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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

REPORT No. 528

REDUCTION OF HINGE MOMENTS OF AIRPLANE CONTROL SURFACES BY TABS

By THOMAS A. HARRIS

1935

AERONAUTIC SYMBOLS

1. FUNDAMENTAL AND DERIVED UNITS

	Symbol	Metric		English	
		Unit	Abbreviation	Unit	Abbreviation
Length	l	meter	m	foot (or mile)	ft. (or mi.)
Time	t	second	s	second (or hour)	sec. (or hr.)
Force	F	weight of 1 kilogram	kg	weight of 1 pound	lb.
Power	P	horsepower (metric)		horsepower	hp.
Speed	V	kilometers per hour	k.p.h.	miles per hour	m.p.h.
		meters per second	m.p.s.	feet per second	f.p.s.

2. GENERAL SYMBOLS

W, Weight $=mg$

g, Standard acceleration of gravity $=9.80665$ m/s² or 32.1740 ft./sec.²

m, Mass $=\frac{W}{g}$

I, Moment of inertia $=mk^2$. (Indicate axis of radius of gyration k by proper subscript.)

μ, Coefficient of viscosity

ν, Kinematic viscosity

ρ, Density (mass per unit volume)

Standard density of dry air, 0.12497 kg-m^{-4}-s^2 at 15° C. and 760 mm; or 0.002378 lb.-ft.$^{-4}$-sec.^{2}

Specific weight of "standard" air, 1.2255 kg/m³ or 0.07651 lb./cu.ft.

3. AERODYNAMIC SYMBOLS

S, Area

S_w, Area of wing

G, Gap

b, Span

c, Chord

$\frac{b^2}{S}$, Aspect ratio

V, True air speed

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

L, Lift, absolute coefficient $C_L=\frac{L}{qS}$

D, Drag, absolute coefficient $C_D=\frac{D}{qS}$

D_o, Profile drag, absolute coefficient $C_{D_o}=\frac{D_o}{qS}$

D_i, Induced drag, absolute coefficient $C_{D_i}=\frac{D_i}{qS}$

D_p, Parasite drag, absolute coefficient $C_{D_p}=\frac{D_p}{qS}$

C, Cross-wind force, absolute coefficient $C_C=\frac{C}{qS}$

R, Resultant force

i_w, Angle of setting of wings (relative to thrust line)

i_t, Angle of stabilizer setting (relative to thrust line)

Q, Resultant moment

Ω, Resultant angular velocity

$\rho\frac{Vl}{\mu}$, Reynolds Number, where l is a linear dimension (e.g., for a model airfoil 3 in. chord, 100 m.p.h. normal pressure at 15° C., the corresponding number is 234,000; or for a model of 10 cm chord, 40 m.p.s. the corresponding number is 274,000)

C_p, Center-of-pressure coefficient (ratio of distance of *c.p.* from leading edge to chord length)

α, Angle of attack

ϵ, Angle of downwash

α_o, Angle of attack, infinite aspect ratio

α_i, Angle of attack, induced

α_a, Angle of attack, absolute (measured from zero-lift position)

γ, Flight-path angle

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REDUCTION OF HINGE MOMENTS OF AIRPLANE CONTROL SURFACES BY TABS

By Thomas A. Harris

SUMMARY

An investigation was conducted in the N. A. C. A. 7- by 10-foot wind tunnel of control surfaces equipped with tabs for reducing the control forces or trimming the aircraft. Two sizes of ordinary ailerons with several sizes of attached and inset tabs were tested on a Clark Y wing. Tabs were also tested in combination with auxiliary balances of the horn and paddle types, and with a Frise balanced aileron. A tail-surface model of symmetrical section, equipped with tabs, was tested with 40 percent of the area movable (elevator) when used as a horizontal tail and 60 percent of the area movable (rudder) when used as a vertical tail. The half-span tail-surface model was tested with and without a reflection plane.

Complete detailed results of the tests are tabulated in standard nondimensional coefficient form. The aileron test data are discussed for one aileron movement and graphs of control force against rolling-moment coefficient are included. Curves showing the effect of the tabs as trimming or as servo-control devices are given. For the tail surfaces, the effectiveness of tabs in reducing the control force and in trimming and servo operation is discussed and figures are included.

The effect of angular velocities on the application of the data to complete airplanes is considered and also the effect of the difference in the wind-tunnel test set-up from the actual arrangement on an airplane.

The results of the tests indicated that inset tabs were superior to attached tabs for the same ratio of tab/control-surface deflection. The greatest reduction in control force occurred at 0° angle of attack. The tabs could be used satisfactorily as trimming devices and also to reduce the control force for control moments as large as those ordinarily obtained by deflecting the control surface 15° or less. The reduction of hinge moments due to tabs could be added directly to the reduction due to paddle, horn, or Frise types of balance. Angles of yaw up to 20° had no appreciable effect on the reduction of hinge moments due to tabs.

INTRODUCTION

For large airplanes, designers have found it necessary to provide some means of balancing the excessive aerodynamic forces on the control surfaces. Aerodynamic methods of balance such as horns, paddles, and inset-hinge arrangements have been used to a considerable extent. A mechanical device is not desirable because the hinge moment varies with the speed of the airplane; whereas balancing force is independent of speed.

In recent designs, auxiliary airfoils attached to the control surfaces have been used for balance and also for trimming the airplane. This type of aerodynamic balance is a development of the "Flettner rudder," which has been in use for a number of years on large vessels. Such an auxiliary airfoil has been referred to in this paper as a "tab" and may be inset, attached, or mounted on outriggers from the trailing edge of the control surface. The tabs, when linked, move in the opposite direction to that of the control surface and thereby decrease the hinge moment for a given deflection of the control surface. Various arrangements of inset tabs are shown in figure 1. When the tab is used to actuate the control surface, it is referred to as a "servo-control tab."

In reference 1 the theoretical expressions for the hinge moment about any hinge position have been deduced for flaps on a rectangular airfoil of finite span and applied to an airfoil fitted with a servo-operated flap. The theoretical discussion by Kirste (reference 2) also includes complete tests of a symmetrical rectangular airfoil with a flap and a tab.

