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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED
January 1943 as
Advance Restricted Report

WIND-TUNNEL INVESTIGATION OF A PLAIN AILERON WITH VARIOUS TRAILING-EDGE MODIFICATIONS ON A TAPERED WING

III - AILERONS WITH SIMPLE AND SPRING-LINKED BALANCING TABS

By F. M. Rogallo and Paul E. Purser

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NACA

WASHINGTON

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

ADVANCE RESTRICTED REPORT

WIND-TUNNEL INVESTIGATION OF A PLAIN AILERON WITH VARIOUS

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III - AILERONS WITH SIMPLE AND SPRING-LINKED BALANCING TABS

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SUMMARY

An investigation was made in the LMAL 7- by 10-foot tunnel of various modifications to the trailing edge of a 0.155-chord plain aileron on a semispan model of the tapered wing of a fighter airplane. The modifications considered in the present report are inset trailing-edge tabs linked to the aileron in such a way that the tab deflects in the opposite direction from the aileron and reduces the aileron stick forces. Tests were made to determine the effect of the gap at the aileron nose and the effects of tab span and location.

An analysis was made of the use of a spring in the aileron-tab linkage to eliminate the possibility of overbalance at low speeds and to reduce the variation of stick force with speed.

The stick forces and rates of roll were estimated for a fighter airplane with plain ailerons, ailerons with simple balancing tabs, and ailerons with spring-linked balancing tabs.

The results of the tests and computations indicated that the use of ailerons with simple or spring-linked tabs would reduce the high-speed stick forces to considerably less than those experienced in the use of plain sealed ailerons if the aileron deflections were not excessive. The use of spring-linked tabs designed to give the desired characteristics at high speed would reduce the variation of stick force with speed and would also cause an increase in aileron effectiveness for a given stick deflection as the speed was reduced. The possibility of flutter being introduced by the presence of the spring was not investigated.

The results of the various investigations of the spring tab both here and in England indicate that this device is very promising as a means of adjusting control-surface hinge moments and it is recommended that further investigation of it be carried out in flight.

INTRODUCTION

In view of the increased importance of obtaining adequate lateral control with reasonable stick forces under all flight conditions for high-speed airplanes, the NACA has engaged in an extensive program of lateral-control research. The purposes of this program are to determine the characteristics of existing lateral-control devices, to determine the effects of various modifications to existing devices, and to develop new devices that show promise of being more satisfactory than those now in use. The present tests were made to furnish aerodynamic data for use in the design of linked balancing tabs and to determine the effects of varying the tab span and location. Rolling moments, yawing moments, and aileron hinge moments were obtained with the tab locked at various deflections, for aileron gap sealed and unsealed, and are presented as characteristics of the individual aileron. Also presented are the estimated aileron control characteristics of a pursuit airplane equipped with plain unbalanced ailerons and with two arrangements of tab-balanced ailerons.

APPARATUS AND METHODS

Test Installation

A semispan-wing model was suspended in the LMAL 7- by 10-foot tunnel (reference 1) 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 in this setup is essentially the same as it would be over a complete wing in a 7- by 20-foot tunnel. Although a very small clearance was maintained between the root chord of the model and the tunnel wall, no part of the model was fastened to or in contact with the tunnel wall. The model was suspended entirely from the balance frame, as shown in figure 1, in such a way that all the forces and moments acting on it might be determined. Provision was made for changing the angle of attack while the tunnel was in operation.

The aileron was deflected by means of a calibrated torque rod connecting the outboard end of the aileron with a crank outside the tunnel wall and the aileron hinge moments were determined from the twist of the rod (fig. 1). Tab hinge moments were not determined.

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Model

The tapered-wing model used in these tests was built to the plan form shown in figure 2 and represents the cross-hatched portion of the airplane shown in figure 3. The basic airfoil sections were of the NACA 230 series tapering in thickness from approximately $15\frac{1}{2}$ percent at the root to $8\frac{1}{4}$ percent at the tip. The basic chord c_1 of the model was increased 0.3 inch at every spanwise station to reduce the trailing-edge thickness and the last few stations were refaired to give a smooth contour. Ordinates for the extended and refaired sections are given in table I. The details of the aileron and the full-span tab are shown in figure 4. The tab was divided into three segments of equal span that could be deflected independently of one another.

Test Conditions

All the tests were made 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 based on the wing mean aerodynamic chord of 33.66 inches. The effective Reynolds number of the tests was about 2,460,000 based on a turbulence factor of 1.6 for the LMAL 7- by 10-foot tunnel. The present tests were made at low scale, low velocity, and high turbulence relative to flight conditions to which the results are applied. The effects of these variables were not determined or estimated.

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 $(H/qb_a\bar{c}_a^2)$

ΔC_h C_h of up aileron - C_h of down aileron

c actual wing chord at any spanwise location

c_1 chord of basic airfoil section at any spanwise location

c' mean aerodynamic chord

c_a aileron chord measured along airfoil chord line from aileron hinge axis to trailing edge of aileron

$\bar{c}_a$ root-mean-square chord of the aileron

c_t tab chord measured along airfoil chord line from tab hinge axis to trailing edge of airfoil

b twice span of semispan model

b_a aileron span

b_t tab span

S twice area of semispan model

L twice lift on semispan model

D twice drag on 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 aileron moment about hinge axis

ΔH algebraic difference of right- and left-hand aileron hinge moments, foot-pounds

q dynamic pressure of air stream uncorrected for blocking $\left(\frac{1}{2}\rho V^2\right)$

V free-stream velocity

V_i indicated velocity

α angle of attack

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

$\Delta\delta_a$ reduction in aileron deflection due to spring deflection, degrees

δ_t tab deflection relative to aileron; positive when trailing edge is down

θ_s control-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

k_s spring constant (one spring), pounds per foot

l_a length of aileron-control horn, feet

l_t length of tab-control horn, feet

l_s length of control stick, feet

A positive value of L' or C_l' corresponds to an increase in lift of the model, and a positive value of N' or C_n' corresponds to a decrease 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 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 correction has been applied to the hinge-moment coefficients. No corrections have been applied to any of the results for blocking, for the effects of the support strut, or for the treatment of the inboard end of the wing, that is, the small gap between the wing and the wall, the leakage through the wall around the support tube, and the boundary layer at the wall. These effects are probably of second-order importance for the rolling- and yawing-moment coefficients (which are basically incremental data) but may have more effect on the other forces and moments, particularly on the drag coefficients. It is for this reason that the drag coefficients are referred to as uncorrected.

Characteristics of Model with Aileron and Tab Neutral

The characteristics of the tapered-wing model with the plain aileron and the tab fixed at zero deflection are shown in figure 5. The presence of a 0.005c gap at the aileron nose had very little effect on the wing characteristics.

Aileron Characteristics

Plain ailerons.- The characteristics of the plain sealed and unsealed ailerons are presented in figure 6. A comparison of the increments between $\delta_a = 15^\circ$ and $\delta_a = -15^\circ$ shows that the presence of the 0.005c gap at the aileron nose reduced the rolling-moment coefficient by about 15 percent and increased the hinge-moment coefficient by about 12 percent but had little effect on the slope of the hinge-moment curve $\partial C_h/\partial\delta_a$ at small deflections.

Ailerons with full-span tabs.- The characteristics of the plain sealed and unsealed ailerons with full-span tabs are shown in figures 7 and 8, respectively. The tab characteristics are essentially the same on the sealed and unsealed ailerons although the variations of rolling- and hinge-moment coefficients with both tab and aileron deflection were generally more irregular for the unsealed aileron than for the sealed aileron. At low deflections of the unsealed aileron (fig. 8) the effective range of tab deflection was $\pm 20^{\circ}$ or less but, at high aileron deflections, the tab appeared to maintain its effectiveness to $\pm 25^{\circ}$, especially when deflected as a balancing tab. The sealed aileron (fig. 7) would probably have exhibited similar characteristics if the tab had been deflected more than $\pm 20^{\circ}$.

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Aileron with partial-span tabs.- The effects of varying the span and the location of the tab on the plain unsealed aileron at a low angle of attack are shown in figure 9. The parameters $\partial C_l{}'/\partial \delta_t$ and $\partial C_h/\partial \delta_t$ in figure 9 are one-twentieth of the increments of rolling- and hinge-moment coefficients between tab deflections of 10° and -10°.

The values of $-\partial C_h/\partial \delta_t$ are larger for the inboard tabs than for the outboard ones, as was expected because of the increase in tab and aileron chord with distance from the wing tip, these chords being a constant percentage of the wing chord. The values of $\partial C_l{}'/\partial \delta_t$ for the 1/3-span tabs are about equal regardless of spanwise location, probably because as the distance from the wing tip increases the increase in the tab chord is roughly compensated by the decrease in the moment arm of the tab about the assumed airplane center line. The differences in the values of $\partial C_l{}'/\partial \delta_t$ for the 2/3-span tabs have not been accounted for.

