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A STUDY OF THE APPLICATION OF DATA ON VARIOUS TYPES OF FLAP TO THE DESIGN OF FIGHTER BRAKES

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ADVANCE CONFIDENTIAL REPORT

A STUDY OF THE APPLICATION OF DATA ON VARIOUS TYPES OF FLAP TO THE DESIGN OF FIGHTER BRAKES

By Paul E. Purser

SUMMARY

An approximate method of applying the available data on various types of flaps in the design of fighter brakes is presented together with several examples of its use. The examples presented herein show the computed results of the application of various arrangements of perforated double-split flaps and combinations of upper-surface perforated split flaps and an NACA slotted flap for use as brakes on a fighter airplane. The computed effects of flap type, size, location, and deflection as well as the effects of altitude and initial velocities on the braking characteristics are shown in the examples.

INTRODUCTION

A need has arisen for devices that will temporarily reduce the velocity of attacking fighter aircraft in order that the pilot will have more time for firing. Two of the desirable characteristics that a fighter brake should have are: (1) enough increase in drag coefficient to decelerate the airplane within a reasonable time after the brakes are applied; and (2) enough increase in lift coefficient to maintain level flight as the velocity is reduced, with as small changes as possible in angle of attack and control position.

In view of this need for fighter brakes, the NACA has undertaken an investigation to determine the applicability of various existing types of flap and to develop methods of applying data on these flaps in the design of fighter brakes.

METHODS OF COMPUTATIONS

The preliminary requirements for brakes on a fighter airplane (fig. 1) were: (1) indicated velocity to be reduced from 400 to 300 miles per hour in 4 seconds, (2) brakes to occupy the same span as the existing flaps, (3) average acceleration to be about 1.5g. The airplane geometric characteristics used in the computations were:

S wing area, 260 square feet

b wing span, 38.0 feet

c wing mean aerodynamic chord, 7.01 feet

b_f flap span, 0.525b (not including fuselage)

c_f average flap chord, 0.208c

W gross weight, 7063 pounds

The effects of the flaps were assumed not to be continuous through the fuselage.

For the preliminary investigation in which the perforated double-split flaps were used, an arbitrary flap motion was assumed: the upper and lower flaps deflect equally to 40° in 1 second, then to a maximum of 60° in the next 3 seconds, and then back to zero in the next second. Angle of attack α, (for constant lift), lift coefficient C_L, drag coefficient C_D, and pitching-moment coefficient C_m, acceleration a, and indicated velocity V' were then determined from the data in reference 1 by a step-by-step method as in reference 2, using half-second intervals and the following relationships:

Change in true velocity V per unit time t,

$$-\frac{\Delta V}{t} = \frac{\Delta C_D}{C_L} g$$

Change in indicated velocity V' per unit time t,

$$-\frac{\Delta V'}{t} = \sigma^{\frac{1}{2}} \frac{\Delta C_D}{C_L} g$$

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where

g gravity (32.2 ft/sec^2 or 21.9 mph/sec)

σ ratio of density at altitude to sea-level density (ρ/ρ_o)

Indicated velocity V', miles per hour

$$V'(t) = V'(t - 0.5) - \left[\sigma^{\frac{1}{2}} (0.5)(21.9) \frac{\Delta C_D}{C_L}\right]$$

at sea level

$$V'(t) = V'(t - 0.5) - \left(10.95 \frac{\Delta C_D}{C_L}\right)$$

at 25,000 feet

$$V'(t) = V'(t - 0.5) - \left[(0.67)(10.95) \frac{\Delta C_D}{C_L}\right]$$

$$C_L = \frac{W}{Sq} = \frac{7063}{260\left(\frac{V'}{100}\right)^2 25.6} = \frac{1.061}{\left(\frac{V'}{100}\right)^2}$$

and q is dynamic pressure $\left(\frac{1}{2}\rho V^2\right)$. The effects of changes in thrust during deceleration were neglected in order to simplify the computations.

In the cases where the angle of attack was maintained at a constant value, the flaps were assumed to operate differentially in such a manner that the larger deflection of the lower flap supplied the lift coefficient necessary to maintain the constant angle of attack and the drag and deceleration characteristics remained the same as those of the arrangement with equal up-and-down deflections.

For the investigation of the use of the slotted flap, an arbitrary acceleration curve was assumed; the acceleration increased uniformly from zero to 1.0g in 1 second, remained constant at 1.0g for 3.5 seconds, and decreased to zero in the next second. From this acceleration curve and the initial velocity and altitude, it was possible to compute the curves of velocity, lift coefficient, and drag coefficient against time. From these basic relationships, the data in references 1 to 3, and the data presented in figure 2, it was possible to compute the characteristics of the various combinations of split flaps and slotted flaps. Figure 2, based on unpublished data, presents estimated characteristics of the fighter wing with a slotted flap.