The results of wind-tunnel tests of a tab attached to the aileron are reported in reference 3. Calculations based on airfoil theory have been made, in references 4 and 5, for the tab deflections required to hold the rudder over for different combinations of tab and rudder settings. The results of these calculations were checked by wind-tunnel tests (reference 6) as well as in flight (reference 7).

A more recent series of tests (reference 8) covers several attached tab arrangements on a symmetrical rectangular wing with a flap. These tests were made with both ordinary and balanced flaps.

The data presented in the present report are the result of a systematic series of wind-tunnel tests on a commonly used wing profile with several arrangements of ailerons and tabs, alone and in conjunction with other types of balance. The tests were also extended to include a tail surface of assumed average proportions with several different tabs. Although the tests do not include all possible tab arrangements, it is hoped that the data are sufficiently general to fulfill most design requirements.

MODELS AND APPARATUS

WING-AILERON ARRANGEMENTS

The models used for the aileron balance tests were rectangular 10- by 60-inch laminated mahogany wings

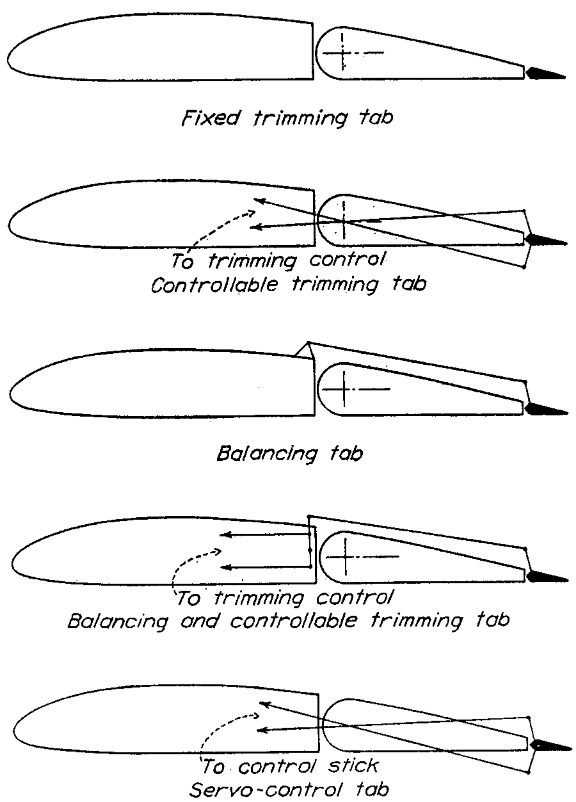


FIGURE 1.—Diagram showing various tab linkage systems.

of Clark Y section constructed to the specified ordinates with a precision of ± 0.005 inch. The right-hand wing tip of each wing model was equipped with a conventional aileron to which the various tabs were fitted. Two sizes of ailerons were tested, one being of 40 percent wing chord by 30 percent wing semispan and referred to as the "short wide aileron"; the other being of 25 percent wing chord by 40 percent wing semispan called the "medium-size aileron." Each aileron was mounted on a different wing.

Attached tabs.—The short wide aileron with attached tabs is shown in figure 2. In the following table the various attached tab arrangements are listed:

Tab chord	Tab span	Span designation
Percent c_A	*Percent b_A*	
5	100	Full-span.
10	100	Full-span.
20	100	Full-span.
20	50	Outboard, Half-span.
20	50	Center, Half-span.
20	50	Inboard, Half-span.
30	100	Full-span.

Where c_A is the chord and b_A the span of the aileron.

"Outboard" refers to outboard end of tab flush with outboard end of aileron, "center" refers to tab symmetrically located with respect to aileron span, and "inboard" refers to inboard end of tab flush with inboard end of aileron.

The attached tabs were constructed of 1/32-inch flat steel and were screwed to a brass trailing-edge piece of the aileron so that when neutral the lower surface of the tab was flush with the lower surface of the aileron. The angle of the tab was adjusted by bending about the trailing edge of the aileron and all openings between tab and aileron were sealed with plasticine.

Inset tabs.—The short wide aileron is shown equipped with inset tabs in figure 3. In the following table the various inset tab arrangements are listed:

Tab chord	Tab span	Span designation
Percent c_A	*Percent b_A*	
5	100	Full-span.
10	100	Full-span.
20	100	Full-span.
20	50	Outboard, Half-span.
20	50	Center, Half-span.
20	50	Inboard, Half-span.

Outboard, center, and inboard have the same meaning as for the attached tabs. The brass inset tabs were attached to the main part of the aileron by soft wire pins that could be bent to obtain the desired tab deflections.

The medium-size aileron (fig. 4) was tested with a tab extending along the entire span of the aileron and with a chord 10 percent of the aileron chord. The aileron was constructed of wood with a brass trailing edge to which the brass tab was secured in a manner similar to that used for the inset tabs on the short wide aileron. For all tests the space between the tab and aileron was sealed with plasticine.

Combination balances.—Additional tests were made at the request of the Bureau of Aeronautics, Navy Department, of the short wide aileron and a center inset tab 20 percent of the aileron chord wide and half of the aileron span long in combination with two sizes of paddles. The paddles were 18.75 and 27.5 percent of the aileron chord wide and 44.5 percent of the aileron span long and were located symmetrically with respect to the aileron span (fig. 5). The duralu-

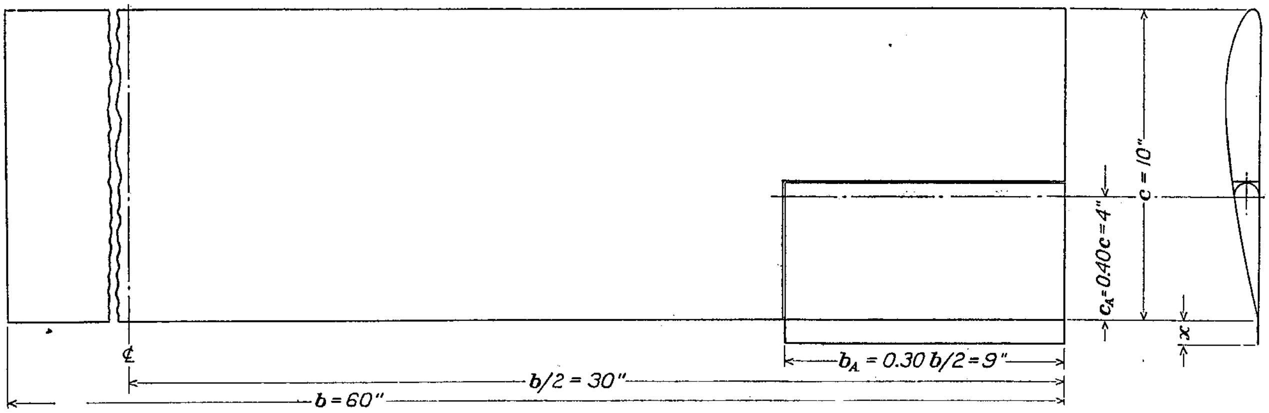


FIGURE 2.—Diagram of wing showing attached tabs on short wide aileron.
NOTE.— x=chord length of tab=5, 10, 20, and 30 percent of c_A. Span of tab=100 and 50 percent of b_A.