Spring-Linked Tabs

Recent studies, particularly in England (references 2 to 4), have suggested that the introduction of springs into the linkage systems of balancing tabs affords a powerful means of utilising the possibilities of this device without the risk of overbalancing the control at low speeds and with the advantage of a reduction in the variation of stick force with speed.

The basic principle of the spring-linked tab is that the tab deflection varies with the force required to operate the aileron instead of varying as a function of only aileron deflection. At high speeds and high aileron deflections the tab deflection is therefore large but, as the speed and/or the aileron deflection decreases, the tab deflection also decreases and the system approaches that of a plain unbalanced aileron; the variation of stick force with speed is thereby reduced and the risk of overbalance at low speeds is eliminated.

A sketch of a spring-linked-tab system is shown in figure 10. If there is no force on the aileron, it can be deflected with no relative deflection between the aileron and the tab. If there is a force on the aileron, however, the spring connected to the aileron through the spring case will deflect and the displacement between the plunger and the case will cause the tab to deflect relative to the aileron. An increase in force on the aileron will increase the spring deflection and thereby the tab deflection. It can be seen, therefore, that the tab deflection will vary with the force on the aileron. In an air stream the tab deflection would reduce the aileron force and a state of equilibrium would be reached at a point depending on the geometry of the system. For a given linkage arrangement, as the stiffness of the spring approaches infinity (or as the speed approaches zero), the system approaches that of a plain aileron and, as the stiffness of the spring approaches zero (or as the speed approaches infinity), the system approaches that of a servotab.

If the spring is preloaded by being installed in a compressed condition (by use of screw caps on the spring case in fig. 10), the tab would not deflect until the aileron force exceeded the amount of spring preload and the initial slope of the stick-force curve would be higher, giving the stick more feel near neutral. An airplane equipped with a tab and preloaded spring has been test-flown in England and the flight-test results agreed reasonably well with the estimated characteristics. These tests indicated that backlash in the tab system should be eliminated.

The types of stick-force curve that may be obtained from ailerons with spring-linked tabs by varying the value of the spring constant k_s and the spring preload are shown in figure 11. The reduction of maximum $pb/2V$ with reduction of stick force (fig. 11(a)) may sometimes be compensated by an increase of aileron deflection.

It has also been suggested (reference 3) that the tab linkage be made in such a way that, with an infinitely strong spring, the tab will tend either to balance or to unbalance the aileron. With such a linkage and a spring of finite stiffness, the stick-force characteristics will be a combination of those of an ordinary balancing (or unbalancing) tab and those of a spring-linked tab.

A characteristic of spring-linked tabs is that, as the upfloating tendency of the aileron is increased, the tab and the aileron tend to deflect upward so as to reduce the load in the system, thus reducing the possibility of overloading the ailerons during accelerated maneuvers; this effect will generally be negligible under steady-flight conditions, particularly if some preload is used. Analysis indicates that tabs as well as ailerons should be statically balanced to avoid oscillations. The possibility of flutter being introduced by the presence of the spring was not investigated.

The general equations used in the design of nonpreloaded spring tabs, if it is assumed that the tab is aerodynamically balanced, are:

$$\Delta H = 2\, k_s l_a l_t \sin \delta_t = 2\left(\frac{\partial C_h}{\partial \delta_t}\delta_t + \frac{\partial C_h}{\partial \delta_a}\delta_a\right) b_a \bar{c}_a^{\,2} q \qquad (1)$$

$$\delta_t = \sin^{-1} \frac{H}{k_s l_a l_t} \qquad (2)$$

$$\Delta\delta_a = \sin^{-1} \frac{H}{k_s l_a^{\,2}} \qquad (3)$$

$$\delta_a - \Delta\delta_a = \text{a constant (for a given value of } \delta_s) \qquad (4)$$

The factor 2 in equation (1) accounts for the fact that there are two ailerons and two springs.

Estimated Rates of Roll and Stick Forces

As an example of the application of the data the rates of roll and the stick forces during steady rolling of the airplane of figure 3 have been estimated for five different aileron arrangements (fig. 12). The rates of roll were estimated by means of the relationship

$$\frac{pb}{2V} = \frac{C_l{}'}{C_{l'_p}} \qquad (5)$$

where the coefficient of damping in roll $C_{l'_p}$ was taken as 0.46 from the data of reference 5. It has been assumed that the rudder will be used to counteract the yawing moment, that the aileron-operating mechanism is nonelastic, and that the wing will not twist. These assumptions lead to computed rates of roll higher than may be expected under actual flight conditions. The stick forces were estimated from the relationship

$$F_e = \Delta H \frac{d(\delta_a + \Delta\delta_a)}{d\theta_s} \frac{1}{l_s} = \frac{90.3}{C_L} \Delta C_h \frac{d(\delta_a + \Delta\delta_a)}{d\theta_s} \qquad (6)$$

and it was assumed that, for any given arrangement,

$$\frac{d(\delta_a + \Delta\delta_a)}{d\theta_s} = \frac{\delta_a + \Delta\delta_a}{\theta_s} = \text{constant} = \left(\frac{\delta_a}{\theta_s}\right)_{F_e = \infty} \qquad (7)$$

Equation (6) 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 (basic)	NACA 230 series
Mean aerodynamic chord, inches	84.14
Weight, pounds	7063
Wing loading, pounds per square foot	27.2
Stick length, feet	2
Maximum stick deflection, θ_s, degrees	±21

The value of the constant in equation (6) is dependent upon the wing loading, the size of the ailerons, and the length of the stick. The tab was assumed to be aerodynamically balanced. The values of $d(\delta_a + \Delta\delta_a)/d\theta_s$ may be determined from equation (7) and from the maximum stick deflection of ±21° and the maximum aileron deflections noted on figure 12. The values of C_l' and ΔC_h used in equations (5) and (6) are the values computed to exist during steady rolling; the local angle of attack at the ailerons during rolling has been taken into account. In order to take into account the local angle of attack at the ailerons, the rolling- and hinge-moment coefficients were replotted against angle of attack for several aileron deflections and the fairing between the two points at $\alpha = 0.1°$ and $\alpha = 13.4°$ was guided by the fairing of the curves for the plain unsealed aileron, which were cross plots of figure 6(b).

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It was hoped that comparisons of the stick-force characteristics could be made with all systems designed to give a maximum computed $pb/2V$ of 0.090 at V_i = 250 miles per hour. Because of the small size of the aileron and tab, however, excessive deflections would be required to reach $pb/2V = 0.090$ and, consequently, the maximum stick force would not be reduced below that for the plain ailerons. (See fig. 12(a).) This result is in agreement with the conclusion of reference 6. Comparison between the plain aileron and the aileron with simple and spring-linked tabs was therefore made with systems designed to give a $pb/2V$ of 0.075 at V_i = 250 miles per hour.

In estimating the rates of roll and the stick forces for the aileron with the spring-linked tab (figs. 10 and 12), curves of $pb/2V$ and aileron hinge moment during steady rolling were plotted against aileron deflection for various values of δ_t at two values of V_i. The characteristics were estimated using the above-mentioned curves and equations (2) to (6).

The value of ΔH was arbitrarily limited to a maximum of 40 foot-pounds at an indicated velocity of 250 miles per hour and the values of l_a, l_t, and l_s were assumed to be 0.2 foot, 0.1 foot, and 2.0 feet, respectively. Under these conditions the values of k_s, δ_a, $\Delta\delta_a$, and δ_t required for a $pb/2V$ of 0.075 at full stick deflection were found to be, respectively, 3420 pounds per foot, ±20°, ±8.4°, and ∓17°. With these constants, equation (6) reduced to $F_s = 0.676\ \Delta H$.

The following table shows the characteristics of the aileron with the spring-linked tab and outlines the procedure by which the estimations were made from the relationships given:

	Assumed	From ΔH and equation (2)	From ΔH and equation (3)	From ΔH, δ_t, and curves	From δ_a, δ_t, and curves	From ΔH and equation (6)	From $(\delta_a+\Delta\delta_a)$ and equation (7)
V_i (mph)	ΔH (ft-lb)	δ_t (deg)	$\Delta\delta_a$ (deg)	δ_a (deg)	pb/2V (radians)	F_e (lb)	θ_s (deg)
250	10.0	∓4.2	∓2.1	±5.8	0.028	6.8	∓5.8
	20.0	∓8.4	∓4.2	±12.0	.054	13.5	∓12.0
	30.0	∓12.7	∓6.3	±16.6	.068	20.3	∓16.9
	40.0	∓17.0	∓8.4	±20.0	.075	27.0	∓21.0
101	6.5	∓2.7	∓1.4	±5.6	.027	4.4	∓5.2
	13.0	∓5.4	∓2.7	±12.0	.057	8.8	∓10.9
	20.0	∓8.4	∓4.2	±17.2	.076	13.5	∓15.8
	29.0	∓12.3	∓6.1	±22.3	.093	19.6	∓21.0

It should be pointed out that the values for aileron and tab deflections are not exact for the low-speed attitude at which the aileron has an upfloating tendency. For simplicity H was assumed to be 1/2 ΔH. Actually, however, the upfloating tendency at low speed reduces the moment on the upgoing aileron and its tab deflection and loss in aileron deflection will therefore be small; whereas for the downgoing aileron the opposite will be true. The stick forces and rates of roll should not be greatly affected but the yawing moment should become slightly less adverse than for a system with equal up- and down-aileron deflection.