It must be remembered that, in the use of data from references 1 and 2, curves for the coefficient increments were drawn through points at flap deflections of 0°, 30°, and 60°, with no intermediate points. Although these data are considered reliable and are sufficient for use in determining the capabilities of a system, it is recommended that more data at intermediate flap deflections be obtained for use in specific designs.

DISCUSSION

Perforated Double-Split Flaps

The computed characteristics of the airplane equipped with various arrangements of perforated double-split flaps are shown in figures 3(a) to 5. The effects of altitude and differential operation of the flaps are shown in figure 3(a) for the flaps located at 0.792c. The effects of increased altitude are to increase the maximum acceleration and to decrease the indicated-velocity reduction. With differential operation of the flaps the changes in the wing pitching-moment coefficients and angle of attack during deceleration can be minimized and in some cases can be eliminated. Figure 3(b) shows that for the same flaps a change in initial indicated velocity from 400 to 300 miles per hour decreased both the maximum acceleration and the indicated-velocity reduction by about 40 percent.

Moving both the flaps forward to the 0.60c line increased both the maximum acceleration and the indicated-velocity reduction by about 10 percent (fig. 4). Figure 5 shows the computed characteristics of the airplane with the upper flap located at 0.792c and the lower flap located at 0.40c; this arrangement produced the same acceleration and indicated-velocity reduction as the arrangement having both flaps at 0.792c but produced a much larger change in wing pitching-moment coefficient. Data in references 1 and 2 indicate, however, that there would be less wake effect on the tail of the fighter airplane under consideration if the staggered flaps were used. The estimated wake locations are indicated in figure 6.

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Combination of Slotted and Split Flaps

The computed characteristics of the airplane equipped with a slotted flap and three sizes of perforated upper-surface split flap located at 0.80c are shown in figures 7 to 9. From these figures it can be seen that the flap-deflection system and the size of the upper-surface flap can be so designed that the effects of the flaps on angle of attack and wing pitching-moment coefficient will be minimized.

A more complete determination of the effects of any of the flap arrangements on the longitudinal stability and control should be made by wind-tunnel tests of a complete model of any proposed installation. Past experience has shown that, in any brake installation utilizing split flaps, the area of the flap should be reduced by at least 25 percent by perforations in order to reduce tail buffeting.

Operating Forces

A large amount of data has been published on the hinge-moment and load characteristics of various split and slotted flaps, but comparatively little is known about the effects of perforations or of various methods of operation on the forces required to deflect split flaps. The results of some experiments on various methods of operating split flaps have been reported in reference 4 but the effects of large amounts of perforation were apparently not considered. In view of the rapid flap operation required at high velocities in the use of fighter brakes, it is recommended that additional research be undertaken to determine the effects of perforations and methods of operation on the loads and the operating forces of brake flaps.

CONCLUDING REMARKS

An approximate method for the application of data on various types of flap to the design of fighter brakes has been presented together with several examples of its application. The examples presented show the computed effects of flap type, size, location, and deflection as well as the effects of altitude and initial velocity on the braking characteristics of a fighter airplane. The results of the study indicated the desirability of obtaining more complete data on the various types of flap and also the desirability of wind-tunnel tests for determining the effects of the brake flaps on the longitudinal stability and control characteristics of the airplane.

In view of the comparatively rapid flap operation required at high velocities in the use of fighter brakes, it appears that additional research on flap loads and operating forces is necessary.

