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WIND-TUNNEL INVESTIGATION OF A TAPERED WING
WITH A PLUG-TYPE SPOILER-SLOT AILERON AND
FULL-SPAN SLOTTED FLAPS

By John G. Lowry and Robert B. Liddell

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NACA

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WIND-TUNNEL INVESTIGATION OF A TAPERED WING
WITH A PLUG-TYPE SPOILER-SLOT AILERON AND
FULL-SPAN SLOTTED FLAPS

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SUMMARY

An investigation was made in the 7- by 10-foot wind tunnel of the Langley Memorial Aeronautical Laboratory of several arrangements of a plug-type spoiler-slot aileron on a tapered wing model of a typical fighter airplane having a full-span slotted flap. The plug-type aileron is essentially a tapered plug that fits into a slot through the wing to conform to the original external wing contour when in the neutral position. When the aileron is deflected, the plug projects from the upper surface of the wing as a spoiler and, at the same time, makes a slot through the wing behind the spoiler. The static rolling-, yawing-, and hinge-moment coefficients were determined and are presented for several angles of attack and flap deflections. Estimates of the rolling effectiveness and the stick forces for a fighter airplane are also given.

The results indicate that a plug-type spoiler-slot aileron will provide satisfactory lateral control on tapered-wing airplanes with full-span slotted flaps. Pivoting the top plate of the plug and providing a simple linkage for deflecting the plate relative to the plug offers a powerful means of adjusting the stick force.

INTRODUCTION

The difficulty of obtaining high lifts for landing and take-off without impairing lateral control is one of the problems arising from the increased speed and wing loading of the modern airplane. In order to obtain solutions to this problem, the NACA is investigating, on a semispan model of the tapered wing of a modern fighter

airplane, lateral-control devices that appeared promising from wind-tunnel tests on a rectangular wing with a square tip.

The present tests were made of a plug-type spoiler-slot aileron on a tapered wing with a full-span NACA slotted flap and may be considered an extension of the work reported in reference 1. The object of the wind-tunnel tests was to determine the lift characteristics and the aileron-control characteristics for various deflections of the slotted flap and various modifications of the plug.

The stick forces and the rates of roll were estimated for an airplane with one of the plug modifications and for two aileron differentials.

In order to make the text and figures herein more concise, the term "plug aileron" will be substituted for the previously used term "plug-type spoiler-slot aileron."

APPARATUS AND METHODS

A semispan wing model was suspended in the 7- by 10-foot wind tunnel (reference 3) of the Langley Memorial Aeronautical Laboratory as shown schematically in figure 1. The root chord of the model was adjacent to one of the vertical walls of the tunnel, the vertical wall thereby serving as a reflection plane. The flow over a semispan model in this set-up is essentially the same as it would be over a complete model in a 7- by 20-foot wind tunnel. Although a very small clearance was maintained between the root chord and the tunnel wall, no part of the model was fastened to or in contact with the tunnel wall. The model was so arranged on the balance frame that all the forces and moments acting on it might be determined. (See fig. 1.) Provisions were made for changing the angle of attack while the tunnel was in operation.

The ailerons were deflected by means of a calibrated torque rod connecting the outboard end of the aileron with a crank outside the tunnel wall and the hinge moments were determined from the twist of the rod (fig. 1).

The semispan wing model used in these tests was built to the plan form shown in figure 2. The ordinates

of the wing sections are given in table I. The airfoil sections of the NACA 230 series tapered in thickness from approximately 15 $\frac{1}{2}$ -percent chord at the root to 8 $\frac{1}{2}$ -percent chord at the tip. The basic chord, c_1 , of the model was arbitrarily increased 3/10 inch to reduce the trailing-edge thickness and the last few stations were refaired to give a smooth contour. The full-span slotted flap, built to conform to the ordinates of table II, was pivoted about the flap pivot point given in table II and could be deflected 40° and 50°. The slot shape for the slotted flap is given in table II. The plug aileron was built of sheet metal to the dimensions given in figure 3. The modifications of the plug aileron are shown in figure 4. The wing model represents the portion of the airplane shown cross-hatched in figure 5.

All tests with the slotted flap retracted were made at a dynamic pressure of 16.37 pounds per square foot, which corresponds to a velocity of about 80 miles per hour and to a test Reynolds number of about 2,050,000 based on the mean aerodynamic chord of 33.66 inches. The tests with the flap deflected were, in general, run at a dynamic pressure of 9.21 pounds per square foot, which corresponds to a velocity of about 60 miles per hour and to a test Reynolds number of about 1,540,000.

RESULTS AND DISCUSSION

Coefficients and Corrections

The symbols used in the presentation of results are:

C_L	lift coefficient (L/qS)
C_D	uncorrected drag coefficient (D/qS)
C_m	pitching-moment coefficient (M/qSc')
C_l'	rolling-moment coefficient (L'/qbS)
C_n'	yawing-moment coefficient (N'/qbS)
C_h	aileron hinge-moment coefficient (H_a/qM')
c	nominal wing chord at any spanwise location with flaps retracted

4

c' mean aerodynamic chord

M' area-moment of aileron top plate about hinge axis of aileron

b twice span of semispan model

b_a aileron span

S twice area of semispan model

L twice lift of semispan model

D twice drag of semispan model

M twice pitching moment of semispan model about support axis

L' rolling moment, due to aileron deflection, about wind axis in plane of symmetry

N' yawing moment, due to aileron deflection, about wind axis in plane of symmetry

H_a aileron moment about hinge axis

q dynamic pressure of air stream ($1/2 \rho V^2$) uncorrected for blocking

α angle of attack

δ_a aileron deflection relative to wing, positive when trailing edge is down

δ_f flap deflection relative to wing, positive when trailing edge is down

δ_p plate deflection from neutral relative to aileron, positive when trailing edge is down

δ_s stick deflection

$C_{l,p}'$ rate of change of rolling-moment coefficient C_l' with helix angle $pb/2V$

p rate of roll

F_s stick force

V free-stream velocity

V_1 indicated velocity, miles per hour

A positive value of L' or C_{l}' corresponds to a decrease in lift of the model and a positive value of M' or C_{m}' corresponds to an increase in drag of the model. Twice the actual lift, drag, pitching moment, area, and span of the model were used in the reduction of the results because the model represented half of a complete wing. The drag coefficient and the angle of attack have been corrected only in accordance with the theory of trailing-vortex images. Corresponding corrections were applied to the rolling- and yawing-moment coefficients. No corrections have been applied to the hinge-moment coefficients and no corrections have been applied to any of the results for the effects of the support strut or the treatment of the inboard end of the wing, that is, for the small gap between the wing and the wall, for the leakage through the wall around the support tube, and for the boundary layer at the wall. The drag data are comparative and are not presented for performance estimations.

The hinge moments of the aileron are presented in coefficient form in this report rather than in the form presented in reference 1, which gave actual hinge moments. The hinge moment is believed to be a function of the plate area-moment about the aileron hinge axis and these results are therefore more conveniently applicable to plug ailerons of different plate area and moment.

LIFT CHARACTERISTICS

The results of tests with the aileron neutral (fig. 6) show that for a flap deflection of 40° the increment of maximum lift coefficient, $\Delta C_{L_{max}}$, is about 1.0 and for a flap deflection of 50° , $\Delta C_{L_{max}}$ is about 1.1. The value of 1.1 for $\Delta C_{L_{max}}$ is about 0.1 higher than $\Delta C_{L_{max}}$ for the best duplex-flap arrangement reported in reference 3. The pitching-moment coefficient is nearly the same with the full-span slotted flap deflected as with the duplex-flap deflected, but the drag coefficient of the full-span slotted flap is lower than that of the duplex flap at any given lift coefficient.

The maximum lift coefficient of the tapered-wing is expected to increase as the Reynolds number increases to full scale. The effects of neither scale nor the tunnel boundaries upon the stall were investigated.

AILERON CHARACTERISTICS

Effects of vent modifications and flap deflection.-

The results presented in figure 7 show the effect of various vent openings on the characteristics of the plug aileron. The main effect on the hinge-moment coefficient resulting from reducing or sealing the vents was to reduce the values of hinge-moment coefficient for full aileron deflection and to give a region of instability near zero deflection. Reducing or sealing the vents increased the rolling-moment coefficient in most cases.

The rolling-moment coefficients were greater with the flap deflected than with the flap neutral. Increasing the flap deflection from 40° to 50° , however, decreased the rolling-moment coefficient for δ_a of -50° by 40 percent at low angles of attack (figs. 7(c) and 7(e)) and by 20 percent at high angles of attack (figs. 7(c) and 7(f)). The aileron effectiveness with the aileron near neutral was also decreased as the flap was deflected from 40° to 50° . The general decrease in effectiveness, which was independent of plug modifications, was probably a result of the flap being stalled at a deflection of 50° . This decrease may not be present or may be much smaller on the airplane because of the increase in Reynolds number. The plug-aileron characteristics with the slotted flap at 50° were somewhat similar to the characteristics obtained with the split flap at 60° (reference 1) and with the Fowler flap at 40° (reference 4).

The rolling-, yawing-, and hinge-moment coefficients at various angles of attack for the tapered wing with plug aileron 1 are shown in figure 8. These curves show the variation of the hinge-moment coefficient to be stable near the neutral aileron position in most cases but the rolling-moment effectiveness is nevertheless low in the small deflection range. The rolling-, yawing-, and hinge-moment coefficients for the tapered wing with plug aileron 5 are shown in figure 9. An analysis of the data presented

in figure 7 indicated that plug aileron 5 would give larger rolling-moment coefficients with lower hinge-moment coefficients and only slight instability near zero deflection than plug aileron 1. The variation of the characteristics with angle of attack are similar to the variations shown in figure 8.

The results show that the plug aileron gives either favorable or only slightly unfavorable yawing-moment coefficients except for the condition with flap fully deflected at a large angle of attack. The variation of rolling-moment coefficient with angle of attack is smaller than was anticipated from the results of reference 1.

Effects of a movable plate.— Previous investigation of the plug aileron (reference 1) has shown that the hinge moments of the aileron may be modified by changing the angle of the plate in relation to the rest of the aileron. Tests of the plug aileron installed in a tapered wing also show that the plate angle setting is critical. Figure 10 shows rolling-, yawing-, and hinge-moment coefficients at various plate deflections, angles of attack, and flap deflections.

Tests of plug aileron 5 with zero plate angle (fig. 9) indicate that, in the high-speed condition, a small overbalance of the control system will likely occur at low negative aileron deflections; whereas, at high negative aileron deflections, the hinge-moment coefficients are of such magnitude as to require excessive control forces. Setting the plate angle at low negative deflections made the hinge-moment-coefficient curves stable throughout the aileron deflection range but increased the value of the hinge-moment coefficients at all negative aileron deflections. With the plate deflected -60° and at high negative aileron deflections, the value of $\partial C_h / \partial \delta_a$ becomes very small (fig. 10) probably because of the stalled attitude of the plate. Increasing the plate angle in a positive direction decreases the hinge-moment coefficients but increases the instability of the aileron at low deflections and decreases aileron effectiveness. Because a given projection is thought to be more effective, in producing roll, near the outboard end of the aileron than at the inboard end and, because the large plate area and large moment arm tend to make the inboard portion of the plate more effective with regard to the aileron hinge moments, it might be advantageous to reduce the hinge moments by

deflecting only the inboard half of the plate. With such an arrangement, a very small amount of aileron effectiveness would be lost.

The effectiveness of the aileron is roughly proportional to its span and to its projection above the wing contour. The aileron projection may be increased by increasing the aileron-plate width or by raising the aileron hinge line, particularly at the outboard end where the maximum projection of the aileron tested was relatively small and where the greatest gain in effectiveness is to be expected. In some installations, it may be advisable to locate one or two of the outboard-aileron pivots above the wing contour and fair over them in order to limit, insofar as possible, their drag and interference.

ESTIMATED RATES OF ROLL AND STICK FORCES

The rates of roll and the stick forces during steady roll for the airplane shown in figure 5 have been estimated from the data of figures 9 and 10. Plug aileron 5 was used for all stick-force computations.

The rates of roll were estimated by means of the relationship

$$\frac{pb}{2V} = \frac{C_{l'}}{C_{l'_p}} \quad (1)$$

where $C_{l'_p}$, the coefficient of damping in roll, was taken as 0.46 from the data of reference 5. ($C_{l'_p}$ is C_{l_p} in reference 5.) Wing twist was neglected. The stick forces were estimated from the relationship

$$F_s = \frac{6.4}{C_L} \left[C_{h_{up}} \left(\frac{\partial \delta_a}{\partial \delta_s} \right)_{up} - C_{h_{down}} \left(\frac{\partial \delta_a}{\partial \delta_s} \right)_{down} \right] \quad (2)$$

which may be derived from the aileron dimensions and the following airplane characteristics:

Wing area, square feet	260
Span, feet	38
Taper ratio	1.67:1
Airfoil section	NACA 230 series
Mean aerodynamic chord, inches	84.14
M^2 , area-moment of aileron top plate about hinge axis of aileron, cubic feet	0.47
Weight, pounds	7063
Wing loading, pounds per square foot	27.2
Stick length, feet	2
Maximum stick deflection, degrees	± 21
Aileron deflection at maximum stick deflection, degrees	
Linkage A	36.6, -50
Linkage B	13.3, -50

The values of $C_{l'}$ and $C_{h'}$ used in equations (1) and (2) are the values thought to exist during steady rolling; the difference in angle of attack of the two wings due to rolling has been taken into account. The subscripts "up" and "down" refer to aileron position.

