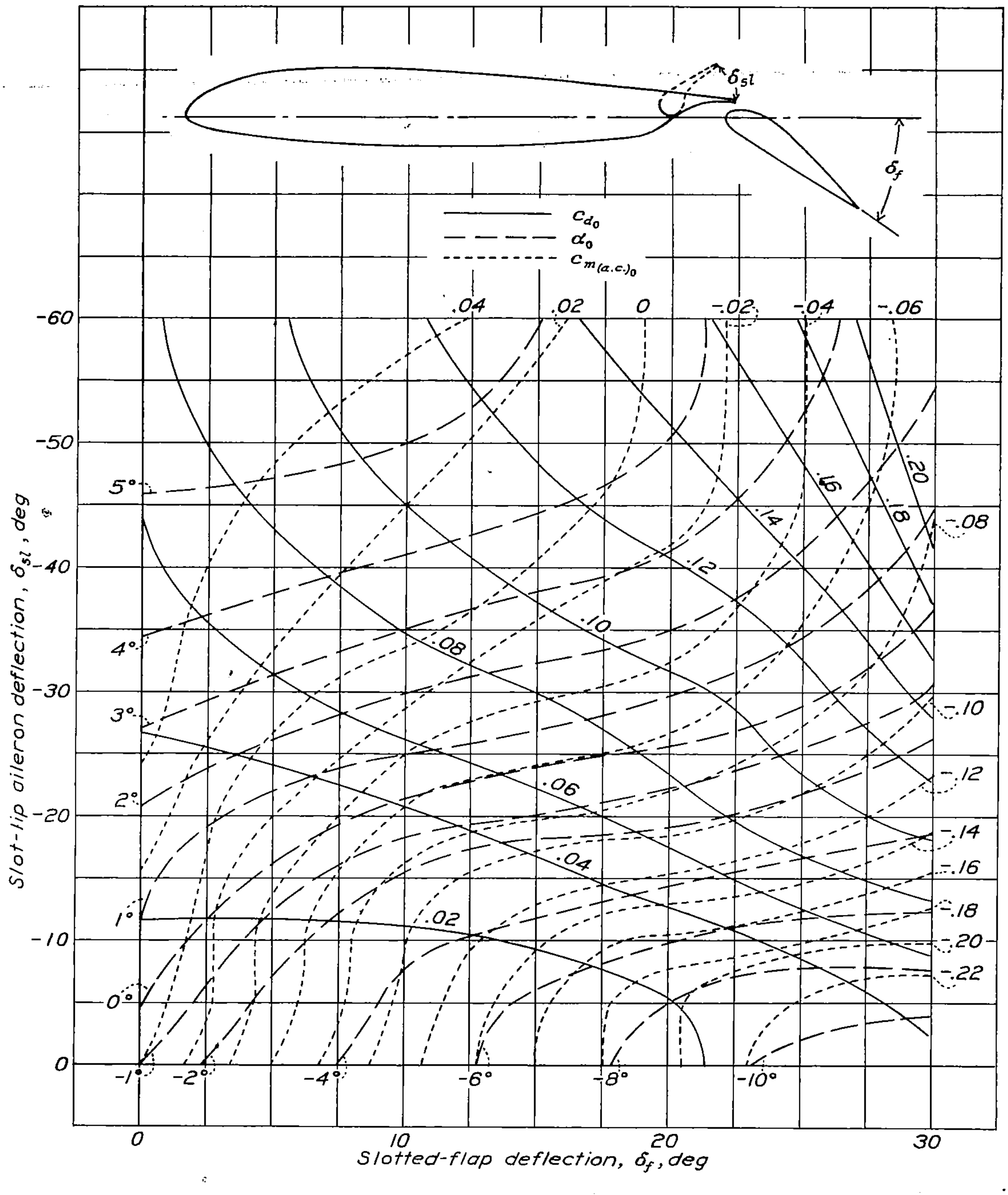

Figure 8.- Contours of c_{d_0}, α_0 and $c_{m(a.c.)_0}$, at $c_l = 0$.

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