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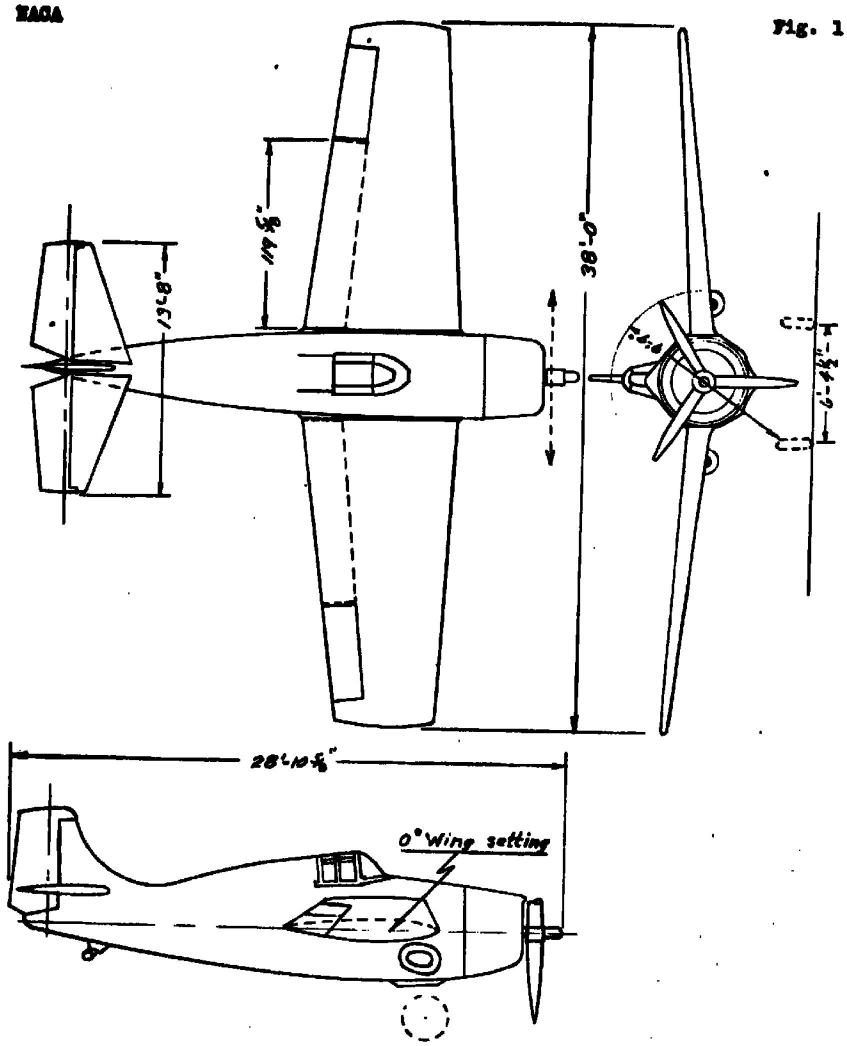

Figure 1.- Three-view drawing of the fighter airplane assumed in the computations.

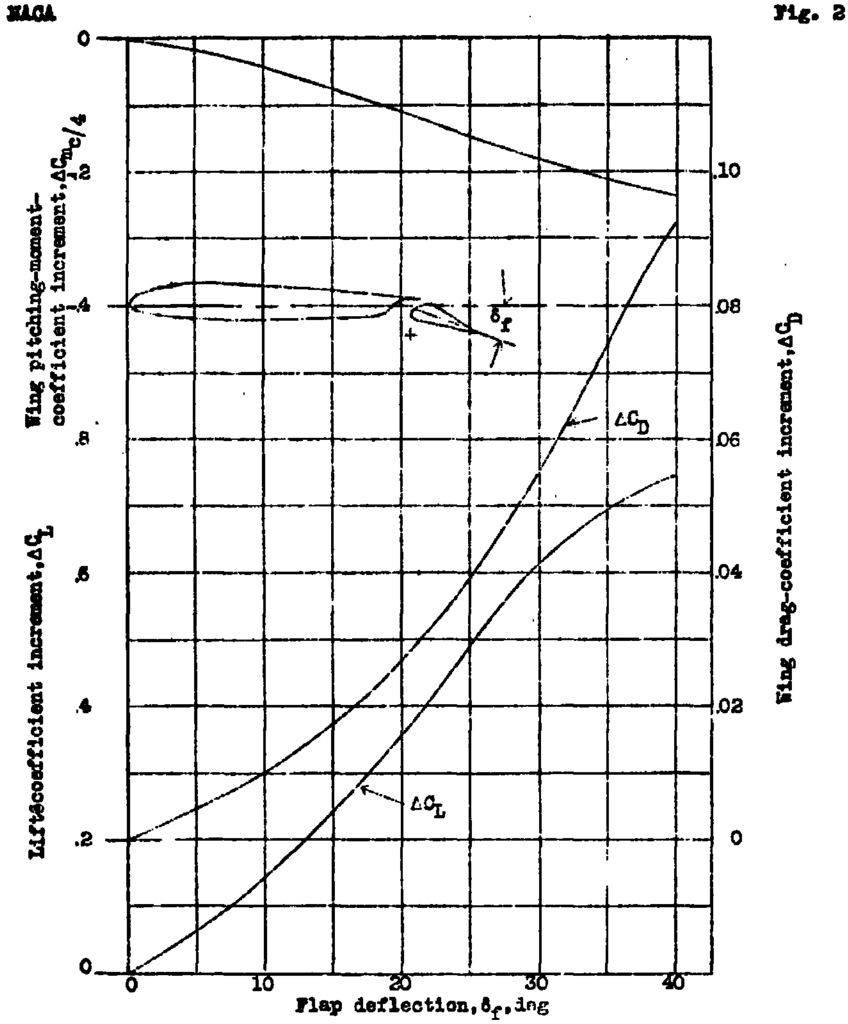

Figure 2.- Estimated increments of lift, drag, and pitching-moment coefficients due to deflecting a (0.208 c by 0.525 b) slotted flap on the wing of a fighter airplane $\alpha = 0^{\circ}$.