Two differential linkages and the corresponding stick-aileron motions are shown in figure 11. Figure 12 gives rates of roll as a function of stick forces with the plate neutral and with the two assumed differential linkages. When the flap is neutral, linkage A gives a larger maximum rate of roll than linkage B; whereas the opposite is true with flap deflected 40° . The variation is due to the difference in the down-aileron deflections of the two linkages. The maximum stick force at high speed is probably excessive and a small amount of overbalance is apparent at small stick deflections. The estimated maximum $pb/2V$ available at high speed is somewhat less than the minimum value of 0.07 that is considered satisfactory (reference 5).

As was pointed out in reference 1, the hinge moments can be modified by changing the angle setting of the plate on the top of the aileron. Figure 13 shows the effect of such a plate deflection on stick forces and it is apparent that even a small deflection has a very powerful effect on the resulting stick forces. It would be feasible to set the plate at a small initial negative angle, as was done in the arrangements of reference 1, in order to eliminate the aileron overbalancing tendency at low deflections.

By a suitable plate-linkage arrangement, such as is shown in figure 14, the plate deflection can be varied to give more desirable stick-force characteristics. As the aileron is deflected upward the plate tilts to a negative angle and provides a stable hinge-moment variation at low aileron deflections and, on further aileron deflection, the plate deflection becomes positive, reducing the maximum stick forces. Figure 14 shows plate deflection curves for two plate linkages. By use of plate linkage 1 with aileron linkage A and plate linkage 2 with aileron linkage B, it is possible for the data of figures 9 and 10 to obtain the stick-force curves shown in figure 15. The stick forces for aileron linkage A with plate linkage 1 are considered satisfactory. In the computations, the characteristics of the downgoing aileron were assumed to be independent of plate angle; that is, the small variations shown in figure 10 were neglected. The effects of a change of pivot location and of the moment of the plate about its own pivot point were also neglected.

Effect of yawing moment.- In order to determine the effect of the favorable yawing-moment coefficients on the values of $p_b/2V$ estimated in figures 12, 13, and 15, an analysis was made for the airplane by means of the charts of reference 6. From the charts it was estimated that the favorable yaw for the flap-retracted position would increase the apparently low values of $p_b/2V$. With the flaps deflected the effect of the small adverse yawing-moment coefficient is not important because the estimated $p_b/2V$ is large; a small decrease will not therefore be serious.

CONCLUSIONS

The results of this investigation indicate that a plug aileron will provide satisfactory lateral control on a tapered-wing airplane equipped with full-span slotted flaps. For satisfactory results, it is essential either to obtain the optimum amount of vent opening or to provide means for deflecting the plate relative to the aileron.

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REFERENCES

1. Rogallo, Francis M., and Swanson, Robert S.: Wind-Tunnel Development of a Plug-Type Spoiler-Slot Aileron for a Wing with a Full-Span Slotted Flap and a Discussion of Its Application. NACA A.R.R., Nov. 1941.
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. Rep. No. 664, NACA, 1939.
3. Rogallo, Francis M., and Lowry, John G.: Wind-Tunnel Investigation of a Plain Aileron and a Balanced Aileron on a Tapered Wing with a Full-Span Duplex Flap. NACA A.R.R., July 1942.
4. Rogallo, F. M., and Spano, Bartholomew S.: Wind-Tunnel Investigation of a Spoiler-Slot Aileron on an NACA 23012 Airfoil with a Full-Span Fowler Flap. NACA A.R.R., Dec. 1941.
5. Gilruth, R. R., and Turner, W. N.: Lateral Control Required for Satisfactory Flying Qualities Based on Flight Tests of Numerous Airplanes. Rep. No. 715, NACA, 1941.
6. Fehlner, Leo F.: A Study of the Effects of Vertical Tail Area and Dihedral on the Lateral Maneuverability of an Airplane. NACA A.R.R., Oct. 1941.

TABLE I
ORDINATES FOR AIRFOIL

[Spanwise stations in inches from root section. Chord stations and ordinates in percent of arbitrary wing chord, c_1]

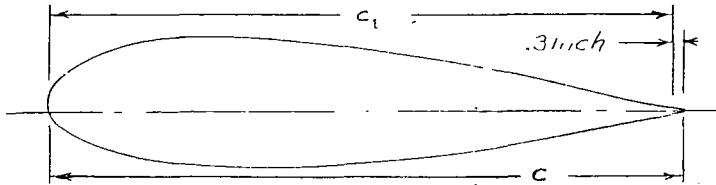
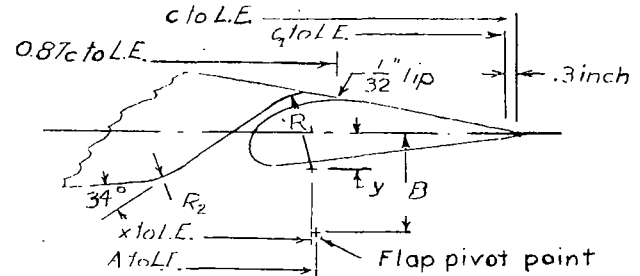


TABLE II
ORDINATES FOR FLAP AND SLOT SHAPES

[Spanwise stations in inches from root section. Chord stations and ordinates in percent of arbitrary wing chord, c_1]



Model wing station 0			Model wing station 58.5		
Station	Upper surface	Lower surface	Station	Upper surface	Lower surface
0	0	0	0	0	0
1.25	3.48	-1.60	1.25	1.89	-.84
2.5	4.61	-2.36	2.5	2.65	-1.07
5	6.10	-3.21	5	3.70	-1.26
7.5	7.14	-3.82	7.5	4.45	-1.40
10	7.89	-4.33	10	4.98	-1.52
15	8.80	-5.12	15	5.54	-1.86
20	9.22	-5.71	20	5.73	-2.22
25	9.40	-6.10	25	5.77	-2.46
30	9.37	-6.28	30	5.71	-2.62
40	8.90	-6.23	40	5.36	-2.70
50	8.02	-5.78	50	4.78	-2.56
60	6.85	-5.05	60	4.06	-2.27
70	5.44	-4.10	70	3.21	-1.87
80	3.87	-2.97	80	2.26	-1.36
90	2.12	-1.67	90	1.22	-.78
95	1.16	-.94	95	.70	-.46
100	.18	-1.16	100	.18	-.14
100.73	.03	-.03	101.2	.05	-.05

L.E. radius: 2.65. Slope of radius through end of chord: 0.305

L.E. radius: 0.70. Slope of radius through end of chord: 0.305

Flap stations

Model wing station 0			Model wing station 58.5		
Station	Upper surface	Lower surface	Station	Upper surface	Lower surface
0	-1.29	-1.29	0	-0.76	-0.76
.52	-.08	-2.30	.53	.01	-1.16
1.04	.48	-2.50	1.06	.36	-1.23
2.07	1.29	-2.60	2.12	.80	-1.22
4.15	2.17	-2.44	4.24	1.30	-1.10
6.22	2.53	-2.18	6.36	1.42	-.99
8.29	2.40	-1.91	8.48	1.35	-.87
12.44	1.65	-1.32	12.72	.93	-.62
16.58	.85	-.69	16.96	.51	-.32
20.72	.03	-.03	21.20	.05	-.05

L.E. radius: 1.19

L.E. radius: 0.32

Slot Shape

	Station 0	Station 58.5
R1	5.3	5.1
R2	2	2
x	85	83.3
y	2.5	3.3

Flap pivot

	Station 0	Station 58.5
A	85.8	84
B	7.7	8

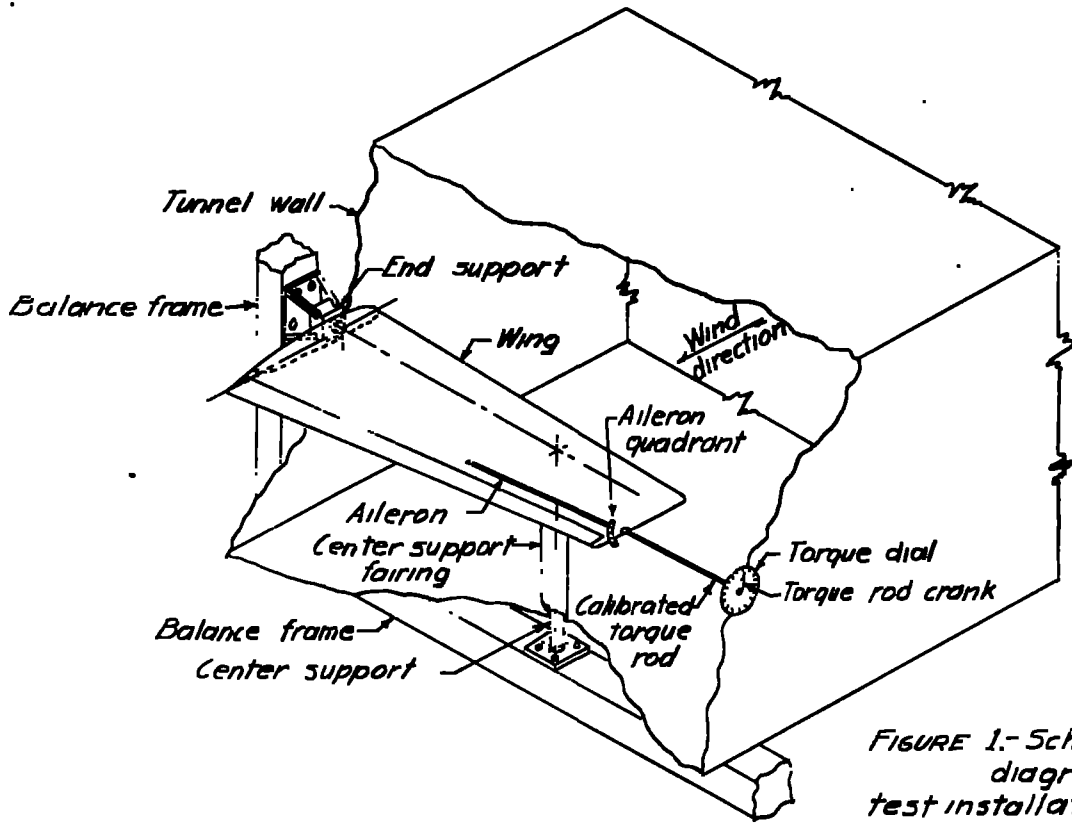


FIGURE 1.- Schematic diagram of test installation.