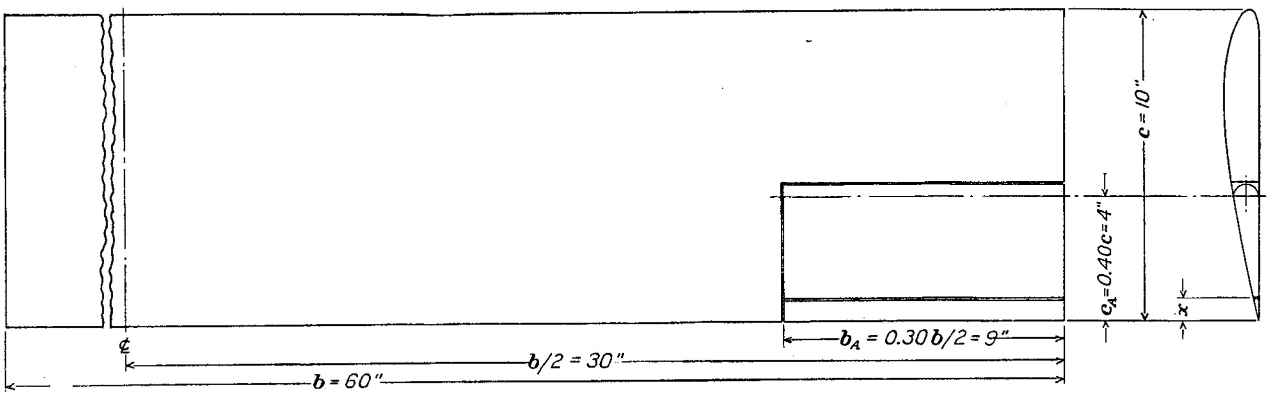


FIGURE 3.—Diagram of wing showing inset tabs on short wide aileron.
NOTE.— x=chord length of tab=5, 10, and 20 percent of c_A. Span of tab=50 and 100 percent of b_A.

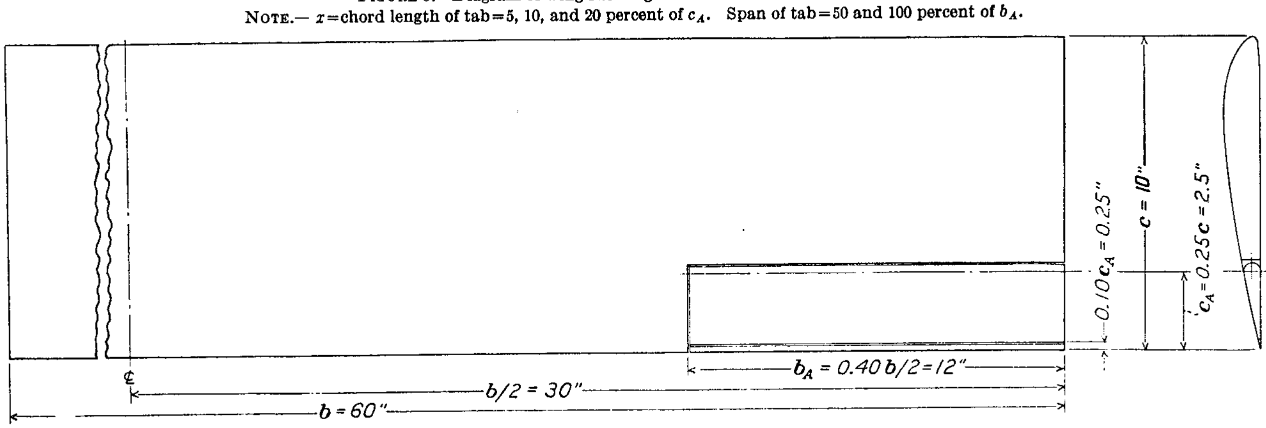


FIGURE 4.—Diagram of wing showing inset tab on medium-size aileron.

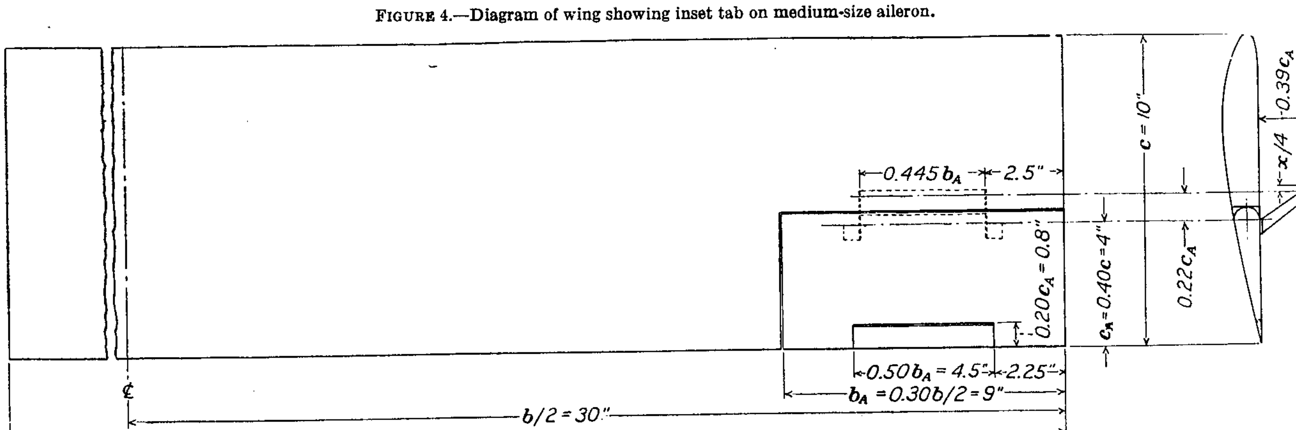


FIGURE 5.—Diagram of wing showing center inset tab and paddle balance on short wide aileron.
NOTE.— x=chord length of paddle balance=18.75 and 27.5 percent c_A.