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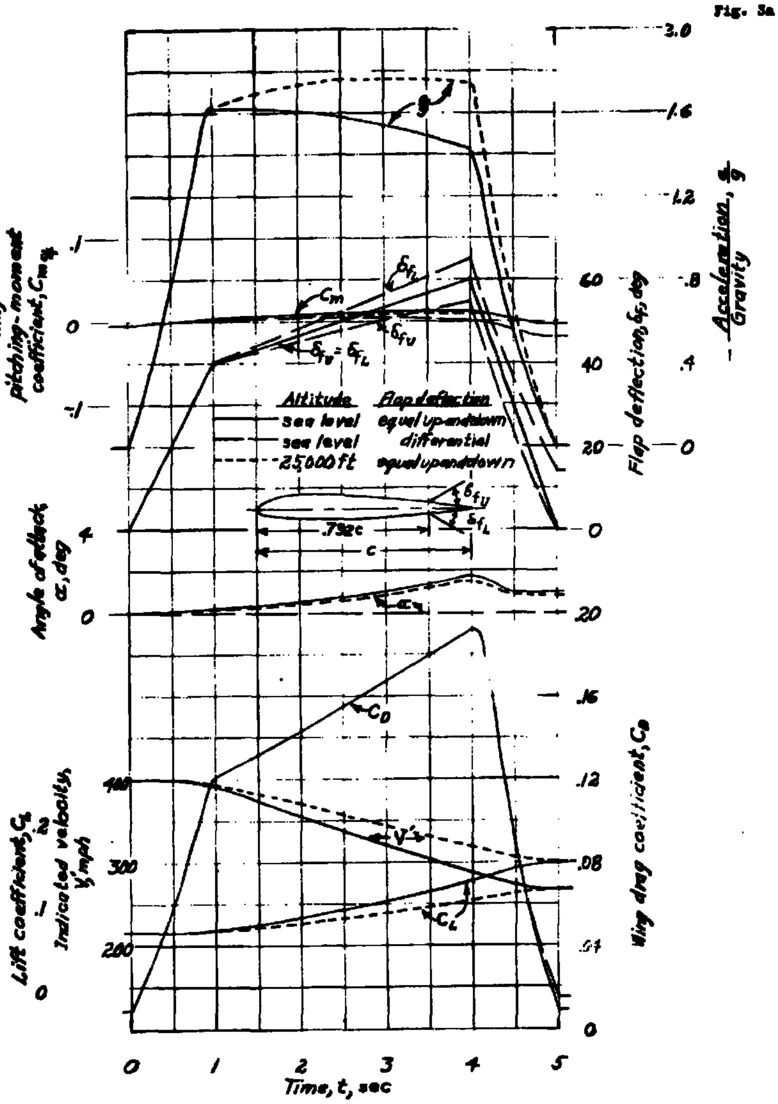
Fig. 8a



(a) Effects of altitude and differential flap operation.

Figure 8.—Computed time-history characteristics during deceleration of the fighter airplane equipped with fighter brakes consisting of 0.208c by 0.525b perforated double split flaps. Flaps located at 0.792c.

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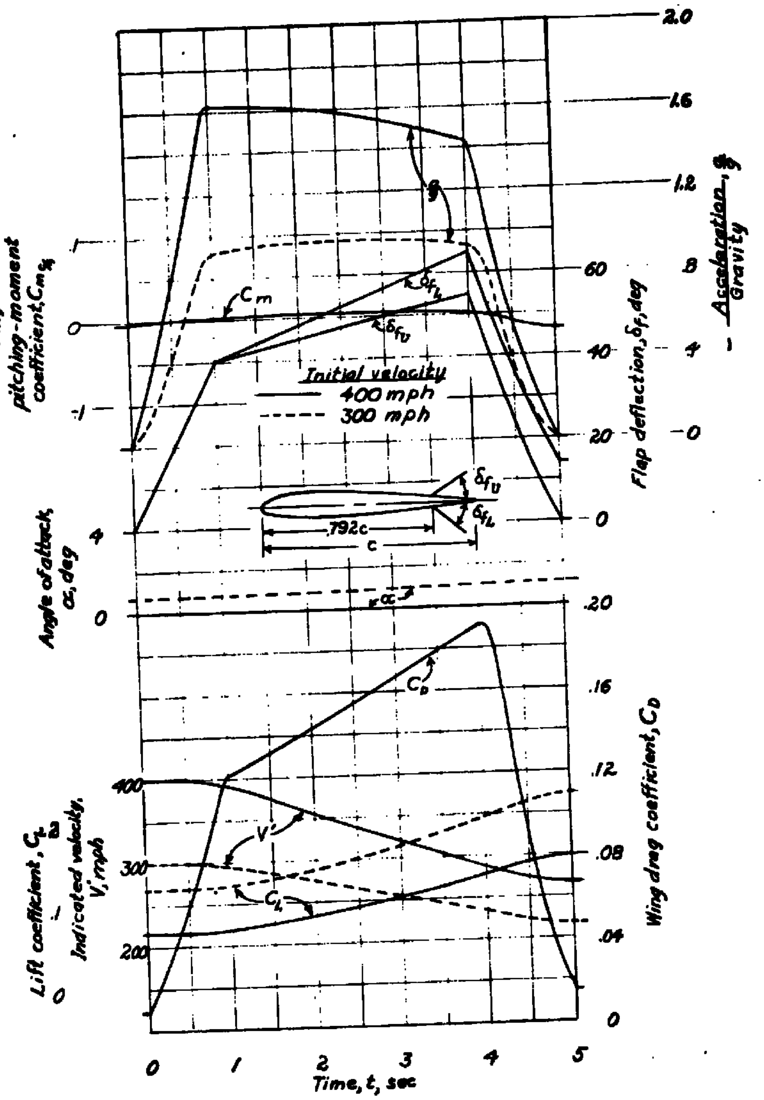