In estimating the stick forces the aileron moments were used in preference to the moment-curve slopes (equation (1)) because of the nonlinearity of the curves for the large aileron and tab deflection used in the present example. The high-speed stick-force curve could be checked reasonably well by the use of slopes and it is probable that such a procedure would be satisfactory for preliminary design purposes or when the ailerons and the tabs used are sufficiently large to remain within the linear ranges as is considered in references 2, 3, and 7.

If the spring were made twice as stiff and if the tab horn were made one-half as long as in the example, the characteristics of the system would be unchanged except for a decrease in the work needed to deflect the spring and a decrease in the value of $\Delta\delta_a$. The decrease in the work required to deflect the spring would reduce the maximum high-speed stick force by about 3 pounds. The decrease in $\Delta\delta_a$ would allow an increase in the ratio of stick deflection to aileron deflection with the result that, for the same maximum aileron deflection of 20° at high speed, the stick forces would be reduced by about 15 percent. It appears advantageous, therefore, to use a spring as stiff as possible without reducing the length of the tab horn to a value so small that the pin and bearing clearances would introduce slack in the tab system.

The results of the computations (fig. 12) indicated that the use of ailerons with simple or spring-linked balancing tabs would reduce the high-speed stick forces to considerably less than those experienced in the use of plain sealed ailerons. For the particular arrangements considered the aileron with the spring-linked tab had about 2 pounds higher maximum stick force at high speed than the aileron with the simple tab. The aileron with the spring-linked tab had the following advantages over the aileron with the simple tab: (1) less variation of stick force with speed, (2) an increase in rolling effectiveness as the speed was reduced, (3) promise of even lower high-speed stick forces without the risk of overbalance at low speed, and (4) a decrease of the load on the aileron system during accelerated maneuvers. As stated before, the comparatively low maximum effectiveness at high speed ($pb/2V = 0.075$) shown in figure 12(b) was determined by the fact that the aileron and the tab were small. Comparable stick-force characteristics but with more rolling effectiveness could be expected from the use of larger ailerons and tabs (reference 7).

Attention is called to the fact that, because it automatically reduces the aileron loads at high speed, the spring tab may prevent overstressing of the aileron system. If so desired, the spring may be designed to close completely at full stick deflection at a particular indicated velocity, thereby limiting the maximum tab deflection. The rapid increase of control force after closure of the spring would tend to limit the stick deflection and thereby limit the aileron loads.

The results of the various investigations of spring tabs both here and in England indicate that this device is very promising as a means of adjusting control-surface hinge moments and it is recommended that further investigations of the device be carried out in flight.

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CONCLUSIONS

The results of the computations and the tests of 0.155-chord ailerons on an NACA 230-series airfoil indicated that, for the arrangement tested, the use of ailerons with simple or spring-linked balancing tabs would reduce the high-speed stick forces to considerably less than those experienced in the use of plain sealed ailerons if the systems were designed for low maximum aileron deflections. The use of spring-linked tabs designed to give the desired characteristics at high speed would reduce the variation of stick force with speed and would also cause an increase in rolling effectiveness for a given stick deflection as the speed was reduced, relative to plain ailerons or ailerons with simple tabs.

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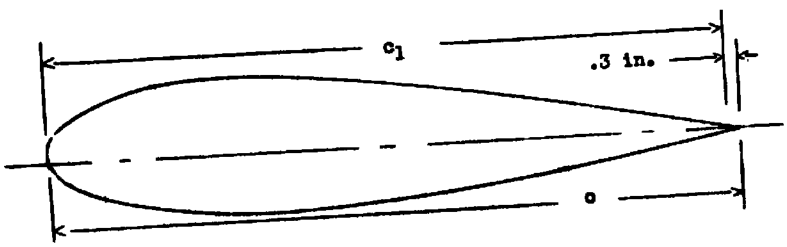
*Available for reference or loan in the Office of Aeronautical Intelligence, NACA.

TABLE I.- ORDINATES FOR AIRFOIL

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



Model wing station 0		
Station	Upper surface	Lower surface
0	0	0
1.25	3.48	-1.60
2.5	4.61	-2.36
5	6.10	-3.21
7.5	7.14	-3.82
10	7.89	-4.33
15	8.80	-5.12
20	9.22	-5.71
25	9.40	-6.10
30	9.37	-6.28
40	8.90	-6.23
50	8.02	-5.78
60	6.85	-5.05
70	5.44	-4.10
80	3.87	-2.97
90	2.12	-1.67
95	1.16	-.94
100	.18	-.16
100.73	.03	-.03
L.E. radius: 2.65. Slope of radius through end of chord: 0.305		

Model wing station 88.8		
Station	Upper surface	Lower surface
0	0	0
1.25	1.89	-.84
2.5	2.65	-1.07
5	3.70	-1.26
7.5	4.45	-1.40
10	4.98	-1.52
15	5.54	-1.86
20	5.73	-2.22
25	5.77	-2.46
30	5.71	-2.62
40	5.36	-2.70
50	4.78	-2.56
60	4.06	-2.27
70	3.21	-1.87
80	2.26	-1.36
90	1.22	-.78
95	.70	-.46
100	.18	-.14
101.2	.05	-.05
L.E. radius: 0.70. Slope of radius through end of chord: 0.305		

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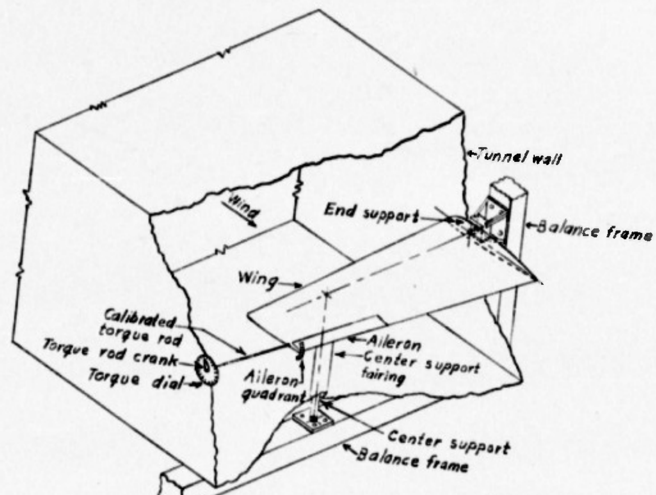

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Figure 1.- Schematic diagram of test installation.

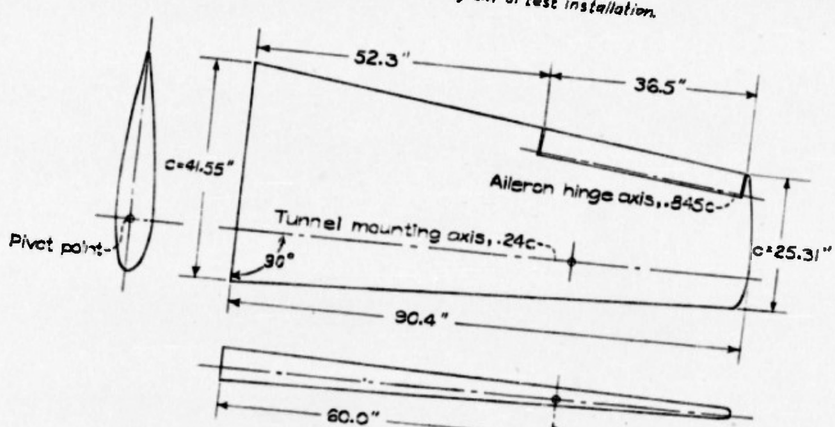

Figure 2.- Semispan model of tapered wing.