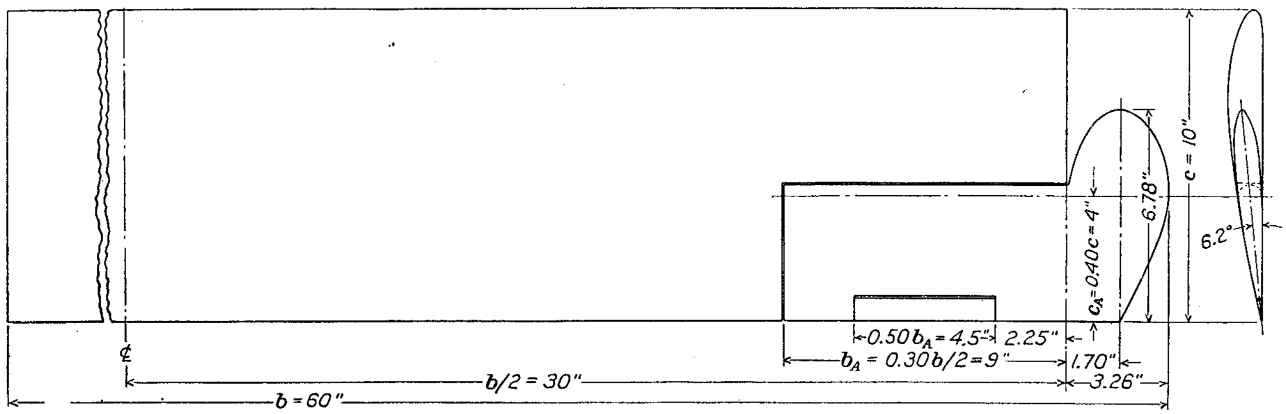


FIGURE 6.—Diagram of wing showing center inset tab and horn balance on short wide aileron.

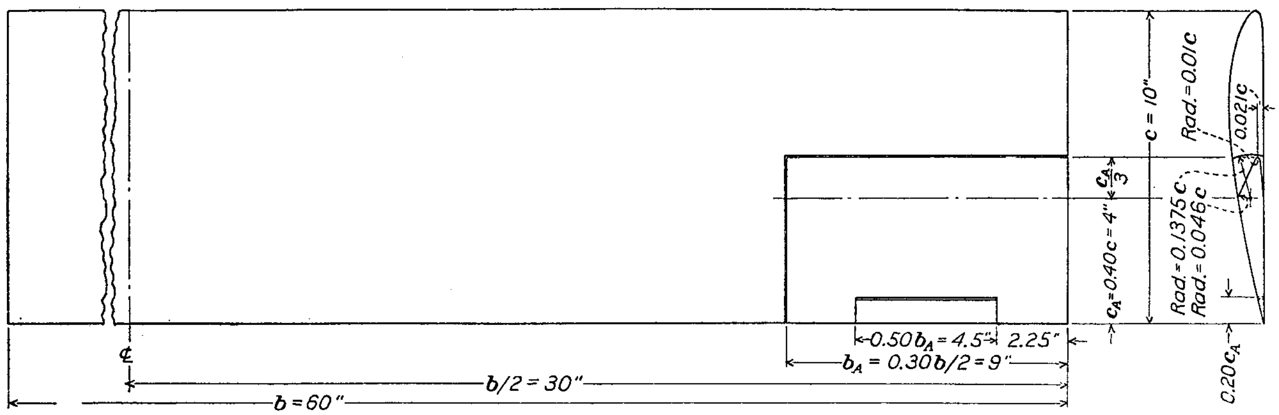


FIGURE 7.—Diagram of wing showing center inset tab on Frise aileron.