(b) Effect of initial velocity with differential flap operation at sea level.

Figure 3.- Concluded.

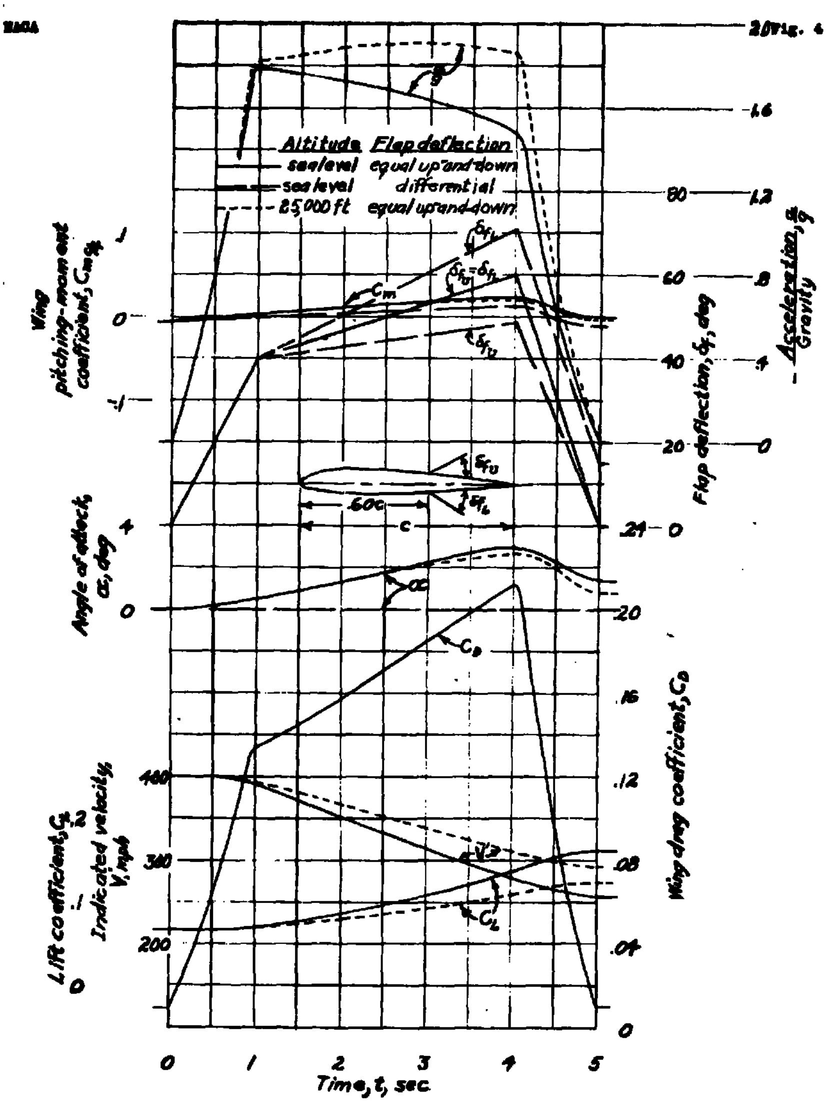

Figure 4.- Computed time-history characteristics during deceleration of the fighter airplane equipped with fighter brakes consisting of 0.208c by 0.525b perforated double split flaps. Flaps located at 0.60c.