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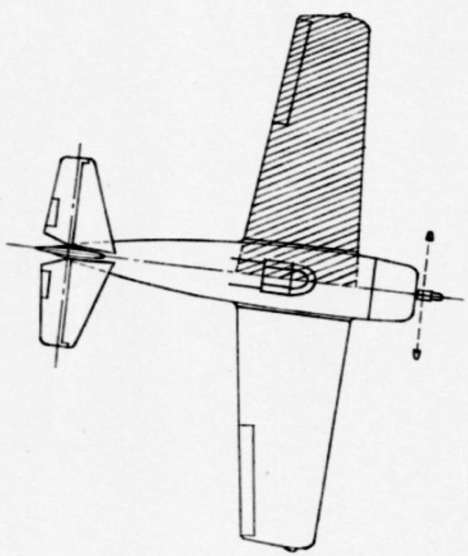
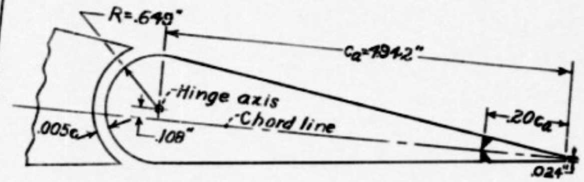
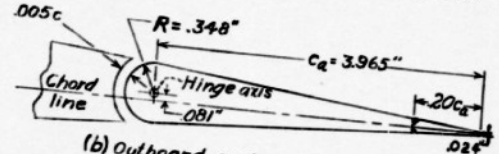


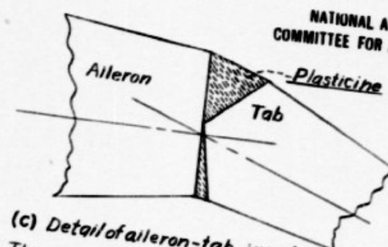
Figure 3.- Portion of airplane simulated by model.



(a) Inboard end; wing chord c = 31.986"



(b) Outboard end; wing chord c = 25.314"



(c) Detail of aileron-tab juncture.

Figure 4.- The 0.155c by 0.405 b/2 plain aileron with the 0.20ca by 1.0ba inset tab tested on the tapered-wing model.

L-470

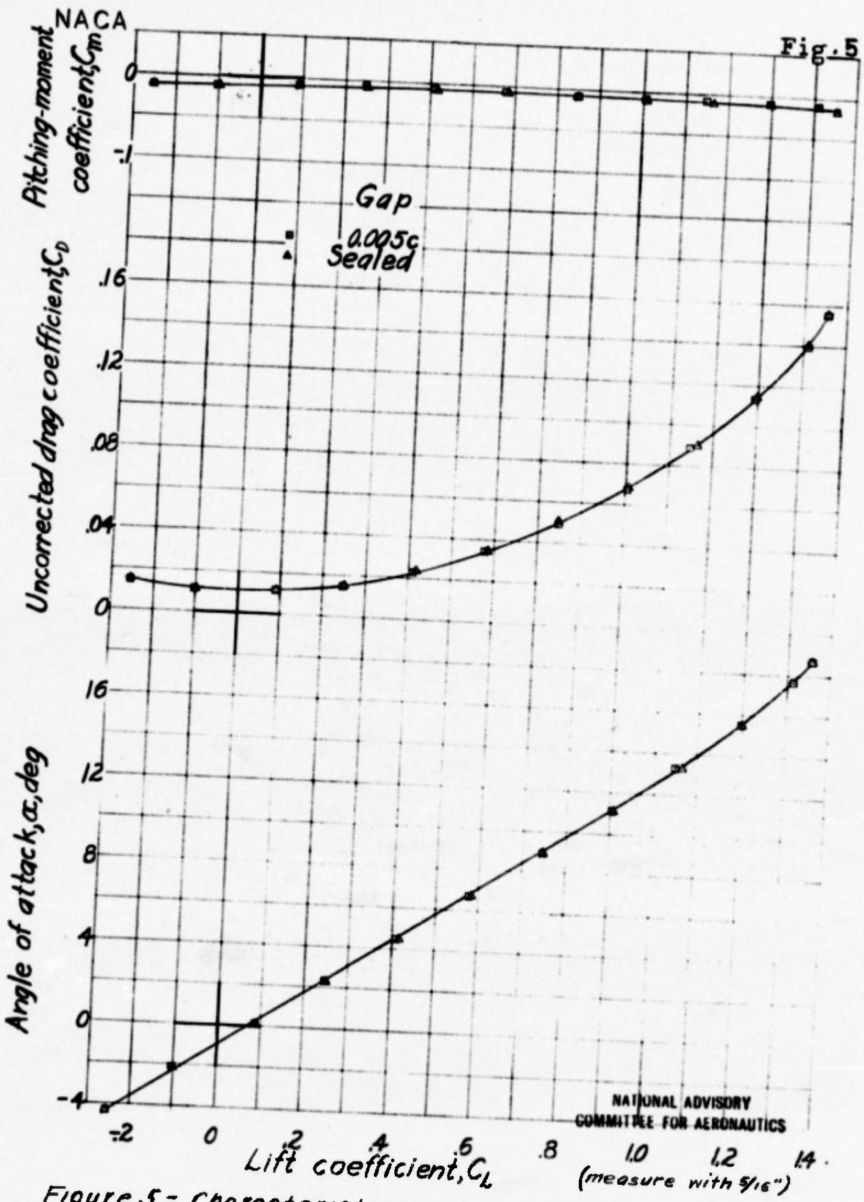
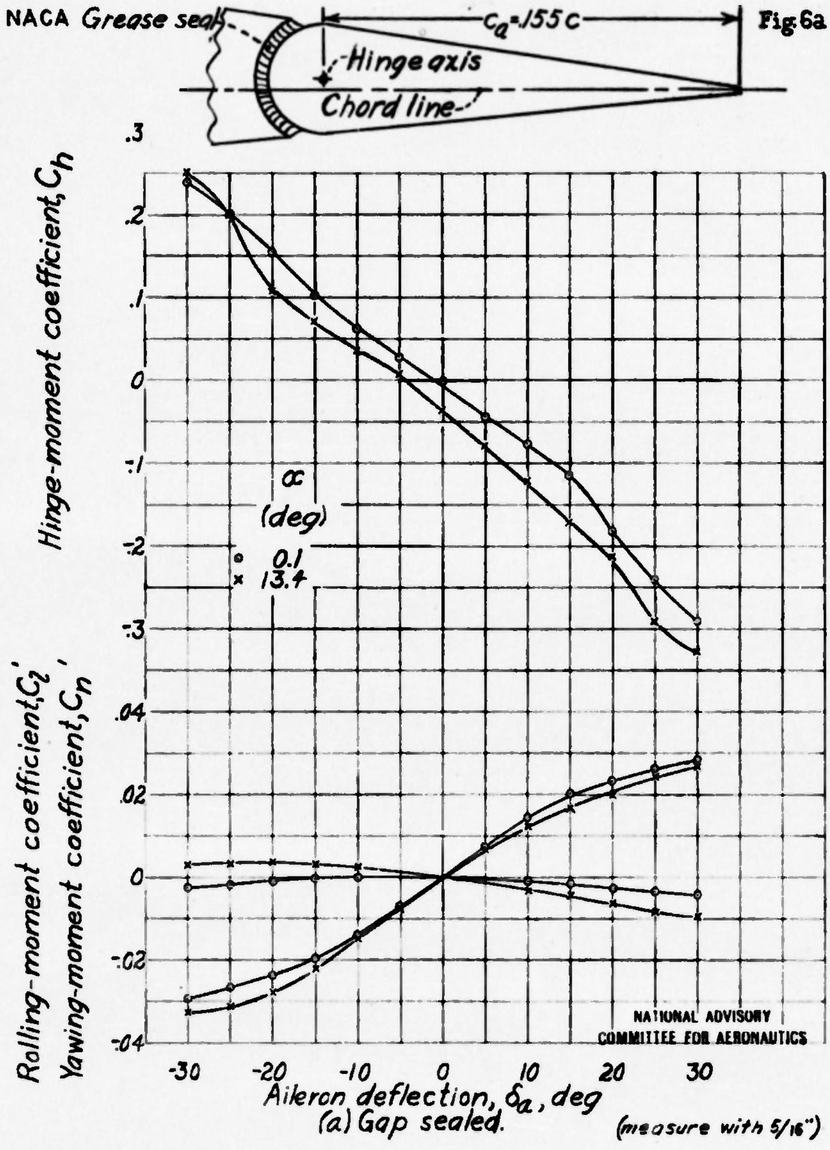


Figure 5.- Characteristics of the tapered-wing model with the plain aileron and the tab fixed at zero.



(a) Gap sealed.

(measure with 5/16")

Figure 6.- Characteristics of the plain aileron on the tapered-wing model.