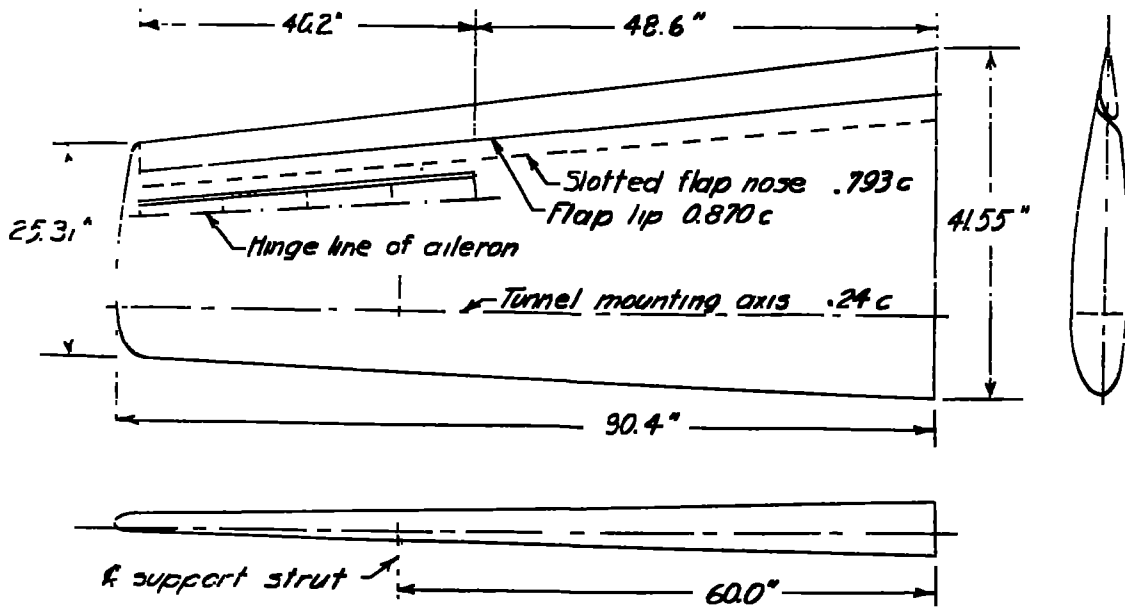
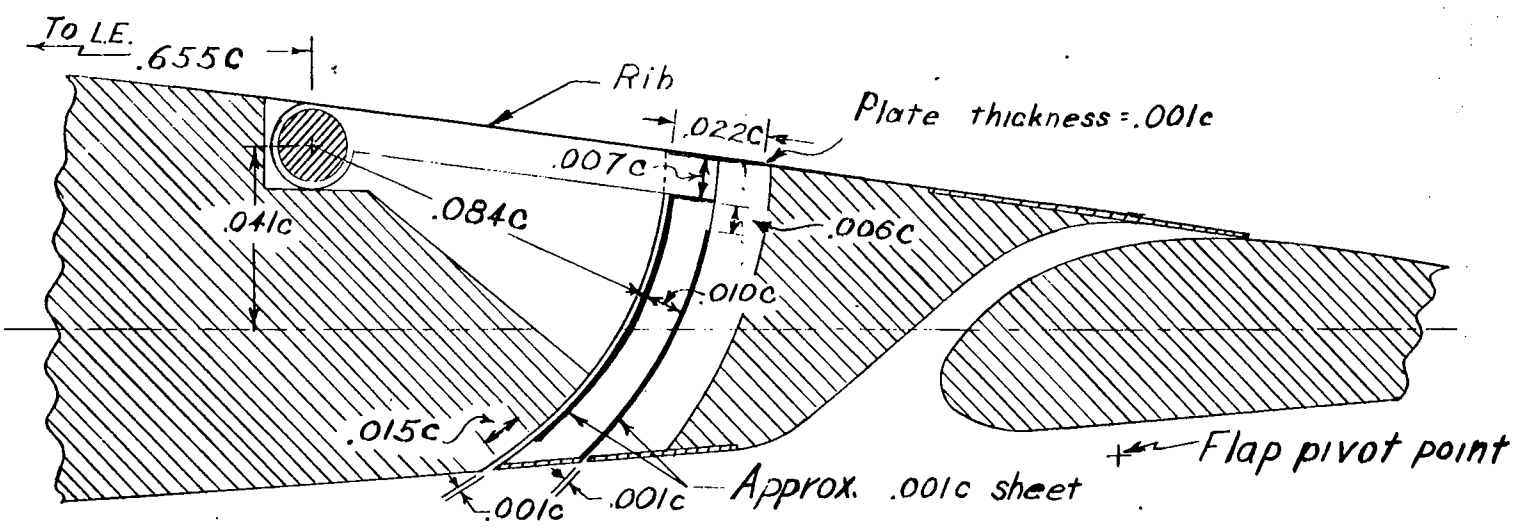
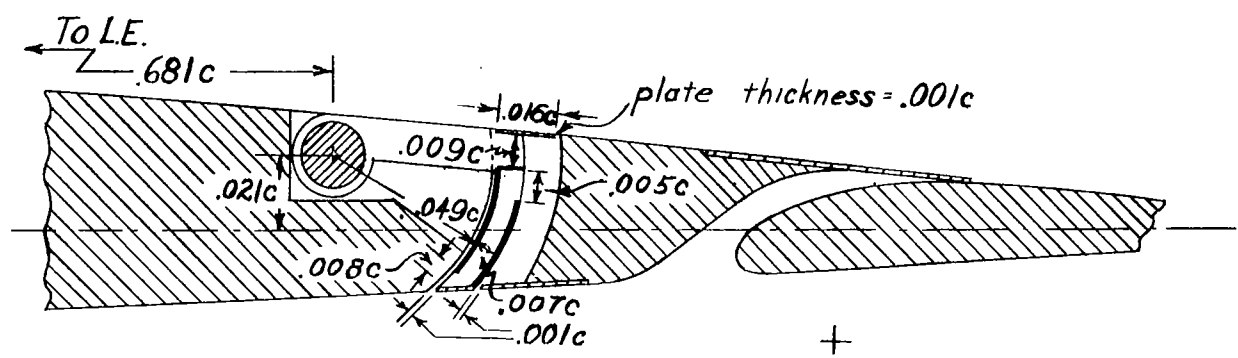


FIGURE 2.- Semispan model of tapered wing.

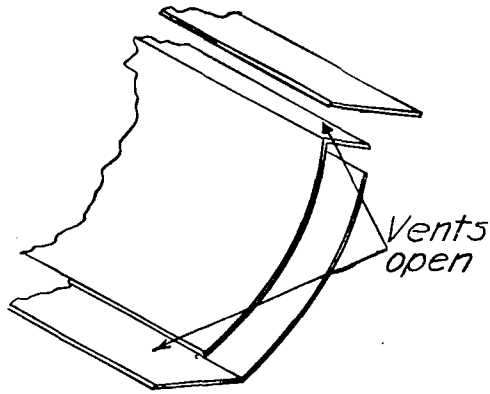


INBOARD SECTION

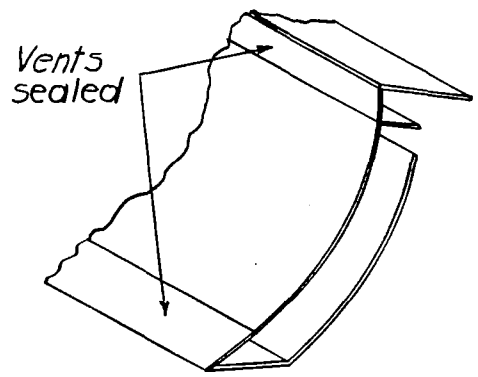


OUTBOARD SECTION

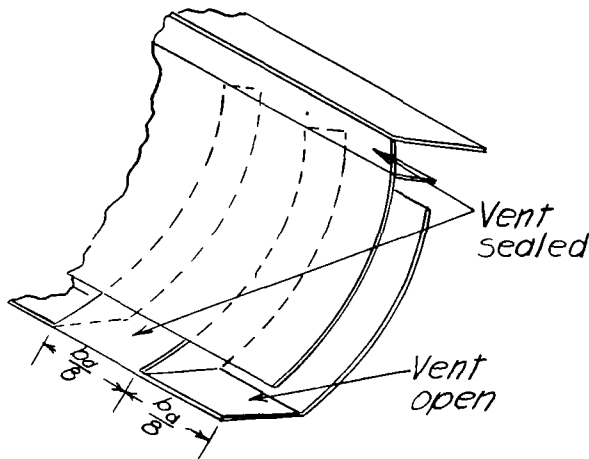
Figure 3.- Details of the plug aileron on the tapered-wing model.



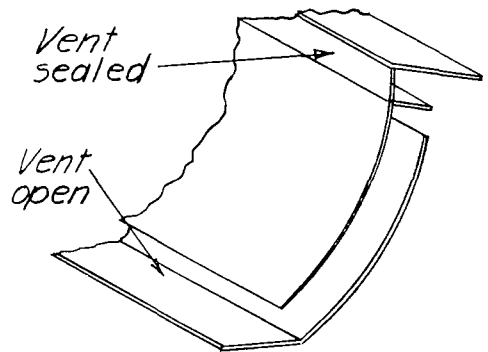
Plug aileron 1



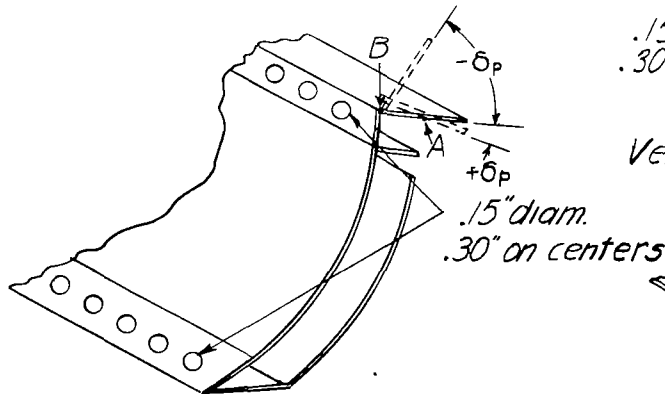
Plug aileron 2



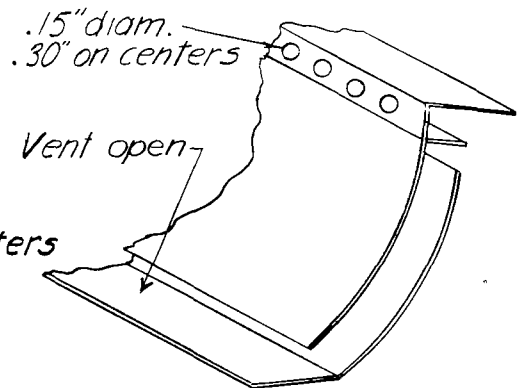
Plug aileron 3



Plug aileron 4



Plug aileron 5



Plug aileron 6

Figure 4.- Details of the modifications on the plug aileron.

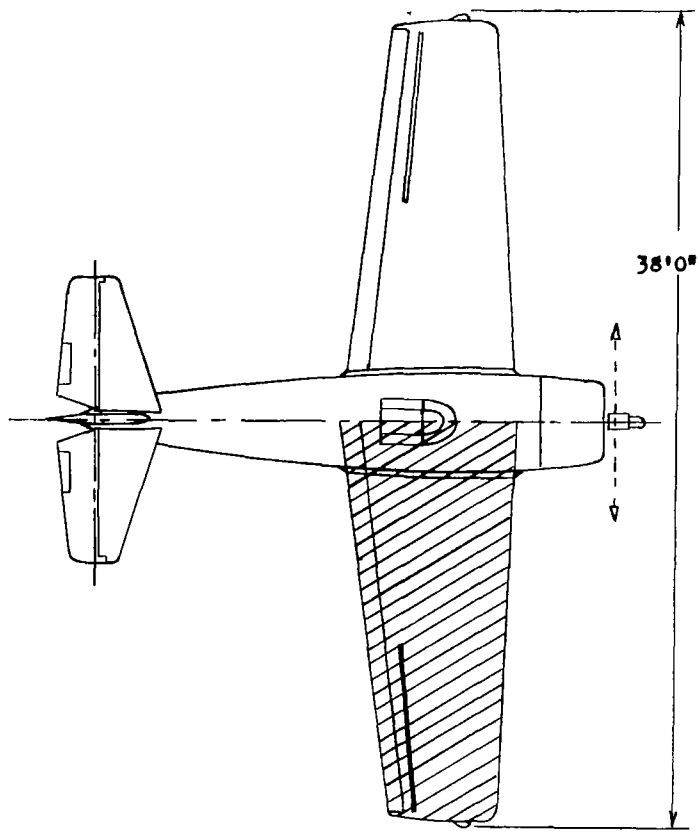


Figure 5. - Portion of airplane simulated.

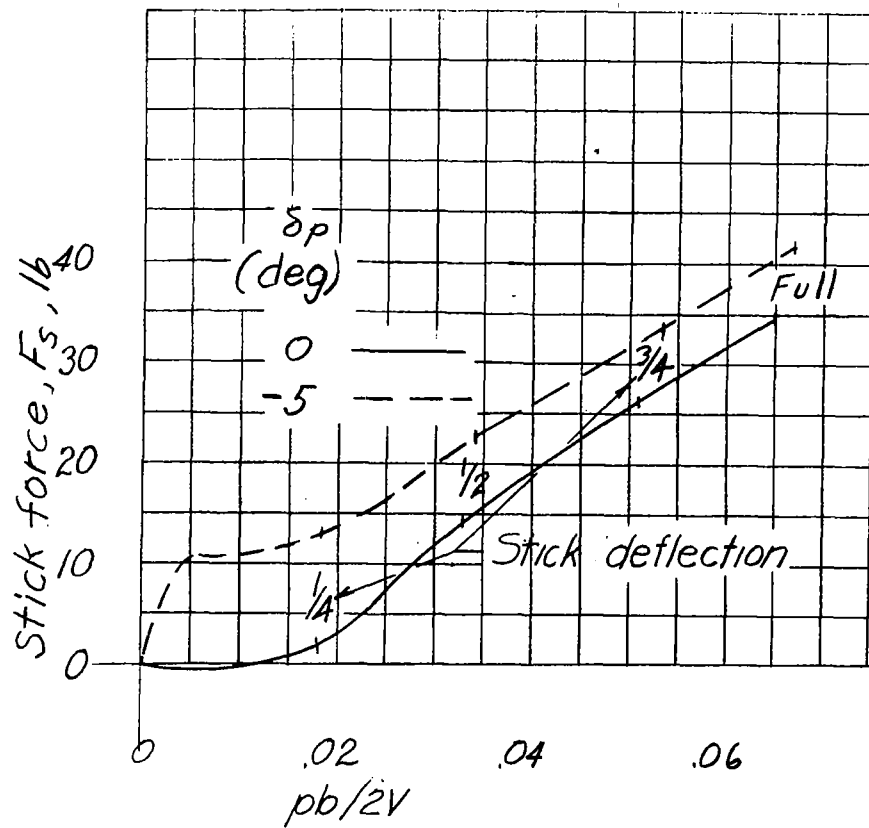


Figure 13.- Aileron control characteristics of the tapered-wing airplane with full-span flaps and plug ailerons. $\delta_f, 0^\circ$; $V_i, 200$ mph.