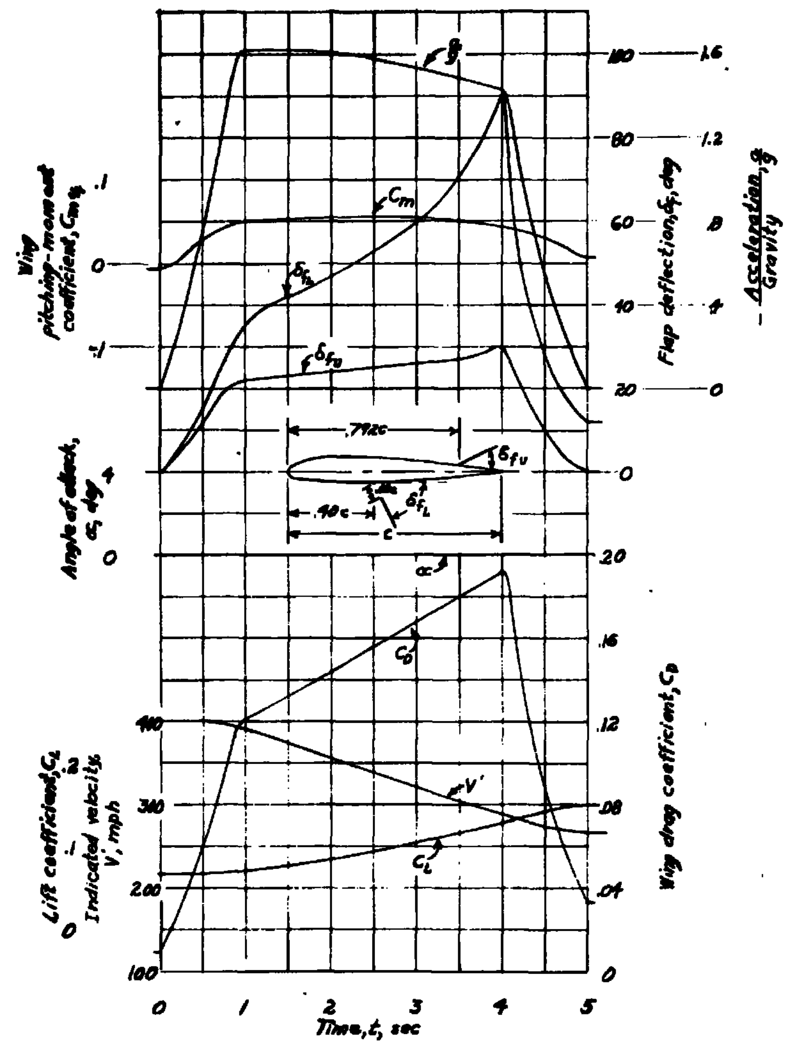

Figure 5.- Computed time-history characteristics during deceleration of the fighter airplane equipped with fighter brakes consisting of 0.208c by 0.525b perforated double split flaps. Upper flap located at 0.792c, lower flap at 0.40c with a 0.10c gap. Flap deflection for constant α. (Computed for sea level)

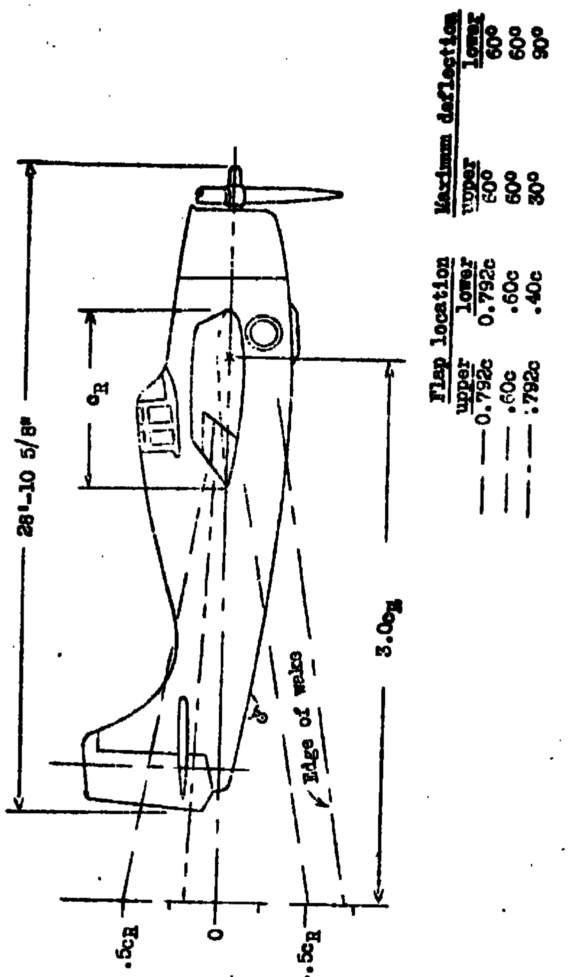

Figure 6.- Estimated wake locations for the fighter airplane equipped with 0.208c by 0.525b perforated double split flaps.