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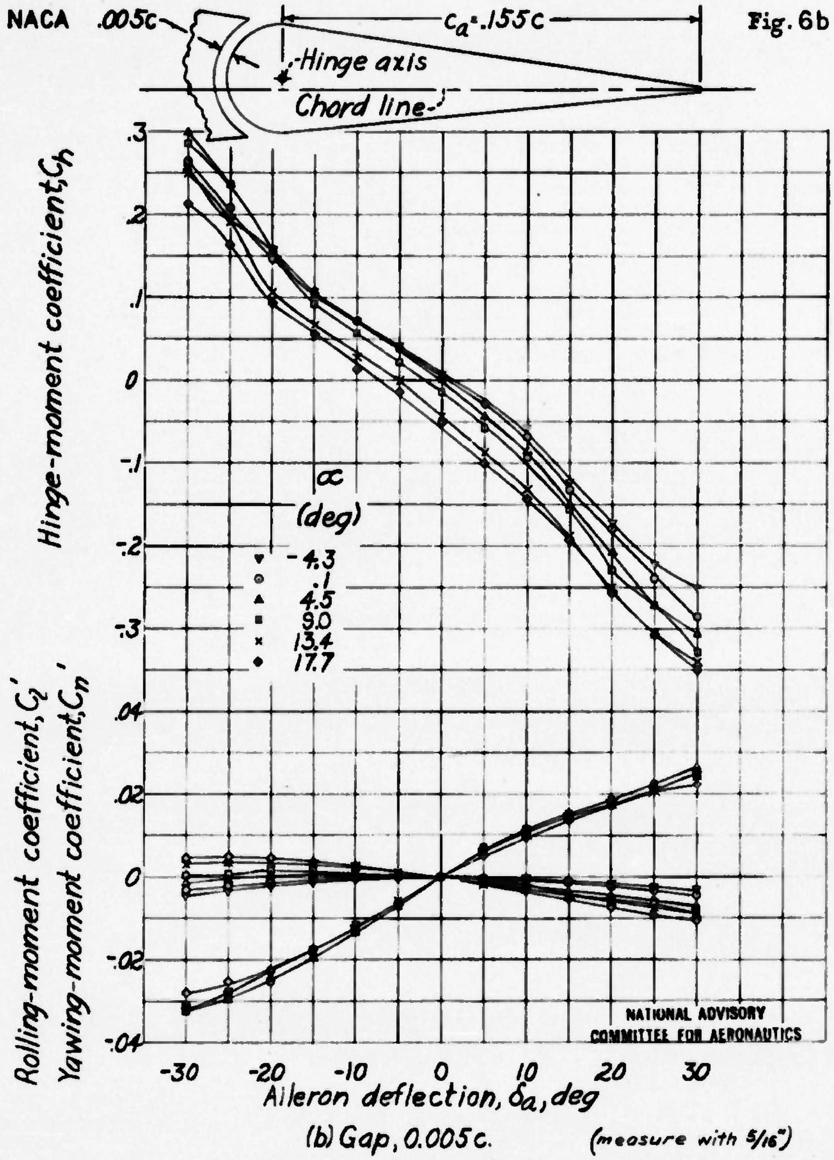

(b) Gap, 0.005c. (measure with 5/16")

Figure 6.- Concluded.

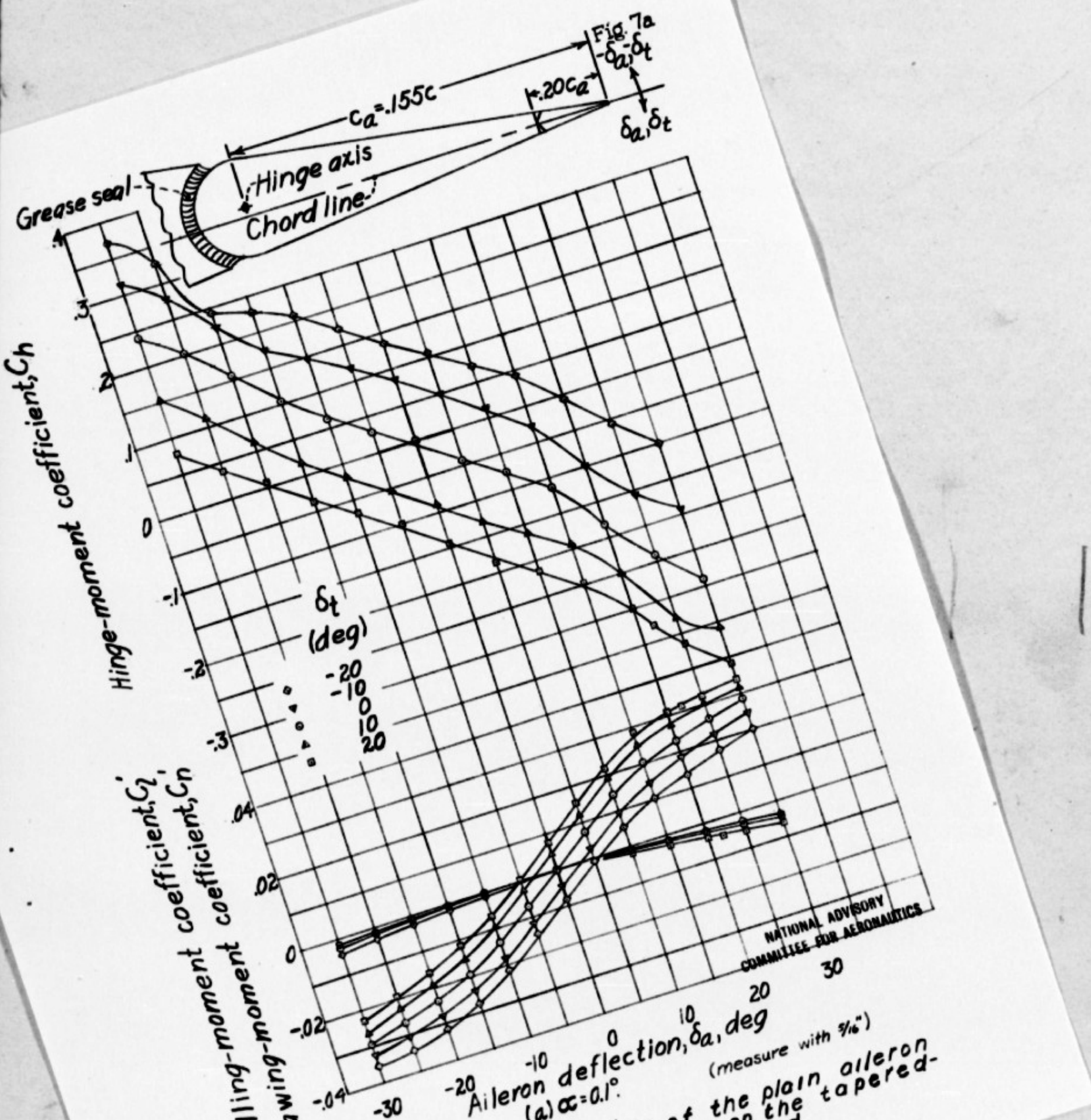

Figure 7.- Characteristics of the plain aileron with a full-span tab on the tapered-wing model. Gap sealed.