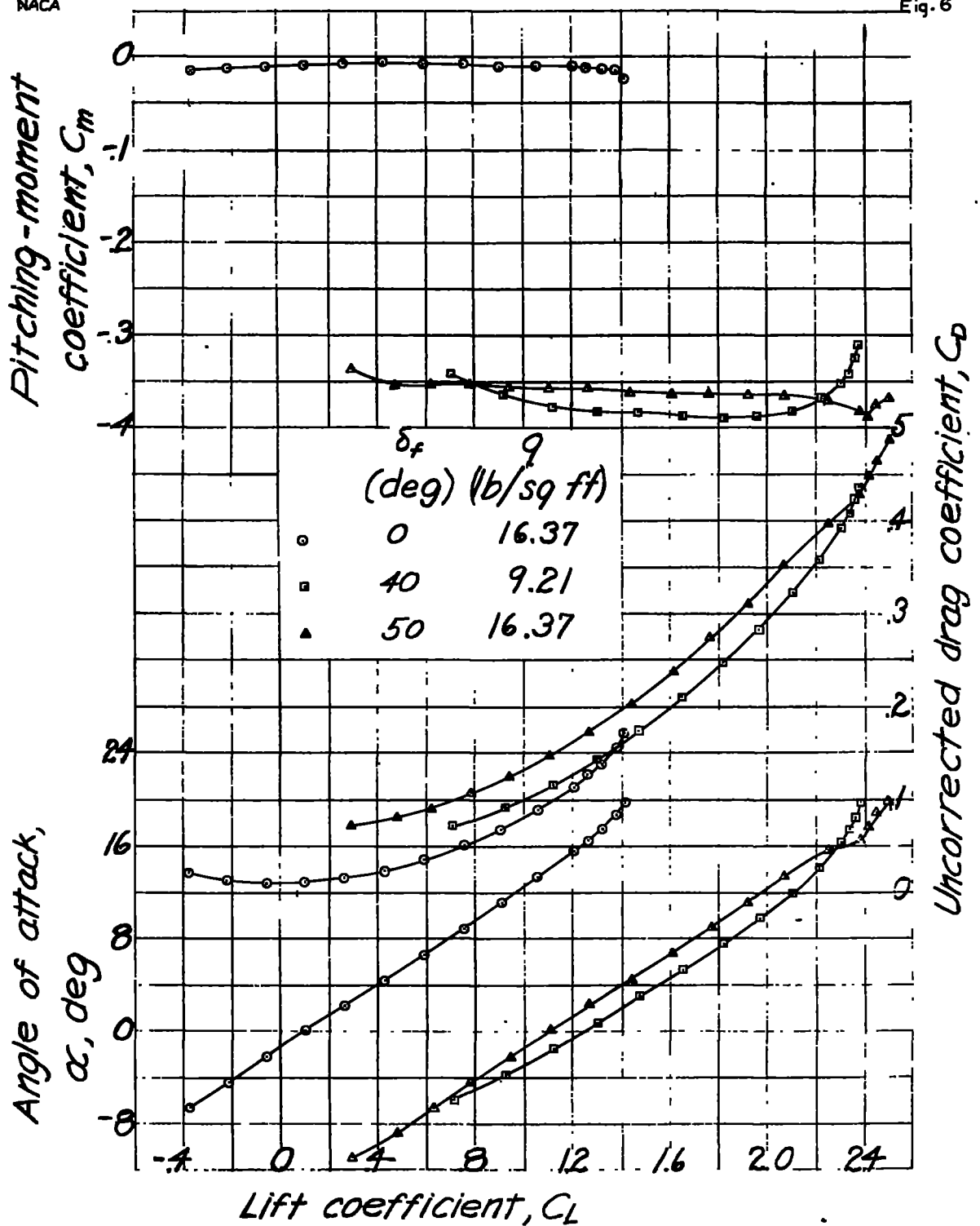
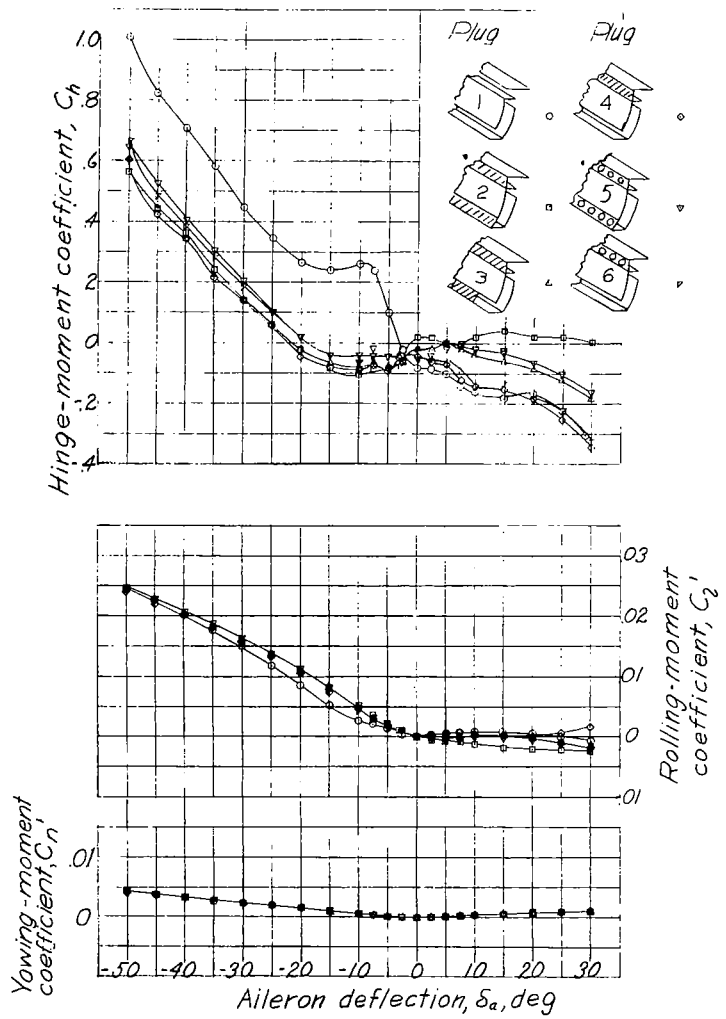
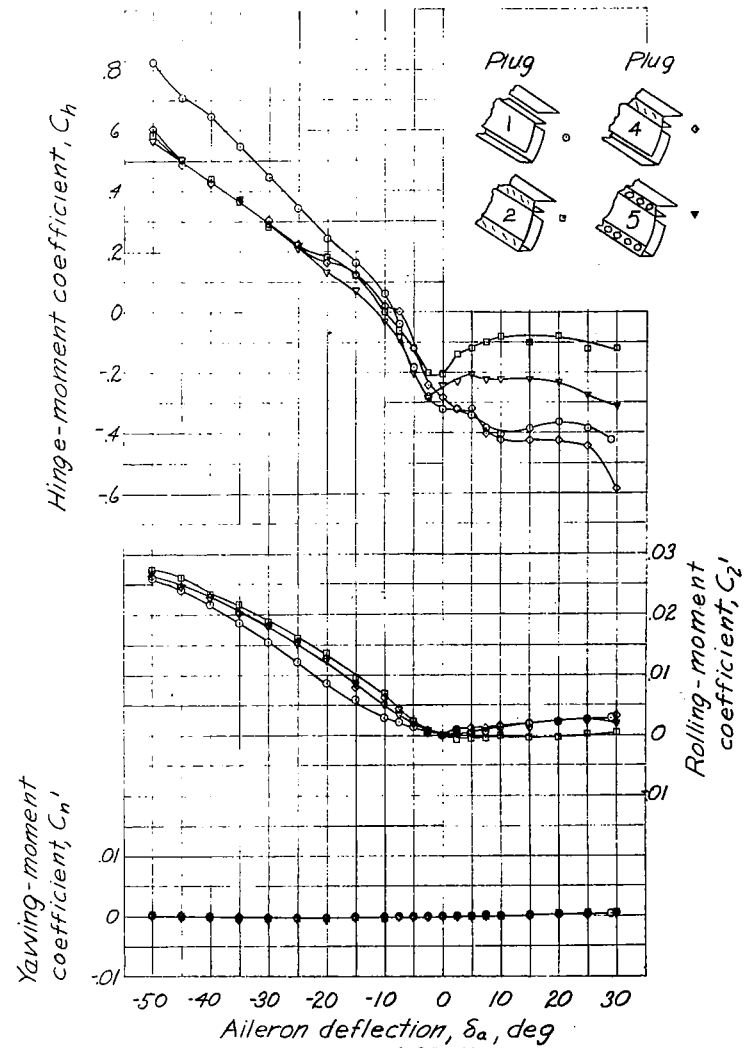


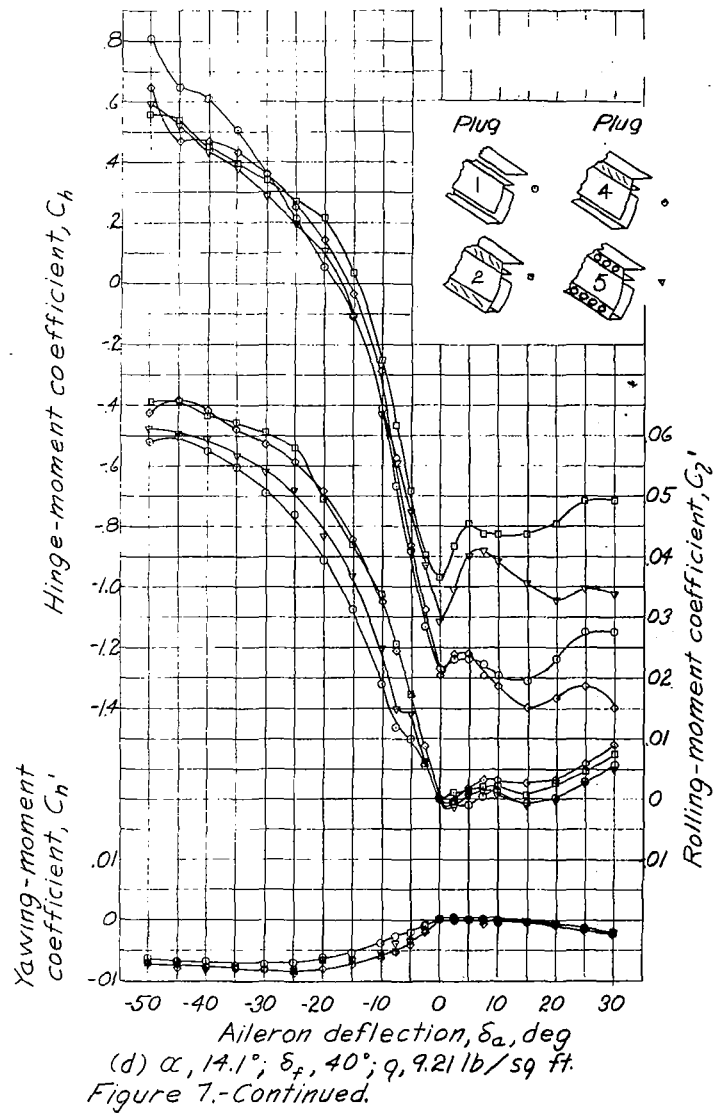
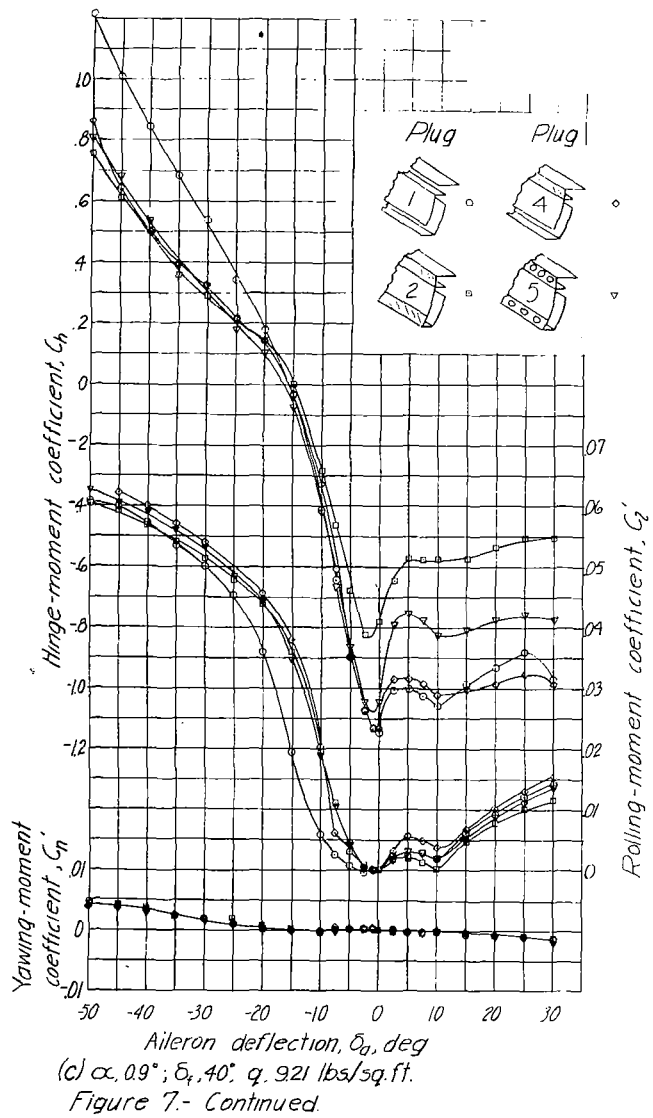
Figure 6.- Lift, drag, and pitching-moment coefficients of the tapered-wing model with full-span flap and plug aileron. $\delta_a = 0^\circ$.