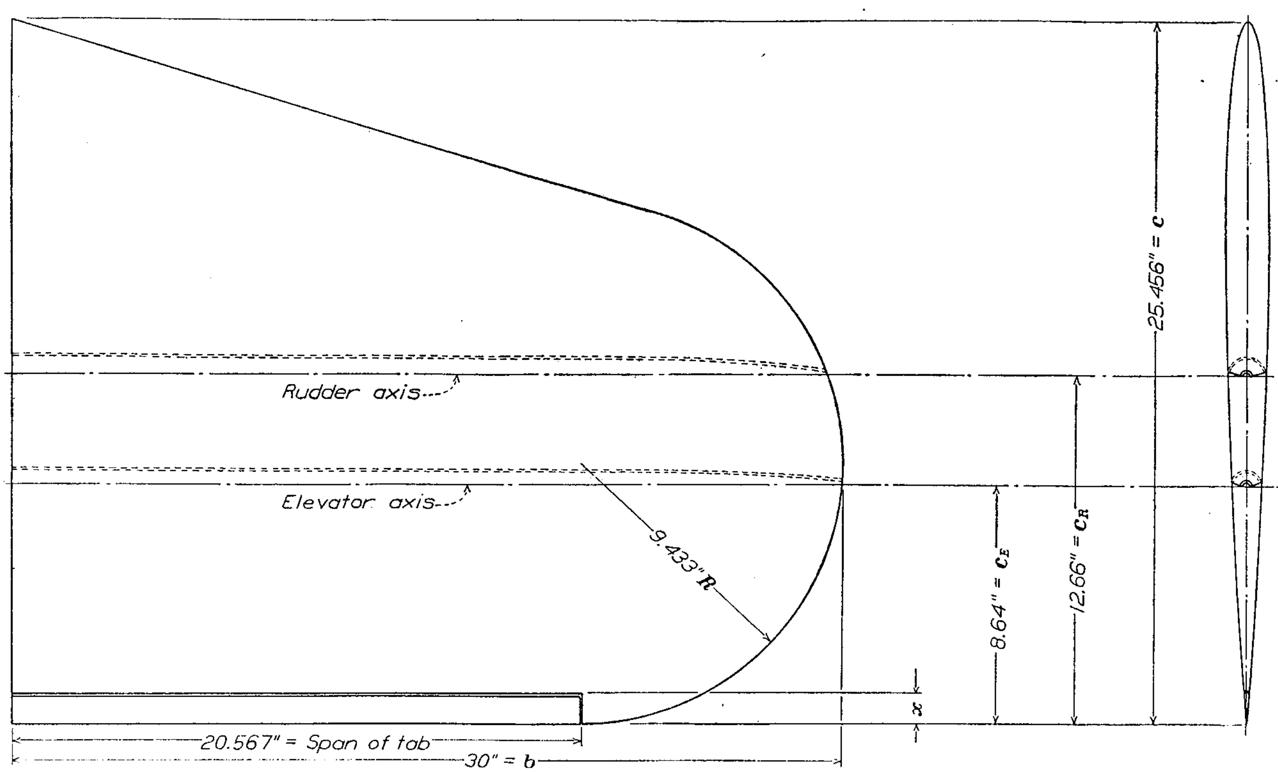


FIGURE 8.—Diagram of tail surface showing details.

NOTE.— For elevator x=5, 10, and 20 percent c_E. For rudder x=20 percent c_E.

min paddles had the N. A. C. A. 0012 profile and were supported in the positions specified with 1/32-inch sheet steel end brackets.

On this same aileron a horn was attached for additional tests. The aileron was faired to a symmetrical section in the horn, the principal dimensions of which are shown in figure 6. The plan of the horn was made to conform to the shape suggested by the Bureau of Aeronautics, Navy Department, the leading-edge portion being half of an ellipse. The horn was constructed of laminated mahogany and was fair to the same precision as the remainder of the model.

The short wide aileron was also tested with a modified Frise type of balance and a tab (fig. 7). The nose shape of the aileron was obtained from a study of available Frise aileron data and was made similar to the Frise aileron of reference 9 with a raised nose. This type of Frise balance gives slightly less balance for low deflections, where overbalance usually occurs, but gives about the same balance as the ordinary Frise aileron at the high deflections. The mahogany nosepiece was attached to the leading edge of the ordinary aileron by screws and a suitable cut-out was made in the wing to provide clearance. (See fig. 7.)

TAIL-SURFACE ARRANGEMENTS

The tail-surface model used in these tests is shown in figure 8. The model of laminated mahogany had an N. A. C. A. 0006 profile faired to about a 1/8-inch radius at the tip and was constructed to a precision of ± 0.005 inch. The plan form of the model was designed to be an average of either a half-span horizontal or a full-span vertical tail. The span of the model was 30 inches and the average chord 20 inches, giving an aspect ratio of 1.5. As a horizontal tail, a portion of the model was hinged along the elevator axis shown in the figure. This arrangement gave an elevator area 40 percent of the total tail area. The inset tabs of different chord lengths were made with a span equal to the span of the straight trailing-edge portion of the elevator. The tab chords tested were 5, 10, and 20 percent of the maximum elevator chord. The tabs were made from the trailing-edge portion of the elevator and were secured to the main part of the elevator by soft wire pins that could be bent to give the desired tab deflections. As a vertical tail, 60 percent of the area of the model was hinged along the rudder axis as shown in figure 8. Only one tab was used; it had the same span as the elevator tab and a chord 20 percent of the maximum rudder chord. In all cases the gap between the tab and the tail surface was sealed with plasticine.

WIND TUNNEL AND BALANCES

The N. A. C. A. 7- by 10-foot wind tunnel in which these tests were made has an open jet and a closed return passage. The tunnel and regular six-component balance are described in detail in reference 10. On this balance the six components of aerodynamic forces and moments are independently and simultaneously measured with respect to the wind axes of the model.

In order to measure the hinge moments simultaneously with the other forces and moments a special hinge-moment balance of the pressure-cell type was used. A diagrammatic drawing of this balance is shown in figure 9. The balance consists of a simple beam supported on an axle in plain bearings and attached to a rubber diaphragm. The space under the diaphragm is connected in parallel with a U-tube and a controllable air-pressure supply. The beam moves between electrical contacts coupled to neon lamps. The beam is balanced by adjusting the air pressure until neither lamp is lighted or until they blink alternately. The pressure is then read on the U-tube, which has been previously calibrated in terms of hinge moments. A spring is incorporated for adjusting the zero reading of the balance and a dashpot is used to damp vibrations. The balance was entirely enclosed in the wing and so mounted that the aileron and balance axes coincided, the aileron being attached directly

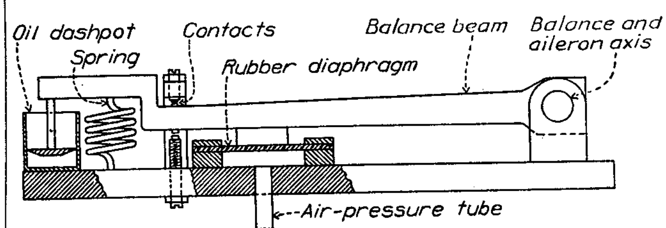


FIGURE 9.—Diagram of hinge-moment balance.

to the balance axle. The leads to the contacts and the pressure tube and also a tube for obtaining the static pressure in the balance recess were brought out through the center of the wing and down the model support to the indicator panel. The static-pressure tube was connected to the static side of the U-tube. A vibrator was mounted on the balance frame to overcome static friction in the system.

In order to use the regular six-component balance for measuring the hinge moments on the tail surfaces, the movable part of the tail was so mounted on the regular model support that the hinge axis was coincident with the lateral axis of the balance. The fixed part of the tail was pivoted to the movable part along the same axis and was supported in front by an adjustable tube attached directly to the lift-scale platform. The angle of attack of the fixed tail was changed by adjusting the length of this tube; whereas the angle of the movable tail was changed by use of the regular angle-of-attack mechanism. With this arrangement it was possible to measure the total lift and drag of the model on the lift and drag scales and at the same time to measure the hinge moment of the movable part of the tail on the regular pitching-moment scale.