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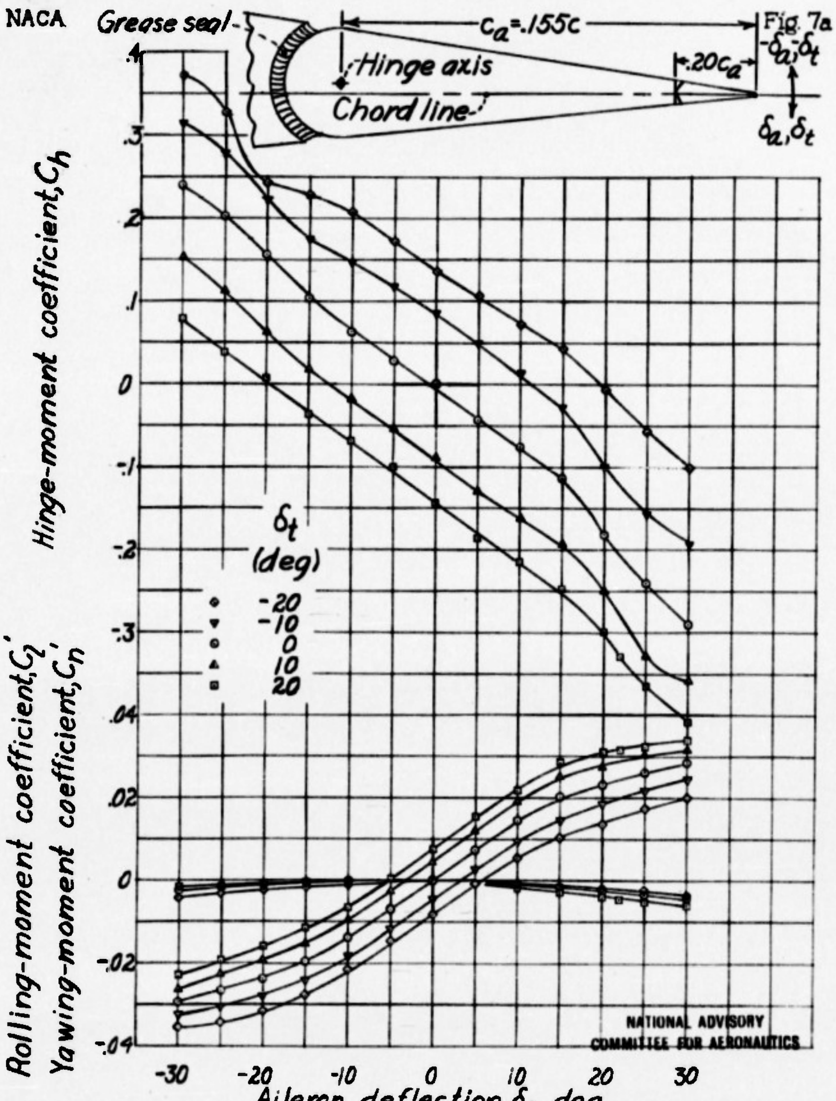
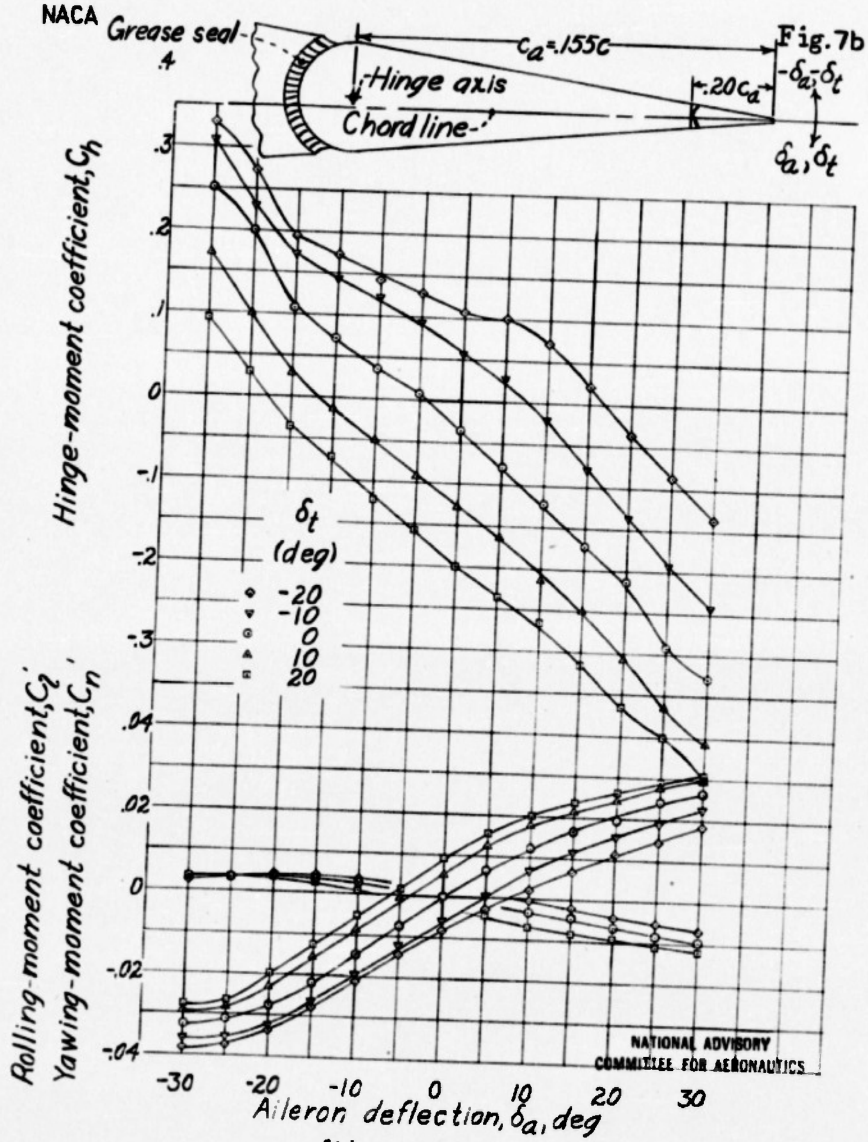
NACA Fig. 7a



(a) $\alpha = 0.1°$.

(measure with 5/16")

Figure 7.- Characteristics of the plain aileron with a full-span tab on the tapered-wing model. Gap sealed.



(b) $\alpha = 13.4°$.

Figure 7.- Concluded.

(measure with 5/16")

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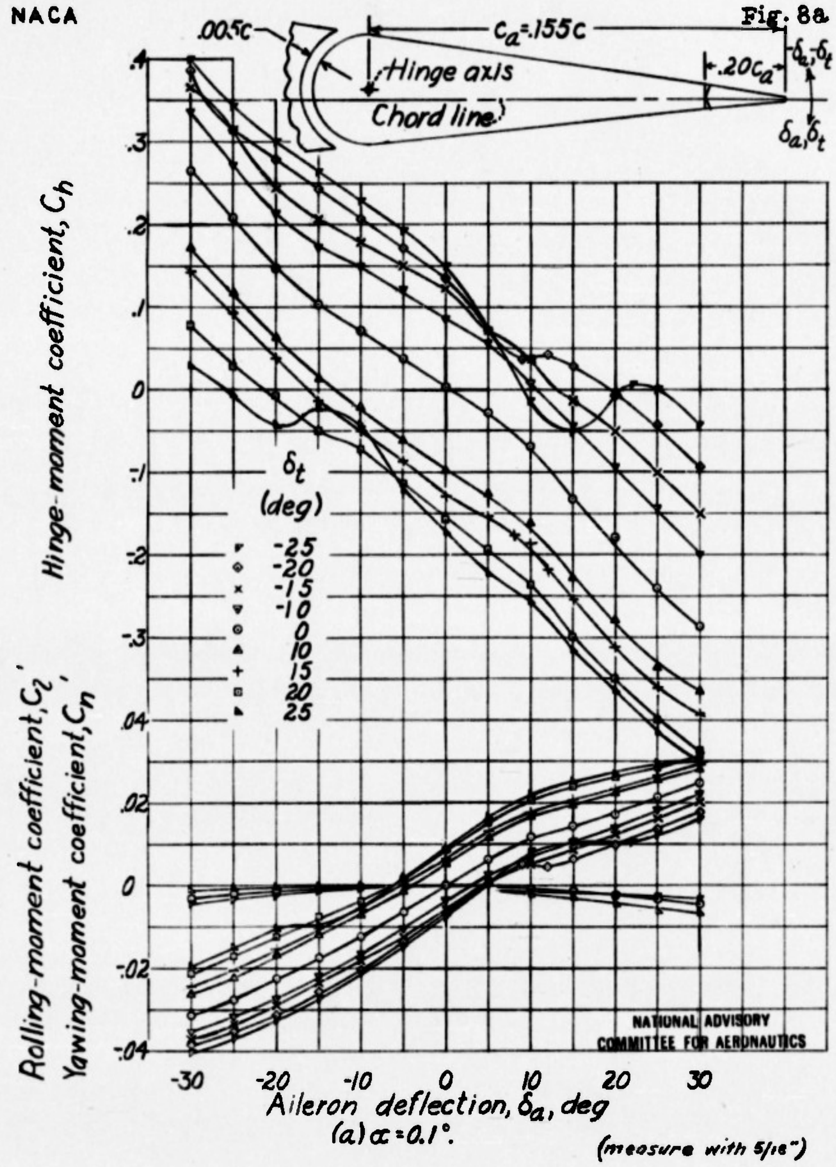


(a) α = 0.1°.