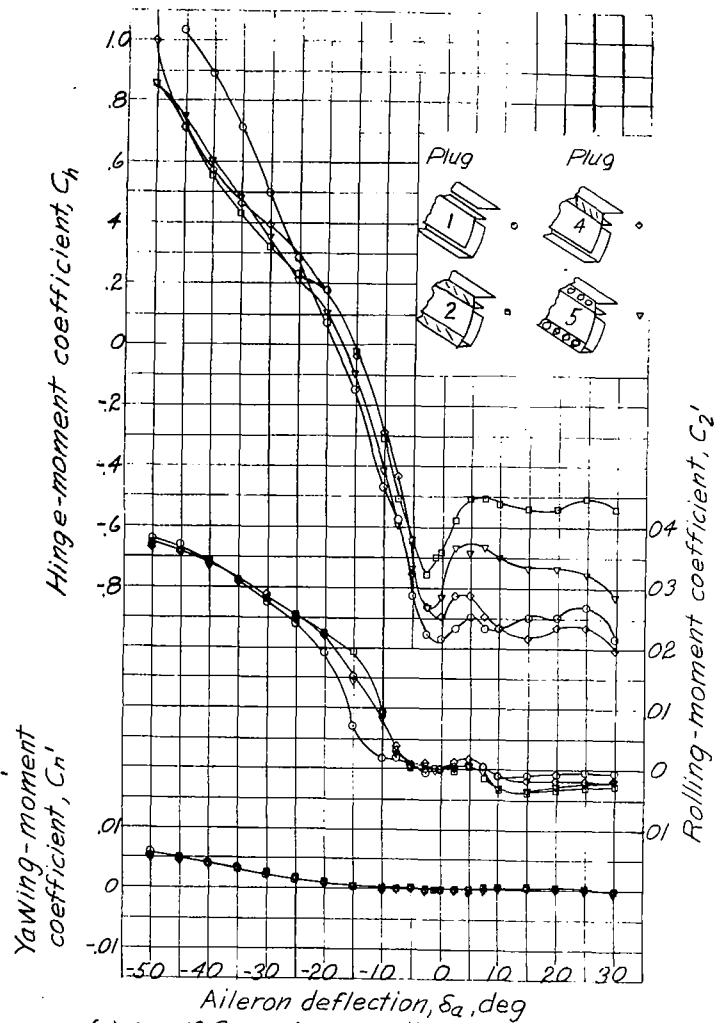


(a) $\alpha, 0.1^\circ; \delta_f, 0^\circ; q, 16.37 \text{ lb/sq ft.}$
 Figure 7.- Rolling, yawing, and hinge-moment coefficients due to aileron deflection for various aileron modifications for the tapered-wing model with full-span flap and plug aileron. $\delta_p, 0^\circ$

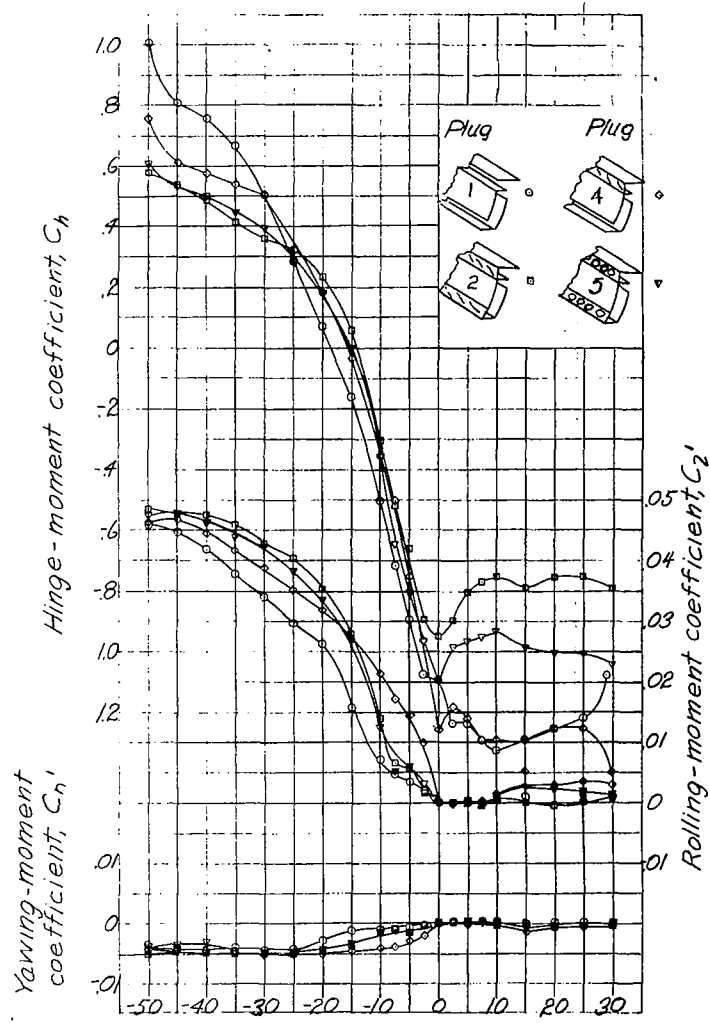


(b) $\alpha, 13.3^\circ; \delta_f, 0^\circ; q, 16.37 \text{ lb/sq ft.}$
 Figure 7.- Continued.

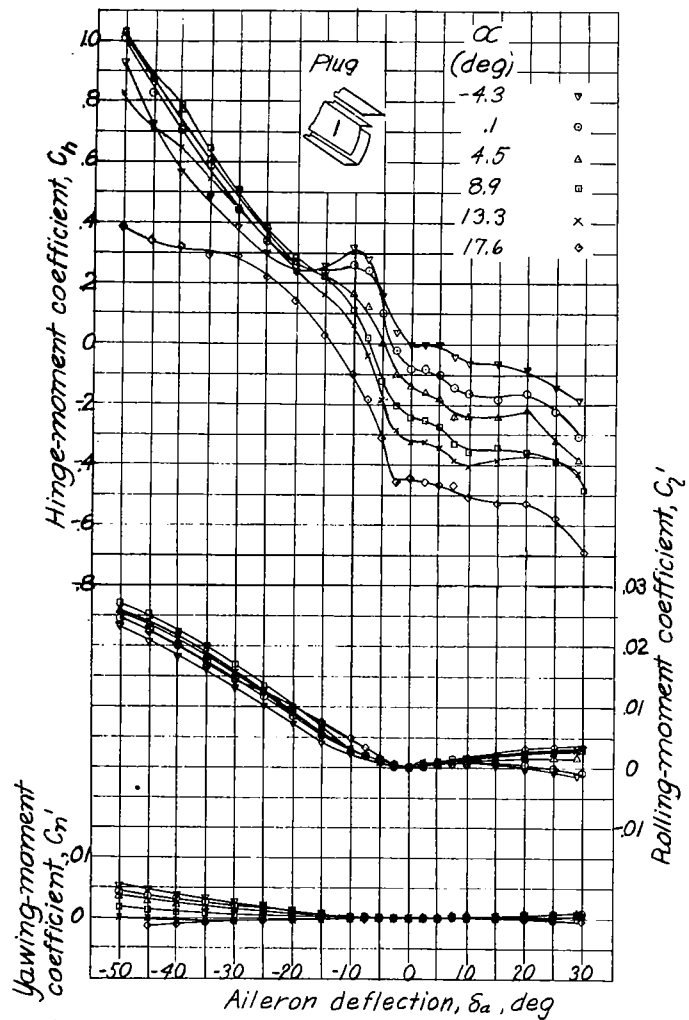




(e) $\alpha, 0.8^\circ; \delta_f, 50^\circ; q, 9.21 \text{ lb/sq ft.}$
 Figure 7.- Continued.

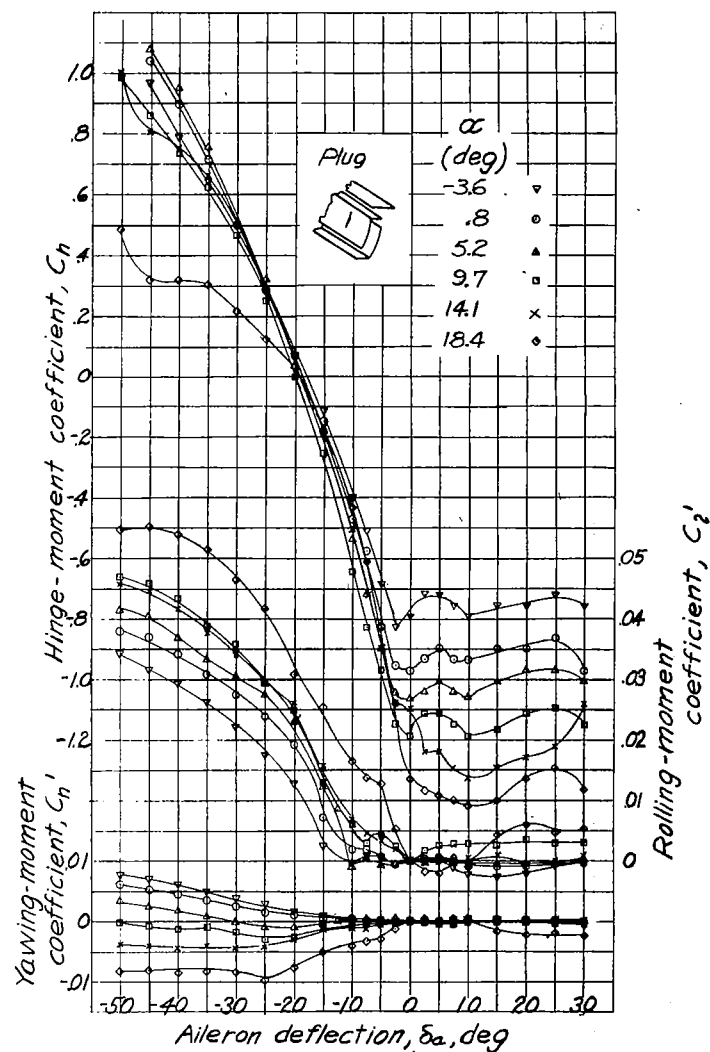


(f) $\alpha, 14.1^\circ; \delta_f, 50^\circ; q, 9.21 \text{ lb/sq ft.}$
 Figure 7.- Concluded.