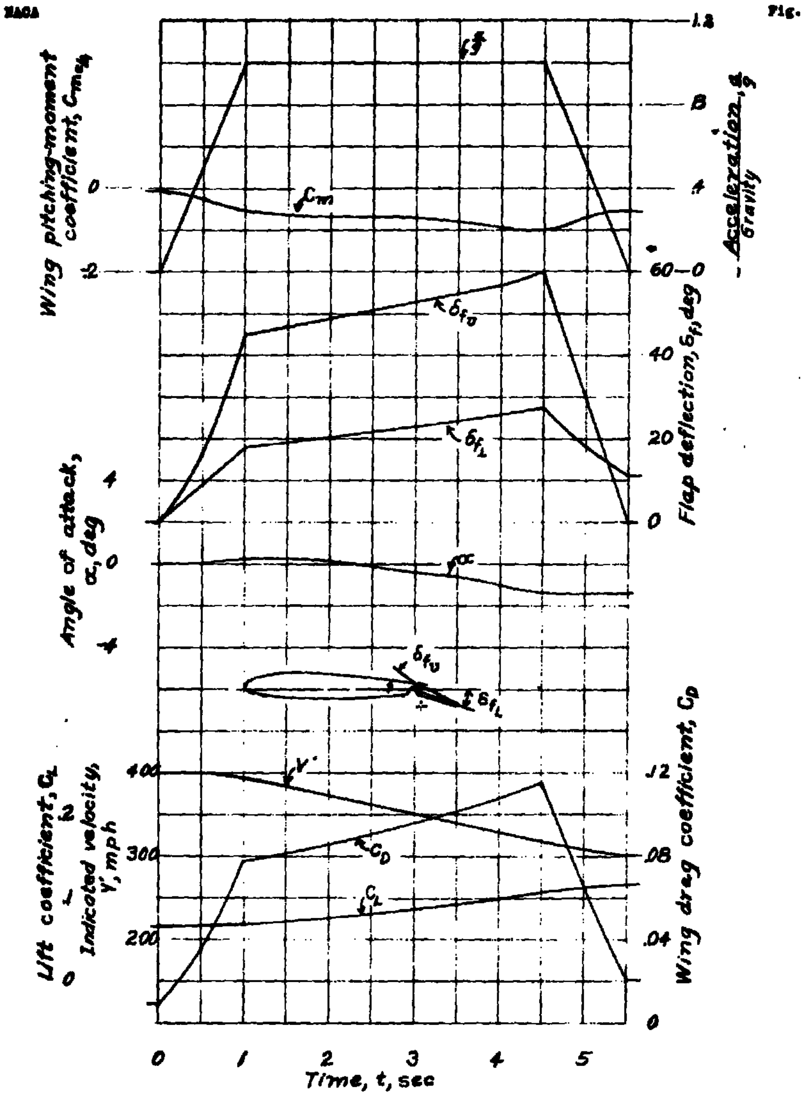

Figure 7. - Computed time-history characteristics during deceleration of the fighter airplane equipped with fighter brakes consisting of a 0.208c by 0.525b slotted flap and a 0.15c by 0.525b upper-surface perforated split flap. Computed for sea level. Upper flap located at 0.80c. P. 3-26-42