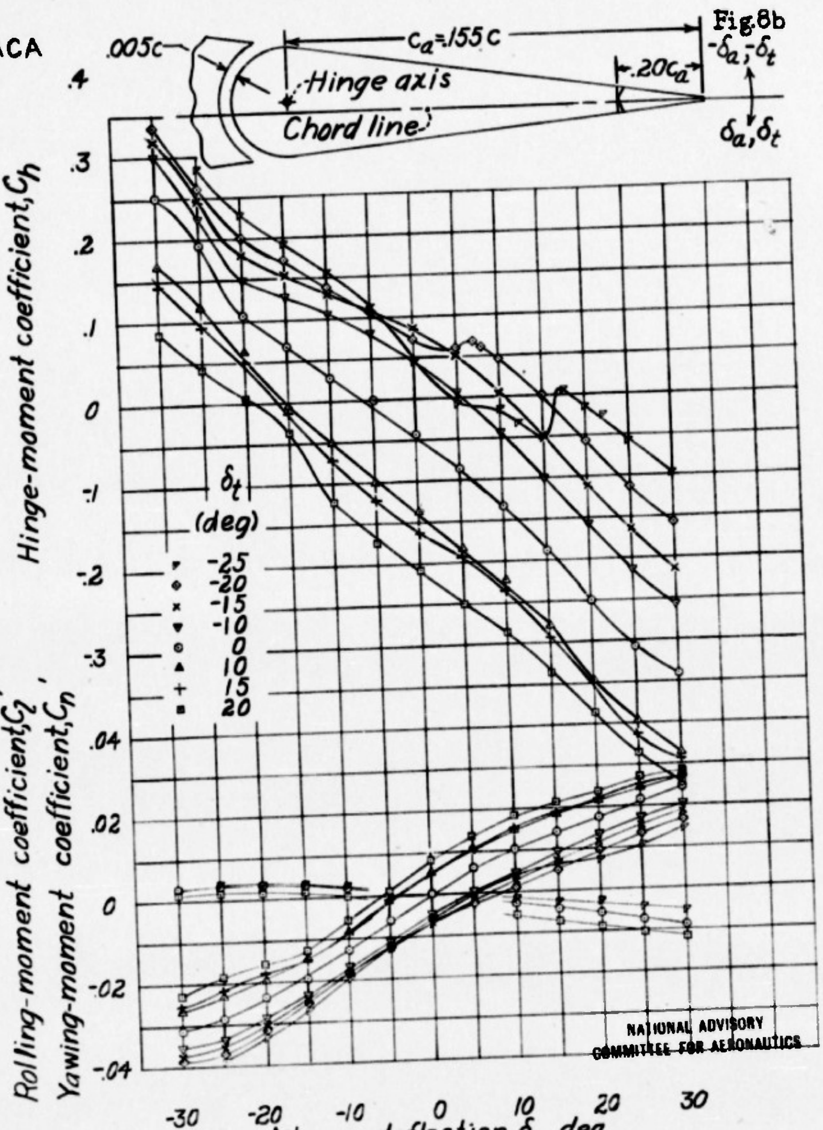
(measure with 5/16")

Figure 8.- Characteristics of the plain aileron with a full-span tab on the tapered-wing model. Gap, 0.005c.

NACA

L-470

Fig. 8b



(b) α = 13.4°.

(measure with 5/16")

Figure 8. - Concluded.

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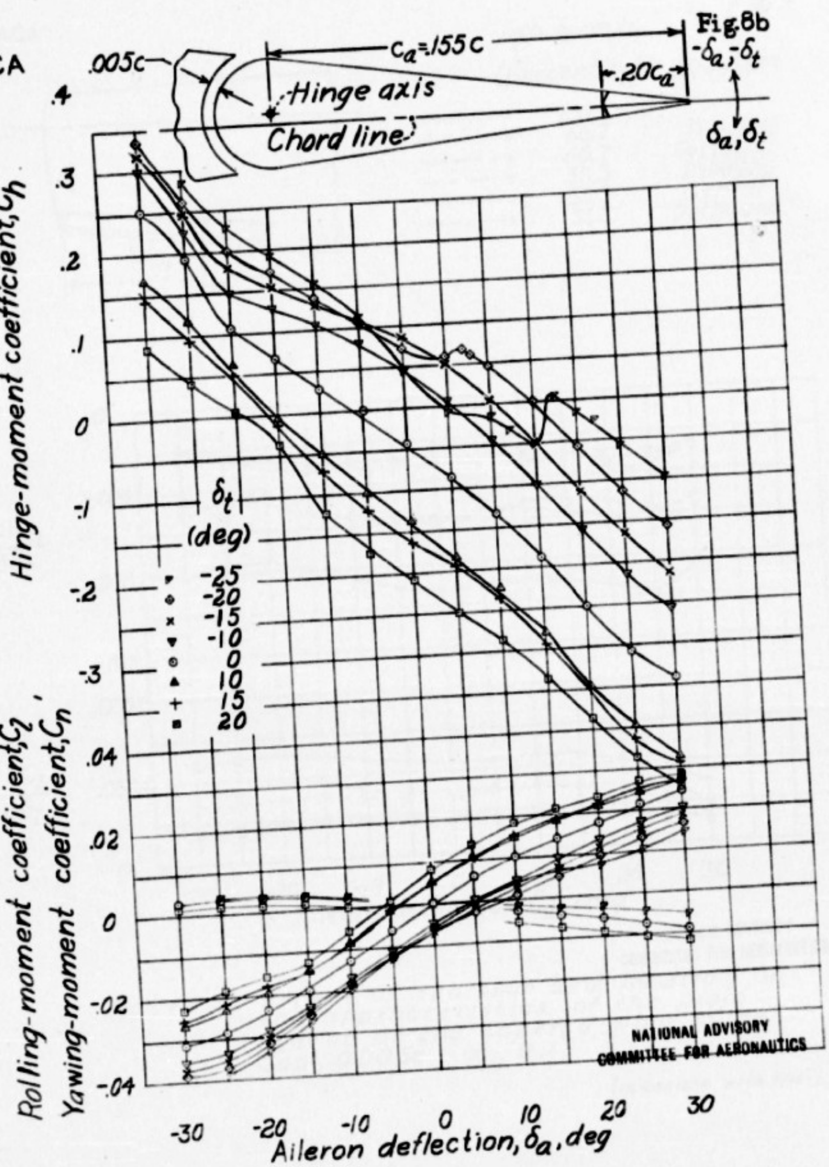

(b) $\alpha = 13.4°$.

(measure with 5/16")

Figure 8. - Concluded.

NACA

Fig. 9

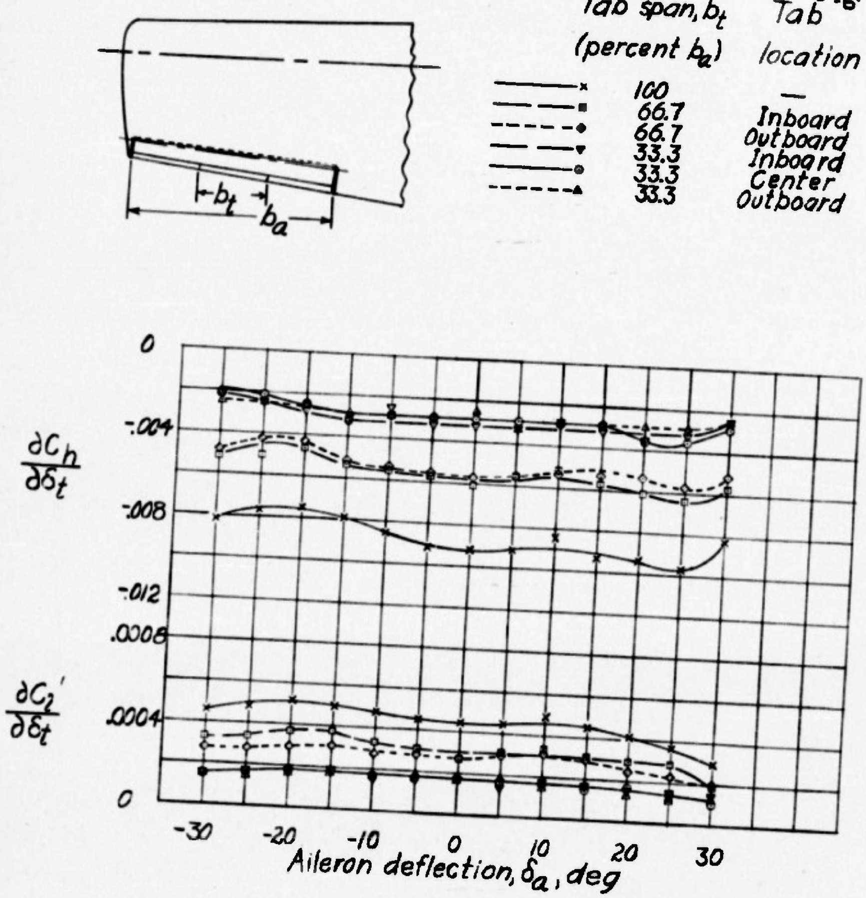

Figure 9.- Effect of tab span and location on the characteristics of the plain aileron on the tapered-wing model. Gap, 0.005c ; α, 0.1°.