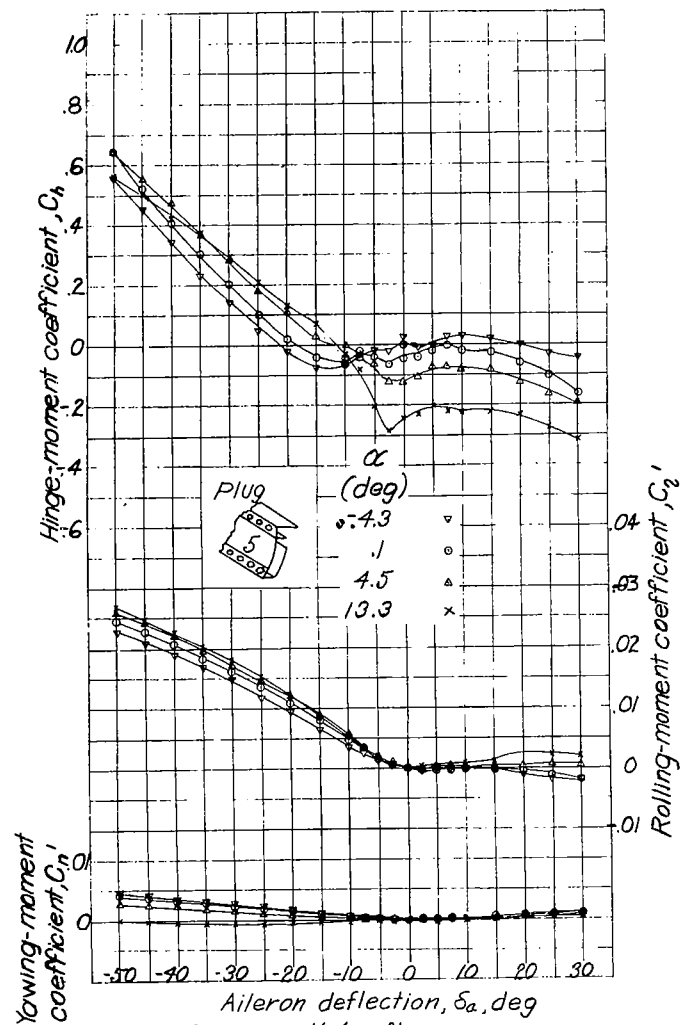
(a) $\delta_F, 0^\circ$; $q, 16.37 \text{ lb/sq ft}$.

Figure 8.- Rolling, yawing, and hinge-moment coefficients due to aileron deflection at various angles of attack for the tapered-wing model with full-span flap and plug aileron. Plug aileron 1; $\delta_p, 0^\circ$.



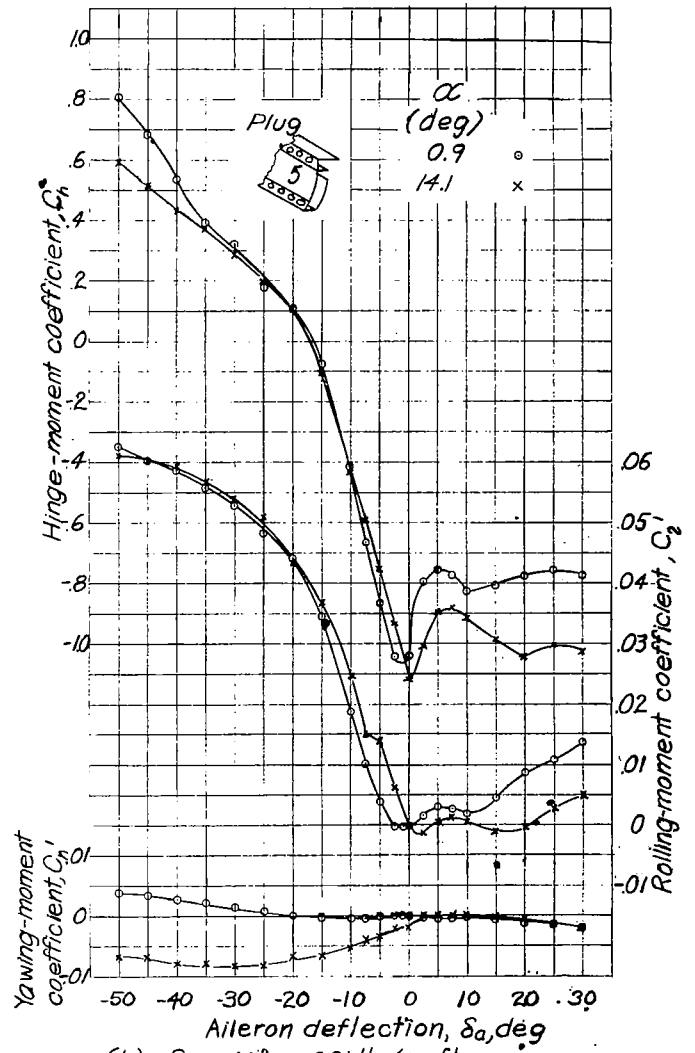
(b) $\delta_F, 50^\circ$; $q, 9.21 \text{ lb/sq ft}$.

Figure 8.- Concluded.



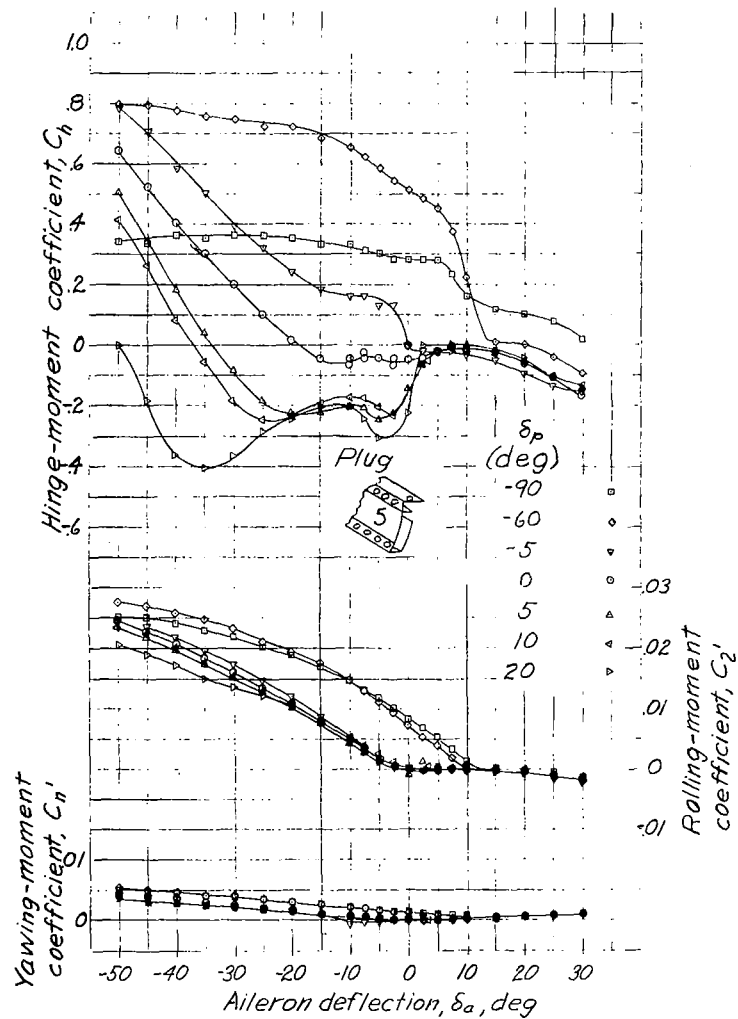
(a) $\delta_f, 0^\circ; q, 16.37 \text{ lb/sq ft.}$

Figure 9.- Rolling, yawing, and hinge-moment coefficients due to aileron deflection at various angles of attack for the tapered-wing model with full-span flap and plug aileron. Plug aileron 5; $\delta_p, 0^\circ$.

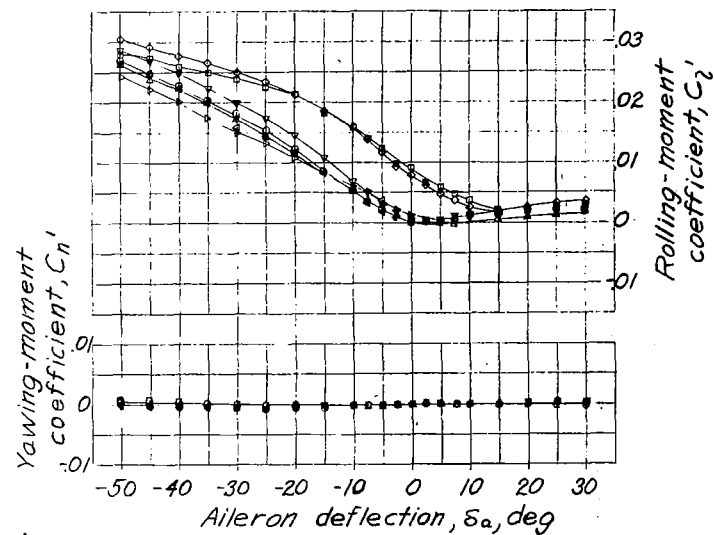
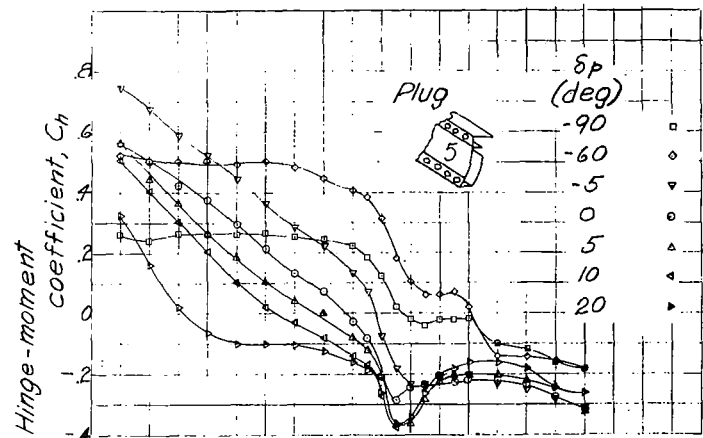


(b) $\delta_f, 40^\circ; q, 9.21 \text{ lb/sq ft.}$

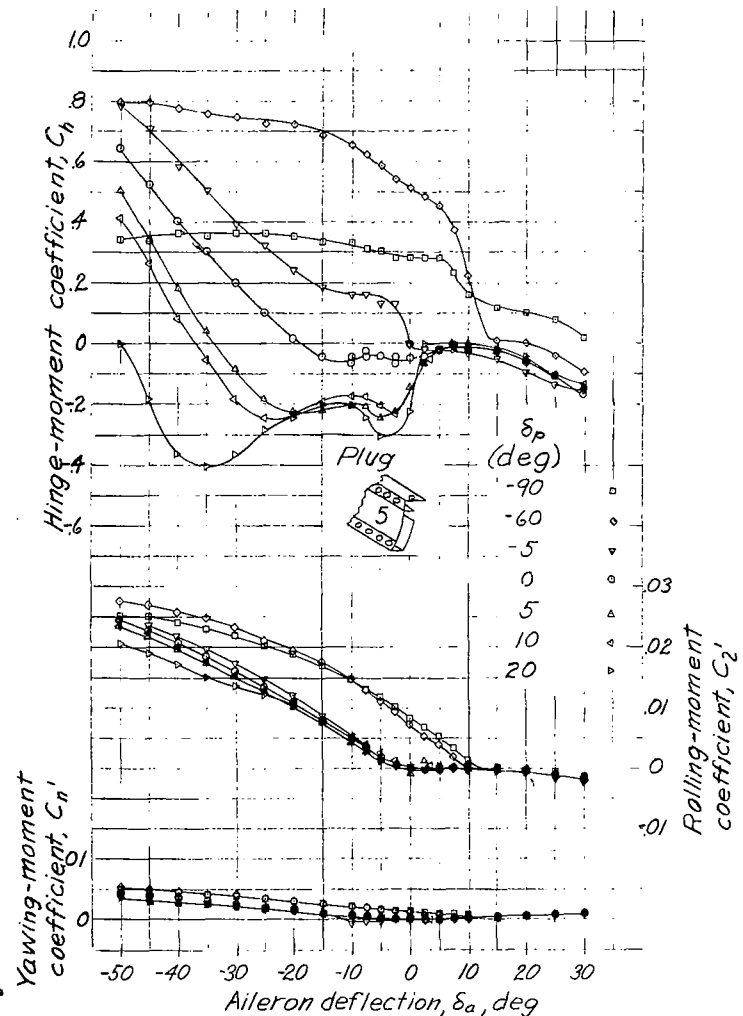
Figure 9.- Concluded.