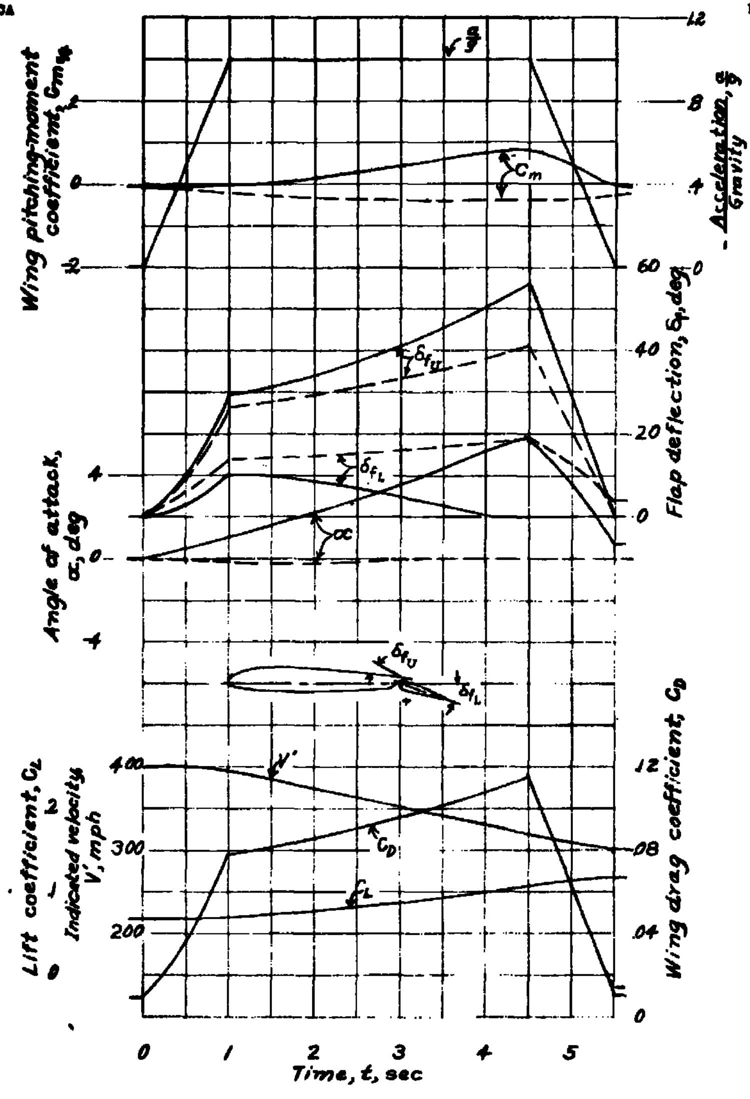

Figure 8 - Computed time-history characteristics during deceleration of the fighter airplane equipped with fighter brakes consisting of a 0.208c by 0.525b slotted flap and a 0.20c by 0.525b upper-surface perforated split flap. (Computed for sea level). Upper-surface flap located at 0.80c. Two flap deflection systems.

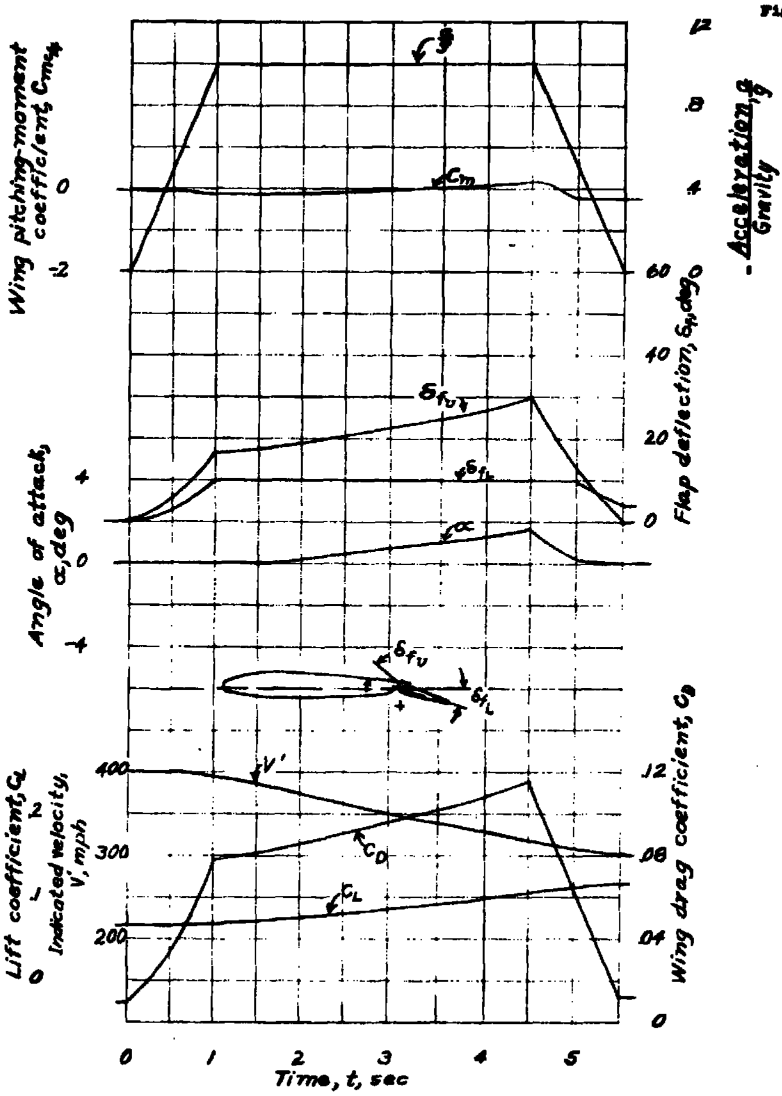

Figure 9.- Computed time-history characteristics during deceleration of the fighter airplane equipped with fighter brakes consisting of a 0.208c by 0.525b slotted flap and a 0.25c by 0.525b upper-surface perforated split flap. (Computed for sea level) Upper-surface flap located at 0.80c.

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