A reflection plane, which was used in conjunction with part of the tail-surface tests, was constructed of ¾-inch plywood. It extended across the air stream from top to bottom and from a point 7 inches upstream from the leading edge of the model to 4 feet downstream from this point. The gap between the model and the reflection plane was approximately 3/64-inch. A telltale light was used to indicate any contact of the reflection plane with the model.

TESTS

All tests were made at a dynamic pressure of 16.37 pounds per square foot, corresponding to an air velocity of 80 miles per hour at standard sea-level atmospheric conditions. Thus, for the wing-aileron tests the average Reynolds Number was 609,000 and for the tail-surface tests it was 1,218,000.

Wing-aileron arrangements.—Most of the tests of the wing-aileron arrangements were made at 0°, 10°, 15°, and 20° angle of attack and at 0° yaw. For the aileron deflections of 0°, −15°, and −30°, the tab was deflected 0°, 10°, 20°, 30°, and 40°, and for aileron deflections of 0°, 15°, and 30°, the tab was deflected 0°, −10°, −20°, −30°, and −40°. In the aileron tests with the paddles, horn, and Frise types of balance the tab deflections were limited to 0°, ±10°, ±20°, and ±30° because previous tests had shown that the 40° deflections gave less reduction in hinge moment than the 30° deflections. Tests were made on the model with the Frise aileron at both 0° and 20° yaw to determine the effect of yaw on the balance of ailerons with tabs. It is believed that the foregoing range of aileron deflections covers the range used on present-day airplanes. In every case a positive deflection means that the trailing edge of the deflected surface moved below its neutral position.

Tail-surface arrangements.—After installation of the reflection plane in the tunnel, dynamic-pressure surveys were made before the tail-surface model was put in place and the reference static pressure was recalibrated for the interference effects. The reflection plane was used in all the tests with the horizontal tail because this arrangement was thought to be more nearly representative of the majority of present-day tail installations. In these tests the stabilizer angles α_S used were −10°, −5°, 0°, 5°, and 10°. For each stabilizer angle the elevator was deflected 0°, −10°, −20°, and −30° from the stabilizer. The 5- and 10-percent-chord tabs were deflected 0°, 10°, 20°, and 30° for each elevator setting and the 20-percent-chord tab was also deflected 40° because it was sometimes more effective at the high deflections.

The vertical tail was tested both with and without the reflection plane in place. The tests were made with the fin angles ψ_F of −10°, −5°, 0°, 5°, and 10°. For each fin setting the rudder was deflected 0°, 10°, 20°, and 30° from the fin and for each rudder setting the tab was deflected 0°, −10°, −20°, and −30° from the rudder. A positive deflection is to the left as seen from the rear.

RESULTS

WING-AILERON ARRANGEMENTS

The results of the tests on the wing-aileron arrangements are given in terms of the following nondimensional coefficients:

$$C_L=\frac{\text{lift}}{qS}$$

$$C_D=\frac{\text{drag}}{qS}$$

$$C_l'=\frac{\text{rolling moment}}{qbS}\text{, wind axis}$$

$$C_n'=\frac{\text{yawing moment}}{qbS}\text{, wind axis}$$

$$C_{h_1}=\frac{\text{hinge moment}}{qc_A{}^2b_A}\text{, aileron axis}$$

where q is dynamic pressure.

S, area of wing (not including attached tabs, paddles, or horns).
b, span of wing (not including horn).
c_A, chord of aileron (not including attached tabs, horns, or Frise balance area).
b_A, span of aileron (not including horn).

The values of C_L, C_D, C_l', and C_n' are read directly on the balances and are comparable for the different arrangements. It should be noted that, with the hinge-moment coefficient based on the dimensions of the aileron to which they apply, comparisons of different values of C_{h_1} for different conditions of any given aileron are valid, but comparisons between hinge-moment coefficients for different ailerons cannot be made simply by comparing values of C_{h_1}. If such a comparison is desired, it will be necessary to recalculate the hinge moments on the basis of some common dimension.

The complete data are presented in tabular form. In table I, C_L and C_D for all the arrangements are listed. The change in lift and drag caused by the attached tabs was within the experimental accuracy of the tests. The data for the tests with the paddles, horn, and Frise aileron have been corrected for one arrangement on each wing tip. The values of C_l', C_n', and C_{h_1} for the attached tabs on the short wide aileron are tabulated as follows: The full-span tabs of different chords in table II and the 20 percent c_A half-span tab at the several locations along the aileron span in table III. The corresponding data for the inset tab on this aileron are given in tables IV and V. The data for the medium-size aileron with the 10 percent c_A full-span inset tab are given in table VI. In table VII the corresponding data are given for the short wide aileron with the 20 percent c_A half-span center inset tab in combination with the paddle, horn, and

Frise types of balance. The data for the Frise aileron when yawed 20° are also given in table VII. It should be noted that the rolling- and yawing-moment coefficients with the ailerons and tabs undeflected are those due to yaw alone; whereas for the tests in which they were deflected the moment coefficients are due to tab or aileron.

In order to obtain the results for two ailerons, one on the right tip and one on the left, it is necessary to change the signs of the data for the down aileron and add. (See reference 11.) By use of this convention in summing up the results for two ailerons the signs will be plus when C_l' is in the desired direction and when C_n' aids the roll. The value of C_{h_1} will be plus when it requires a force to move the stick to obtain larger aileron deflections and minus when the ailerons are overbalanced.

TAIL-SURFACE ARRANGEMENTS

The results of the tests on the tail surfaces are given in the form of the following nondimensional coefficients:

$$C_N=\frac{\text{normal force}}{qS_t}$$

$$C_{h_1}=\frac{\text{hinge moment}}{q(c_{E_{av}}{}^2 \text{ or } c_{R_{av}}{}^2)(b_E \text{ or } b_R)}$$

where S_t, total area of tail surface.

$c_{E_{av}}$ or $c_{R_{av}}$, average chord of elevator or rudder.

b_E or b_R, maximum span of elevator or rudder.

The value of C_N was computed from the lift and drag coefficients as measured and C_{h_1} was computed from the pitching-moment scale readings. The data as tabulated are for negative fixed tail settings with various plus and minus elevator or rudder settings and the corresponding minus and plus tab settings. The complete data for the various chord tabs on the elevator are given in table VIII and for the 20 percent c_R tab on the rudder both with and without the reflection plane in table IX.