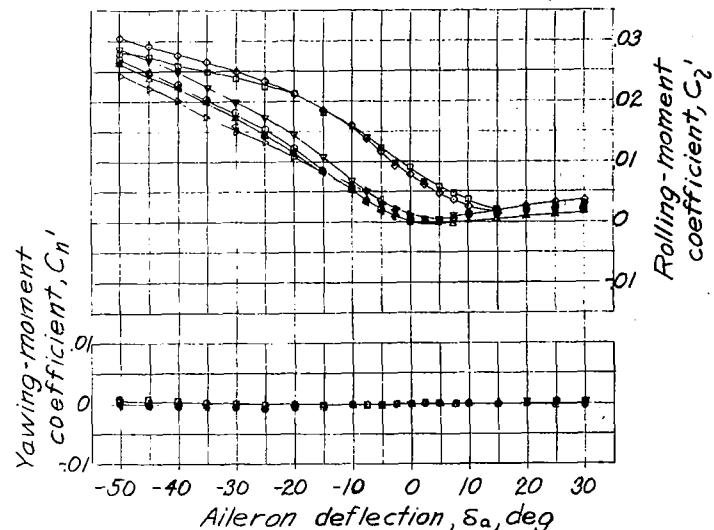
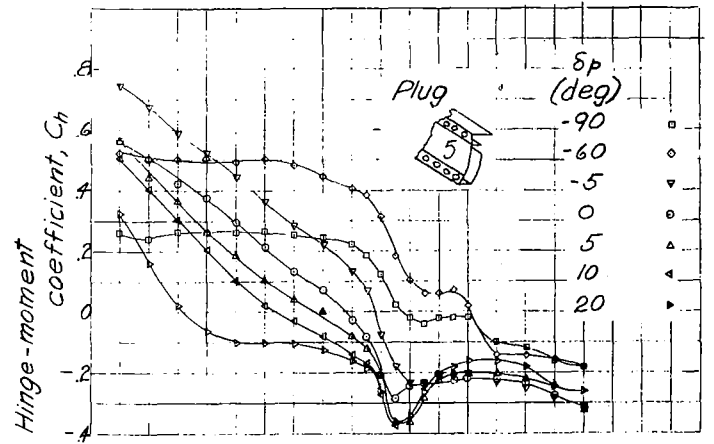
(a) $\alpha, 0.1^\circ; \delta_f, 0^\circ; q, 16.37 \text{ lb/sq ft}$
 Figure 10.-Rolling, yawing, and hinge-moment coefficients due to aileron deflection at various plate angles for the tapered-wing model with full-span flap and plug aileron. Plug aileron 5.



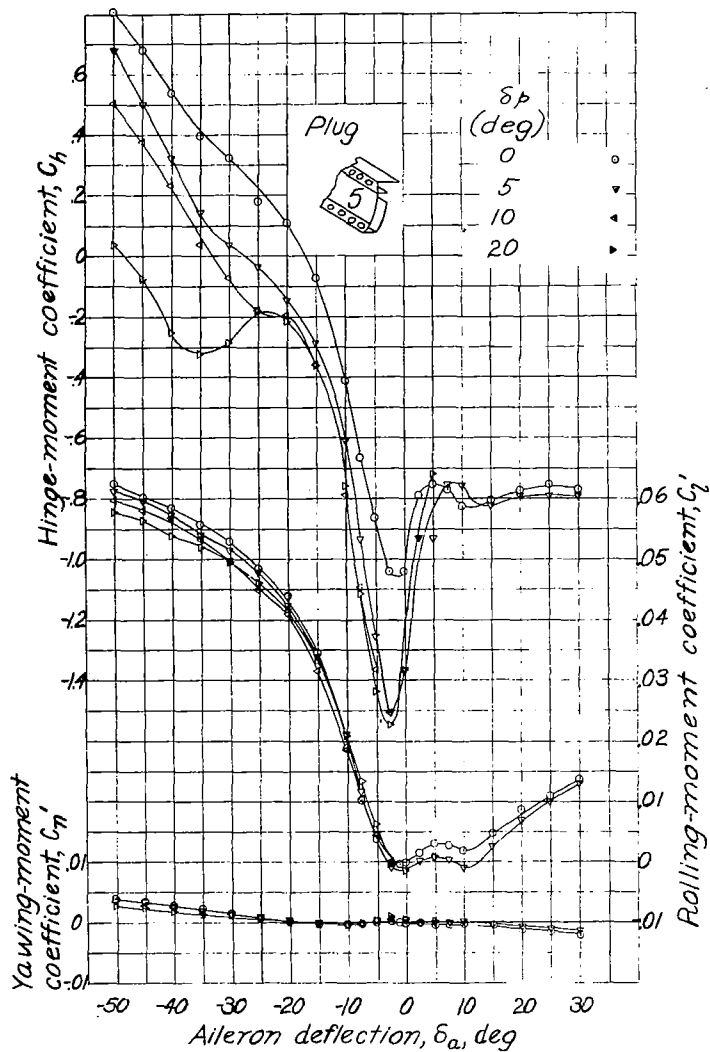
(b) $\alpha, 13.3^\circ; \delta_f, 0^\circ; q, 16.37 \text{ lb/sq ft}$
 Figure 10.-Continued.



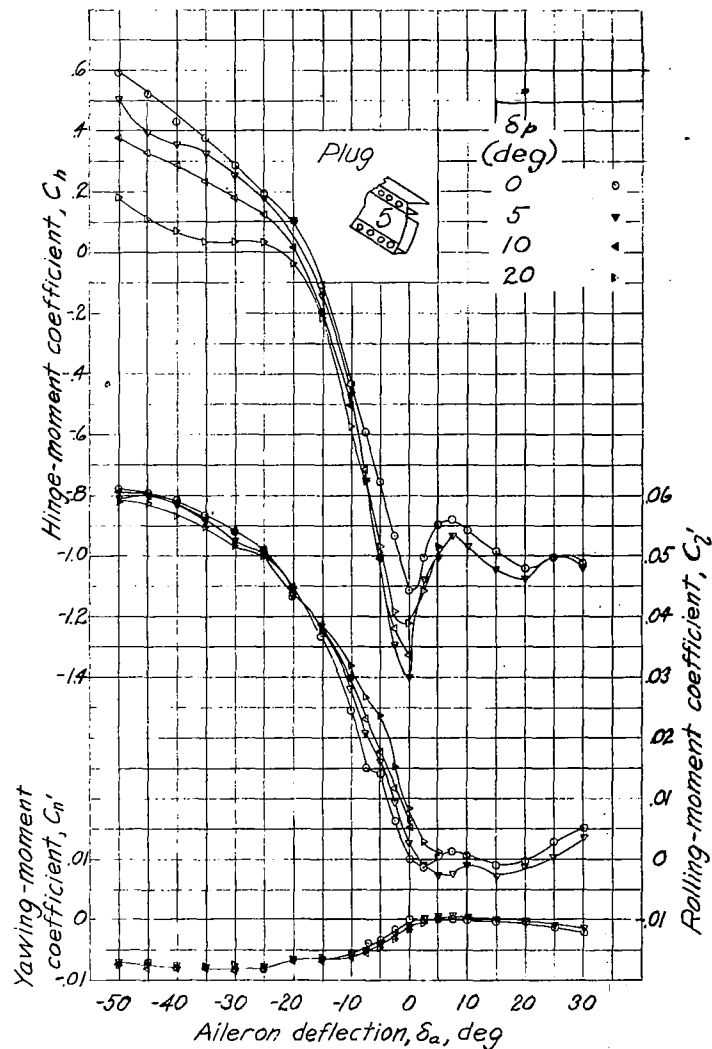
(a) $\alpha, 0.1^\circ; \delta_f, 0^\circ; q, 16.37 \text{ lb/sq ft}$.
 Figure 10.-Rolling, yawing, and hinge-moment coefficients due to aileron deflection at various plate angles for the tapered-wing model with full-span flap and plug aileron. Plug aileron 5.



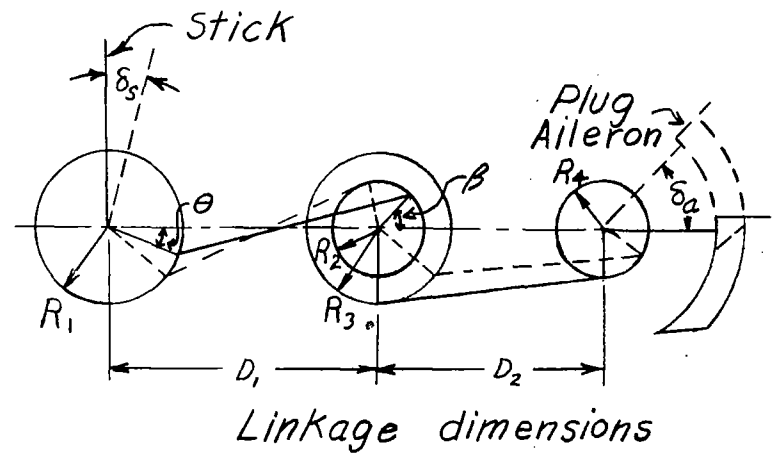
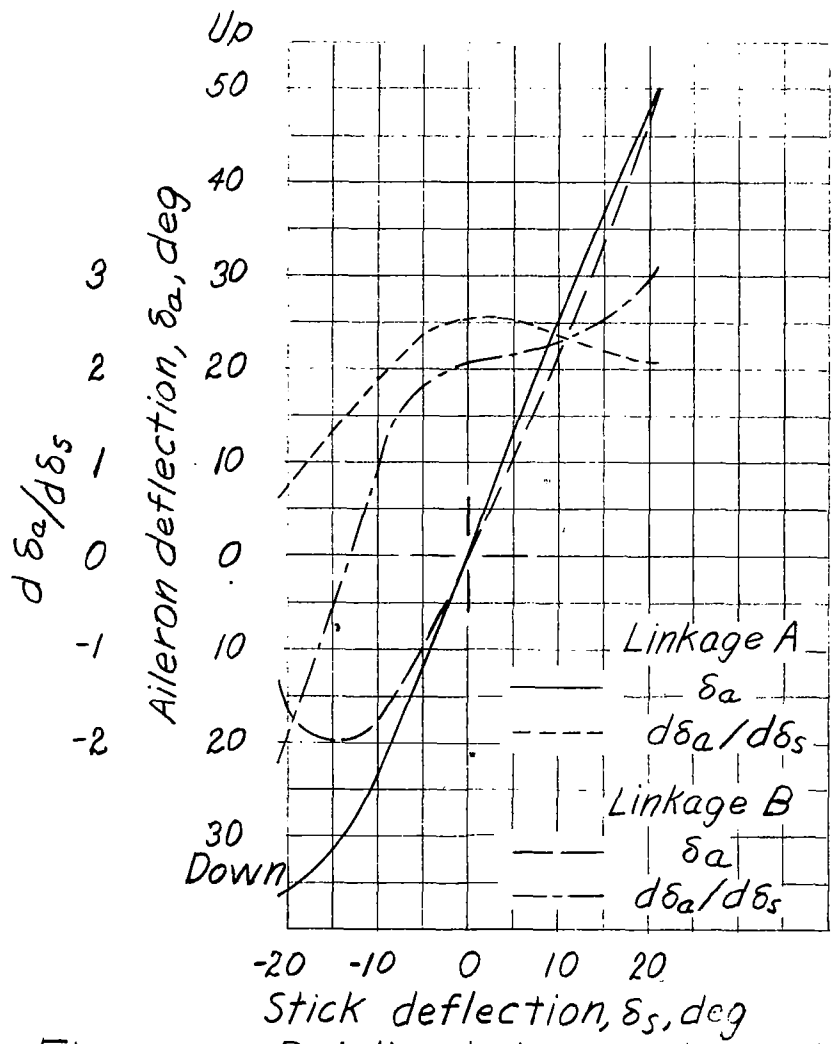
(b) $\alpha, 13.3^\circ; \delta_f, 0^\circ; q, 16.37 \text{ lb/sq ft}$.
 Figure 10.-Continued.



(c) $\alpha, 0.9^\circ$; $\delta_f, 40^\circ$; $q, 9.21 \text{ lb/sq ft}$.
 Figure 10.- Continued.



(d) $\alpha, 14.1^\circ$; $\delta_f, 40^\circ$; $q, 9.21 \text{ lb/sq ft}$.
 Figure 10.- Concluded.



Linkage (deg)	θ (deg)	β (deg)	$\frac{R_2}{R_1}$	$\frac{R_4}{R_3}$	$\frac{D_1}{R_1}$	$\frac{D_2}{R_3}$
A	11.6	92.2	0.6	0.93	1.6	∞
B	13.0	20.0	.5	.64	∞	∞

∞ indicates distance between crank centers large enough to permit neglect of connecting rod angularity.

Figure 11.- Relation between stick and aileron deflection and mechanical advantage for two differential linkages.