(measure with 5/16")

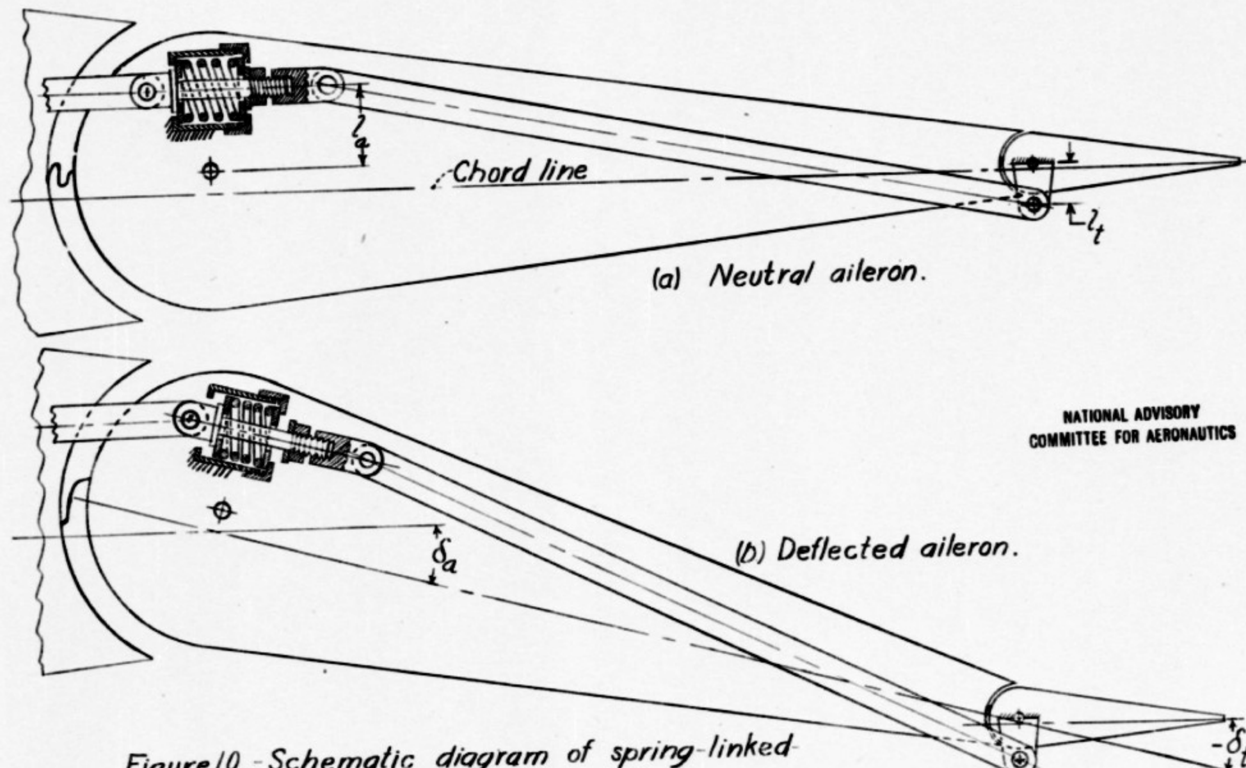

Figure 10.- Schematic diagram of spring-linked tab installation for ailerons.

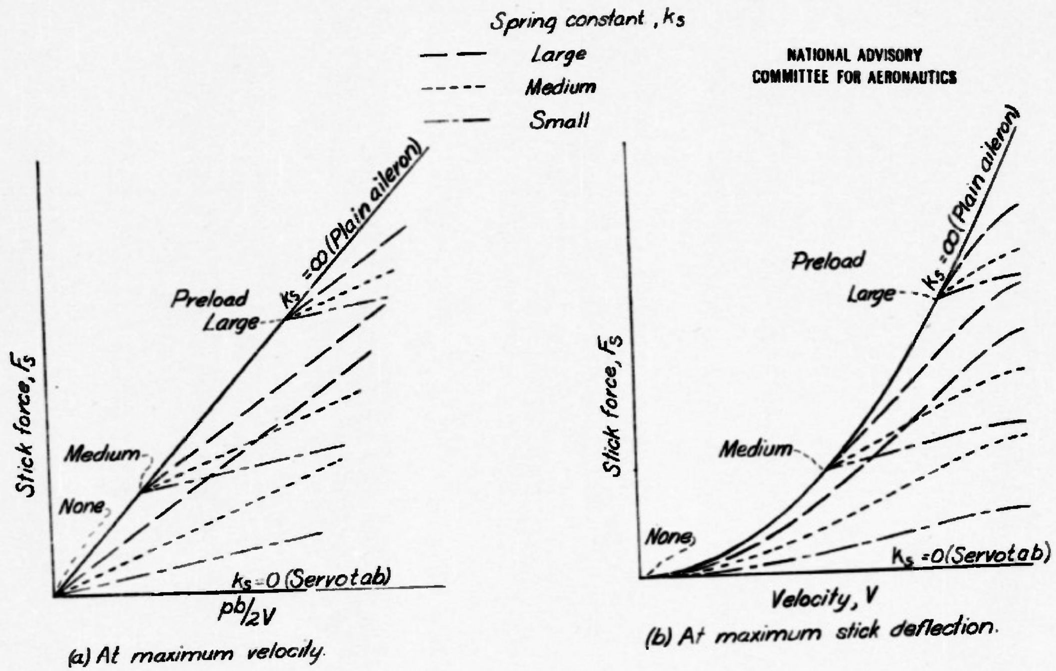

Figure 11.-Variations of stick-force characteristics that may be obtained on a given airplane from ailerons with spring-linked tabs by varying the spring constant k_s and the spring preload. Tabs are assumed aerodynamically balanced and the maximum aileron deflections are assumed equal for all arrangements.

NACA Fig. 12

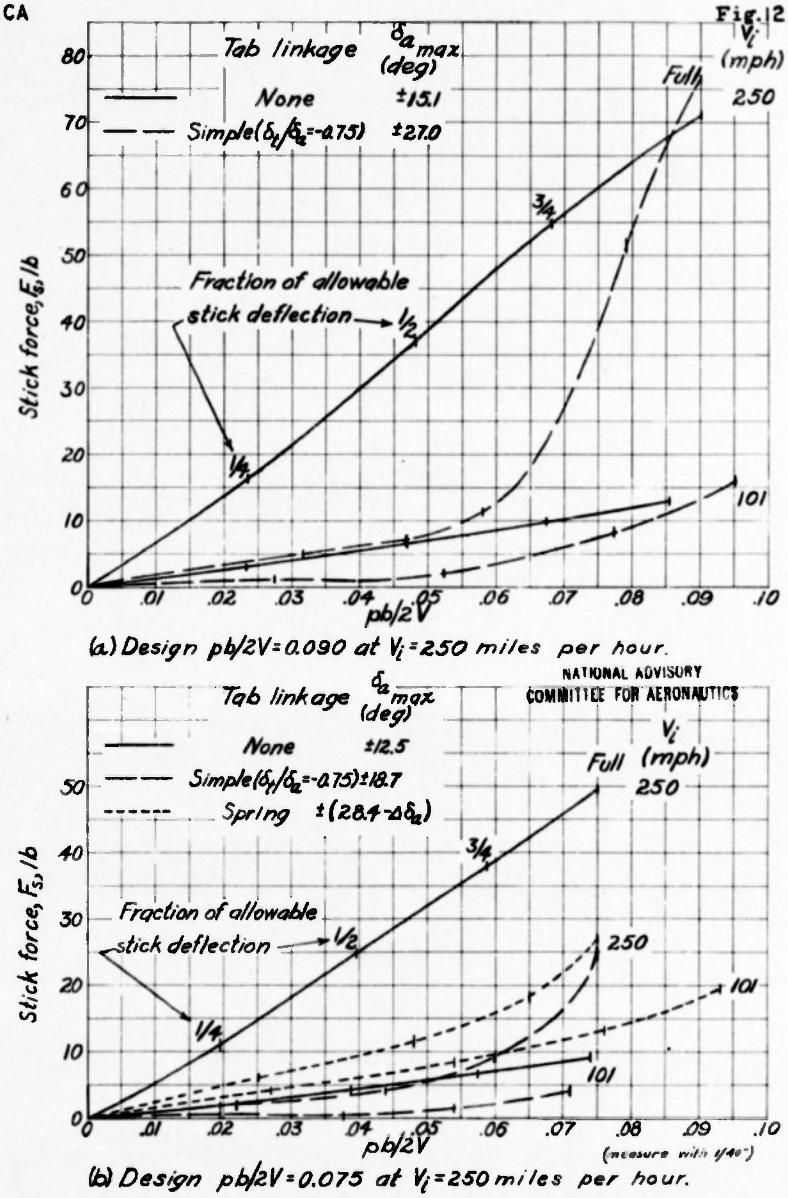

Figure 12.- Stick-force characteristics of the plain ailerons with $0.20c_a$ by $1.0b_a$ linked balancing tabs on the tapered wing. Gap sealed.

REEL – C

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A.T.I.

6391

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ORIGINATING AGENCY: National Advisory Committee for Aeronautics, Washington, D. C.
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ATI- 6391
REVISION (None)
ORIG. AGENCY NO. ARR-L-470
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Aerodynamic Characteristics

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