PRECISION

The coefficients C_L, C_D, and C_N are correct to within ±3 percent and coefficients C_l' and C_n' are, in general, correct to within ±3 percent except at 20° angle of attack. The value of C_{h_1} is correct to within ±3 percent for the ailerons, ±5 percent for the elevator, and ±2 percent for the rudder.

DISCUSSION

METHOD OF COMPARING TABS

In a comparison of the results of tests on tabs it is not sufficient to compare merely the reductions in hinge moments because tabs not only reduce the hinge moment but at the same time reduce the effectiveness of the control surface. A criterion for the comparison of different arrangements of tabs and control surfaces should therefore take into account hinge moment, control deflection, the moment produced by the control surface, and the air speed. For the comparisons made herein, the simple criterions C_l' or C_N were chosen for control effectiveness and $C_{h_1}\delta$ for control force. These criterions do not take into account changes in air speed but are valid for making comparisons at any given angle of attack. Other things being equal, however, the higher the air speed the higher the control force, and vice versa. The control-force criterion also assumes that the stick or rudder bar moves equal amounts for equal values of C_l' or C_N, respectively, the linkage between the stick and control surface being changed accordingly. Therefore, even though C_{h_1} may be reduced considerably, if it is necessary to move the control surface through a very large angle, the product $C_{h_1}\delta$ may be larger with the tab than without it for the same C_l' or C_N.

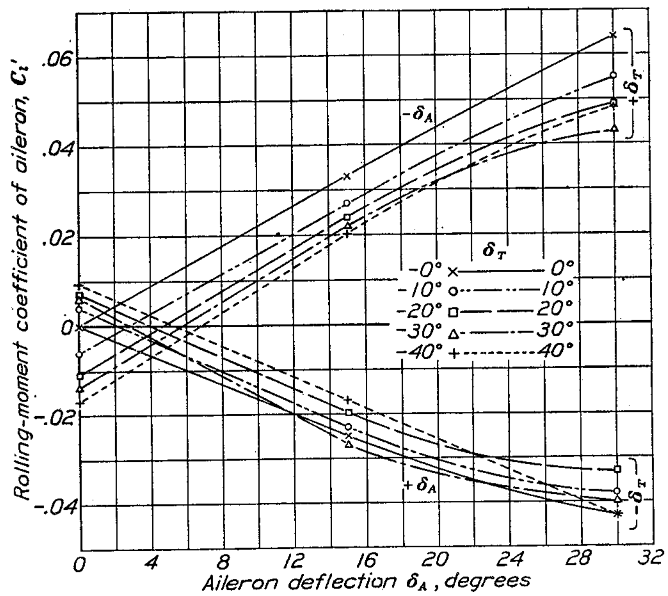


FIGURE 10.—Effect of tab deflection on rolling-moment coefficient. Short wide aileron. 10 percent c_A full-span attached tab. $\alpha=0°$.

In order to obtain the curves of control-force criterion $C_{h_1}\delta$ against C_l' or C_N as used for comparisons in this discussion the procedure is as follows: First, plot either C_l' or C_N and C_{h_1} against δ for the various tab settings. This procedure is illustrated in figures 10 and 11 for the 10 percent c_A full-span attached tab on the short wide aileron. From these curves pick off the values of C_l' and C_{h_1} for the desired aileron deflections and ratios of δ_T/δ_A, sum up the results for the two ailerons, as explained previously, tabulate and compute:

δ_T	δ_A	C_{h_1}	C_l'	$C_{h_1}\delta_A$
Degrees	*Degrees*			
±10	±10	0.092	0.030	0.92
±20	±20	.265	.061	5.30
±30	±30	.578	.083	17.34

The example given is for an equal up-and-down aileron movement and for $\delta_T/\delta_A=1.0$. The best ratio of δ_T/δ_A for a given size of tab can be obtained by making the computations as outlined for several ratios of δ_T/δ_A and then plotting $C_{h_1}\delta_A$ against C_l' and picking the best ratio from this plot. In order to find the optimum size of tab for a given ratio of δ_T/δ_A, the same computations should be made for several sizes of tabs.

The effectiveness of a tab in trimming the aircraft or for complete servo operation of the controls may be determined from data presented as in figures 10 and 11. In this case first find from figure 11 the up-and-down aileron deflection for zero hinge moment for the various tab settings and then, for the corresponding values of aileron and tab deflection, take the values of

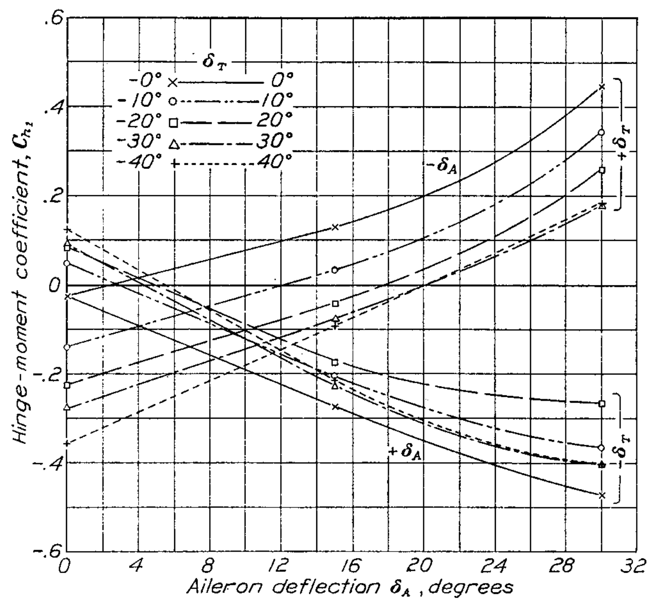


FIGURE 11.—Effect of tab deflection on hinge-moment coefficient. Short wide aileron. 10 percent c_A full-span attached tab. $\alpha=0°$.

C_l' (fig. 10). For ordinary aileron movements it is assumed that the ailerons are so interconnected as to deflect with the desired differential movement.

Figure 11 also shows that for down-aileron deflections the maximum reduction in hinge-moment coefficient would occur with the tab deflected up 20°, and for the up-aileron deflections it is not beneficial to deflect the tab down more than 30°. A further analysis of the data in tables I to IX shows that, in general, the tab cannot be depended upon to give reductions in hinge moments for deflections greater than $\pm 20°$.