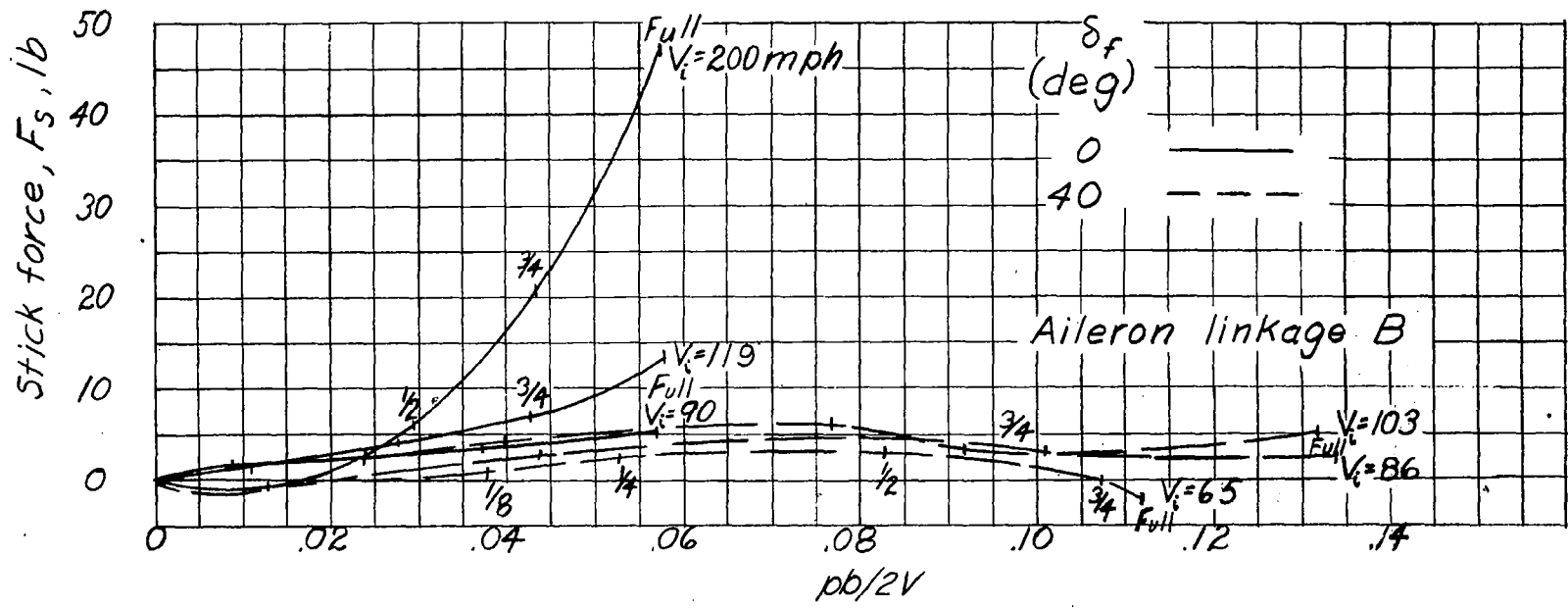
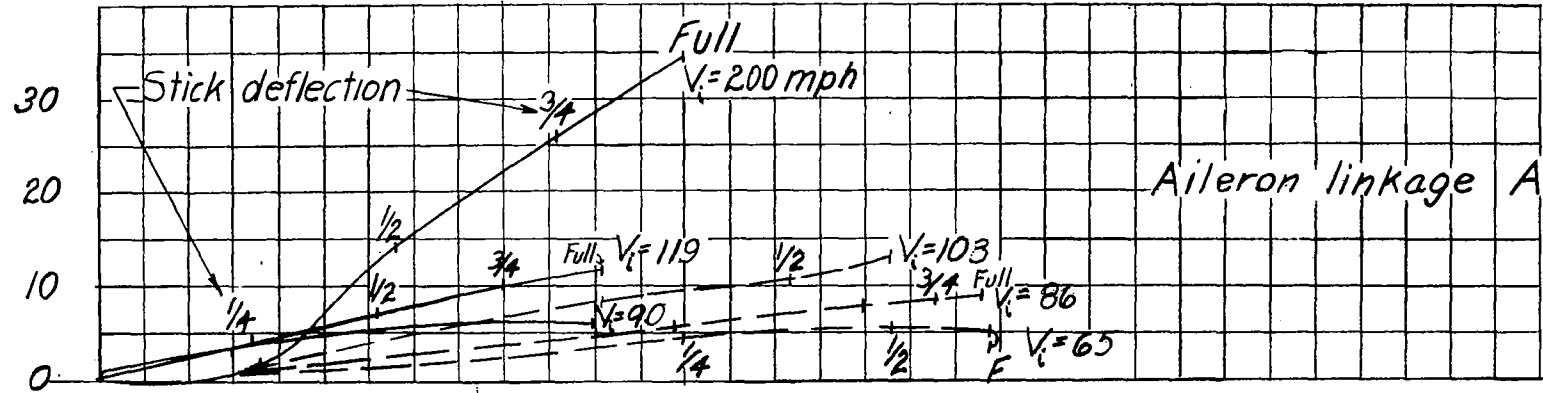
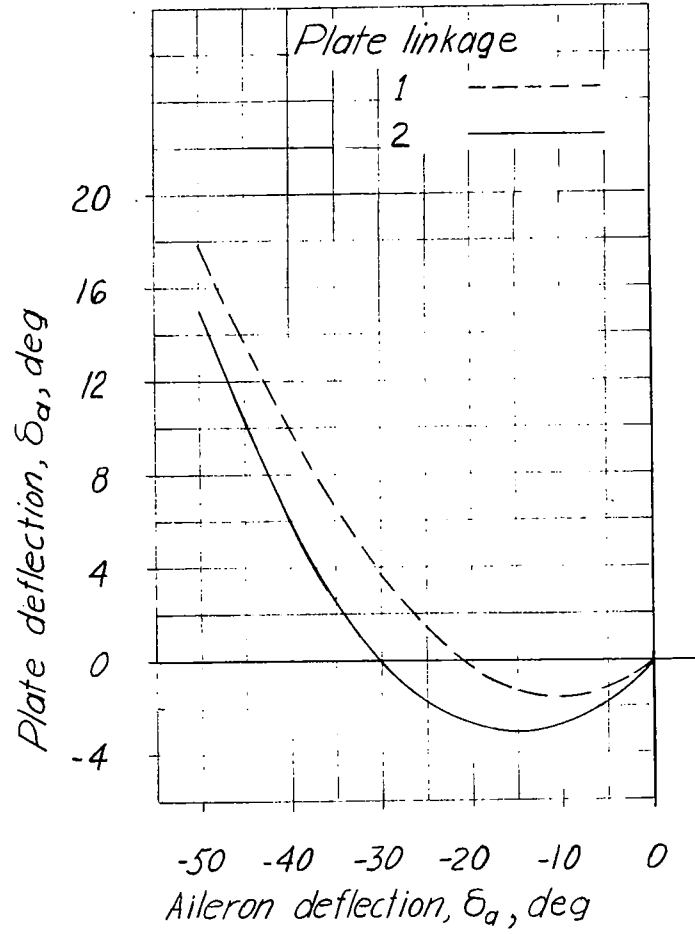


Figure 12.- Aileron control characteristics of the tapered-wing airplane with full-span flaps and plug ailerons. $\delta_p, 0^\circ$; plug aileron 5.



Linkage	d_1/R	d_2/R	l_1/R	l_2/R
1	.172	-.002	200	.734
2	.188	.009	200	.718

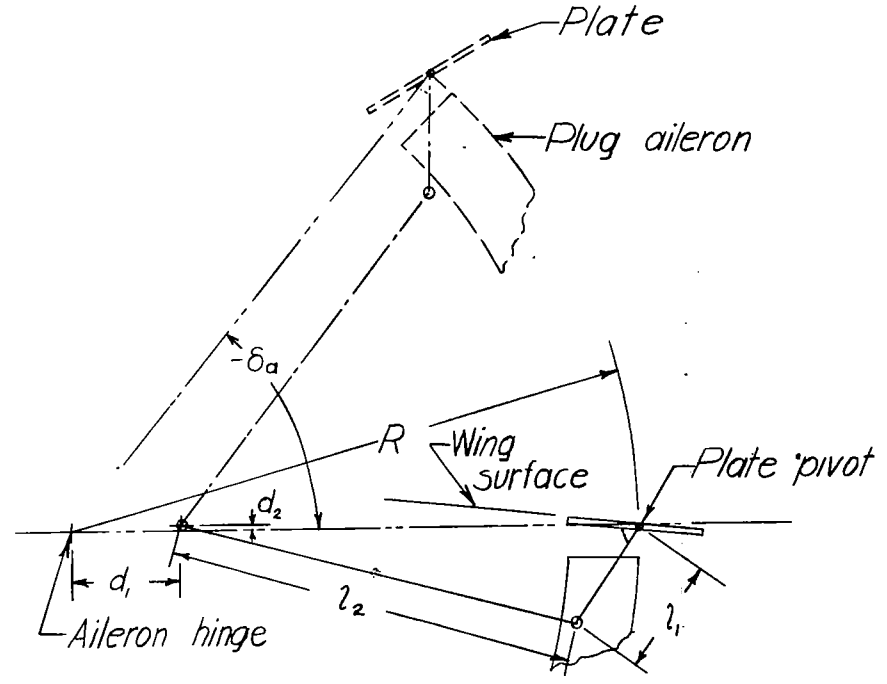


Figure 14.- Variation of plate deflection with aileron deflection and plate-linkage arrangement.

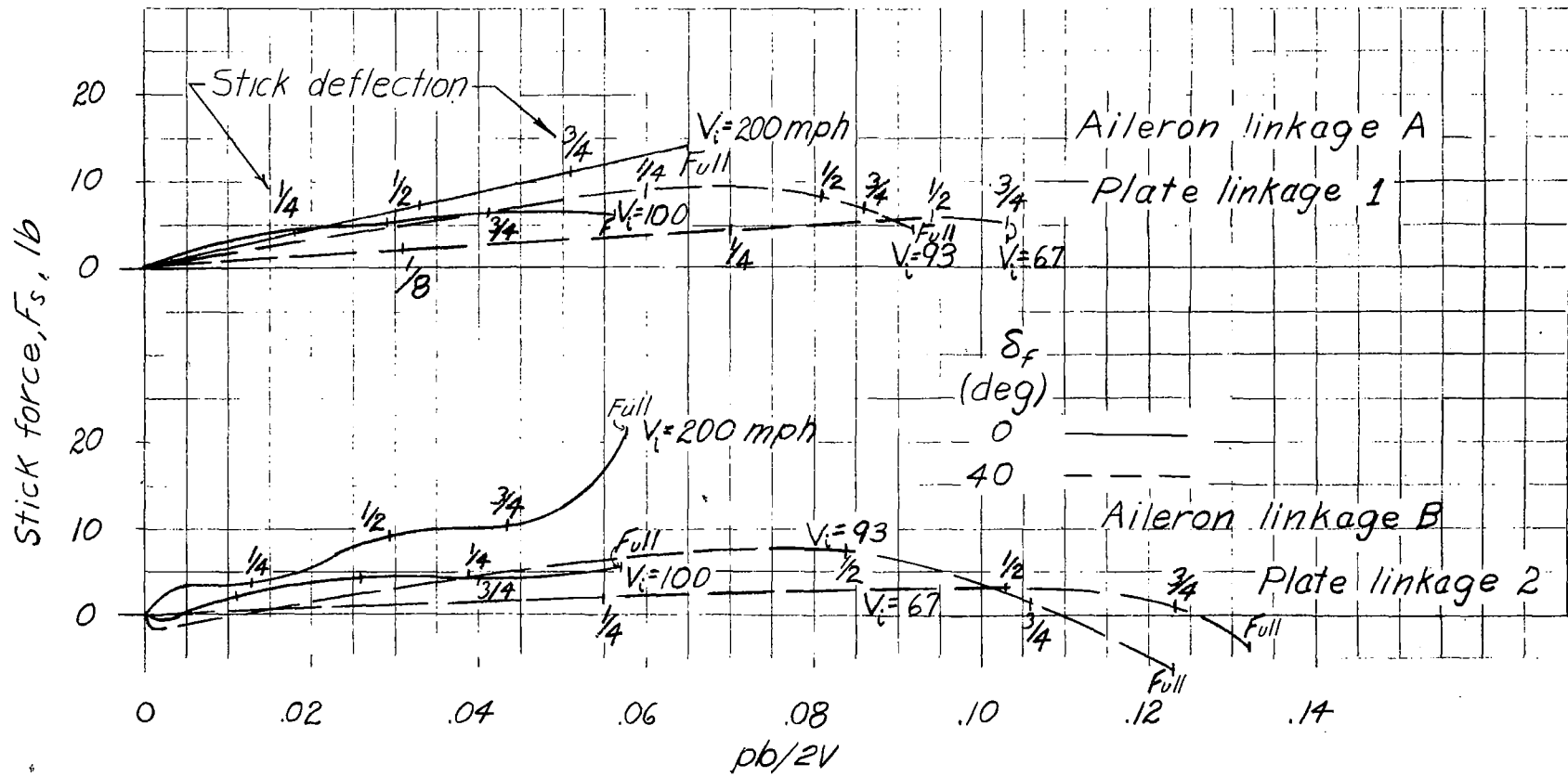


Figure 15.- Aileron control characteristics of the tapered-wing airplane with full-span flaps and plug ailerons. δ_p , movable; plug aileron-5.

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