All the comparisons given as applied to ailerons are for equal up-and-down motion. For the trimming and servo-control tabs it is also assumed that the ailerons are so interconnected as to move equally up and down. Similar curves may be drawn for any desired aileron differential motion.

COMPARISON OF ATTACHED AND INSET TABS

The control-force criterion is plotted against rolling-moment coefficient for the plain aileron, no tab, and for the aileron with the same size attached and inset tabs in figure 12. From this figure it is evident that with the same ratio of δ_T/δ_A the attached tab is inferior to the inset tab for the purpose of reducing the control force for the same rolling-moment coefficient. This result is logical because when a tab is attached to the trailing edge of a control surface the chord is increased and, since the hinge moment is approximately proportional to the square of the control-surface chord and the rolling moment to the first power, the resultant hinge moment would necessarily be greater. The increased moment arm at which the tab is working might be expected to compensate for this increased hinge moment but apparently the compensation is only partial, because the control force with the attached tab is higher than for the plain aileron except over a very small range of aileron deflections. A further study of the data in tables I to IV shows this result to be typical of attached tabs as compared with inset tabs. Since the inset tab is more effective than the attached tab, the remainder of the discussion will be devoted to inset tabs; and, for the aileron portion, only the equal up-and-down movement will be considered for this movement gives representative results.

INSET TABS ON SHORT WIDE AILERONS

Effect of various ratios of δ_T/δ_A on control force.—A comparison of the effect of various ratios of tab deflections to aileron deflection on $C_{h_1}\delta_A$ and C_l' is shown in figure 13 for the 10 percent c_A full-span inset tab on the short wide aileron. It may be seen that all ratios of δ_T/δ_A give a reduction in control force for a given C_l' when C_l' is less than 0.06. As the data are for static-force test conditions and as in flight there is an actual reduction in hinge moment due to rotational velocity in roll, if the control force is reduced to zero according to static-force test data, overbalance will occur in flight. A more detailed analysis of the probable reduction of hinge moment due to rotational velocity in roll is given later in the report. There is also a slight difference in the hinge moments as measured in these tests and those encountered in flight owing to the manner in which the tab is locked to the aileron; this subject will also be discussed later. On the basis of the probable reduction in hinge moment due to rotation for the short wide aileron, the ratio of tab/aileron deflection of 0.75 will reduce the hinge moment to about zero at the low aileron deflections on an airplane in flight. For this deflection ratio, the reduction in control force at $C_l'=0.04$ is 74 percent that of the aileron without tabs. In some cases $C_l'=0.04$ gives satisfactory rolling con-

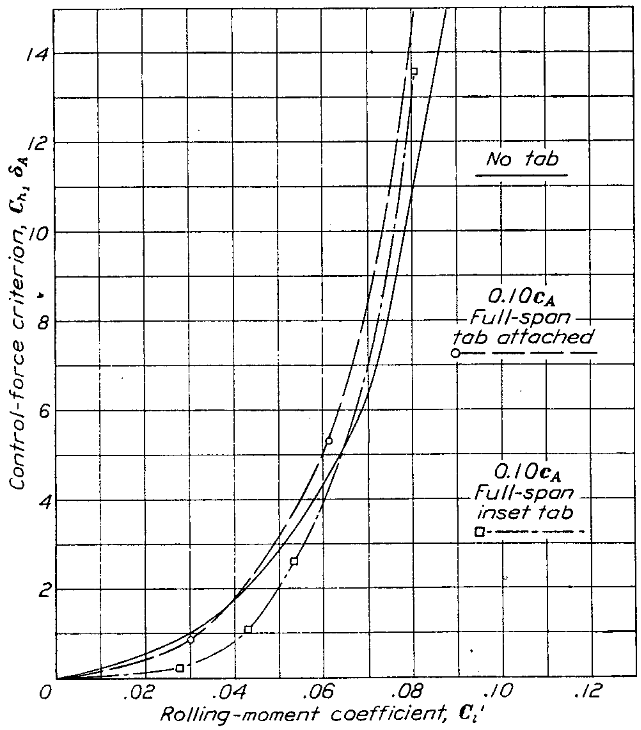


FIGURE 12.—Comparison of effect of attached and inset tabs on the control-force criterion. Short wide ailerons with equal up-and-down deflection $\delta_T/\delta_A=1$. $\alpha=0°$.

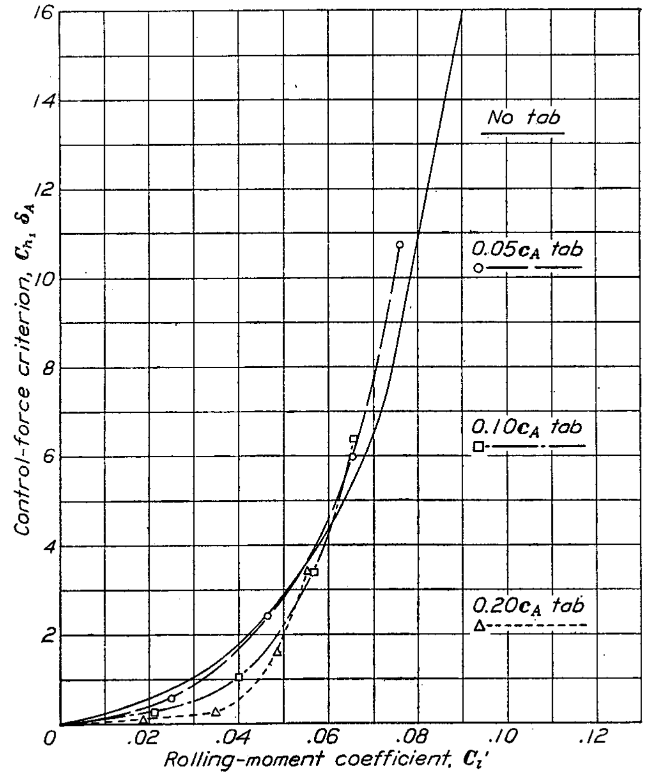


FIGURE 14.—Effect of tab size on the control-force criterion. Short wide ailerons with equal up-and-down deflection. Full-span inset tabs. $\delta_T/\delta_A=0.75$. $\alpha=0°$.

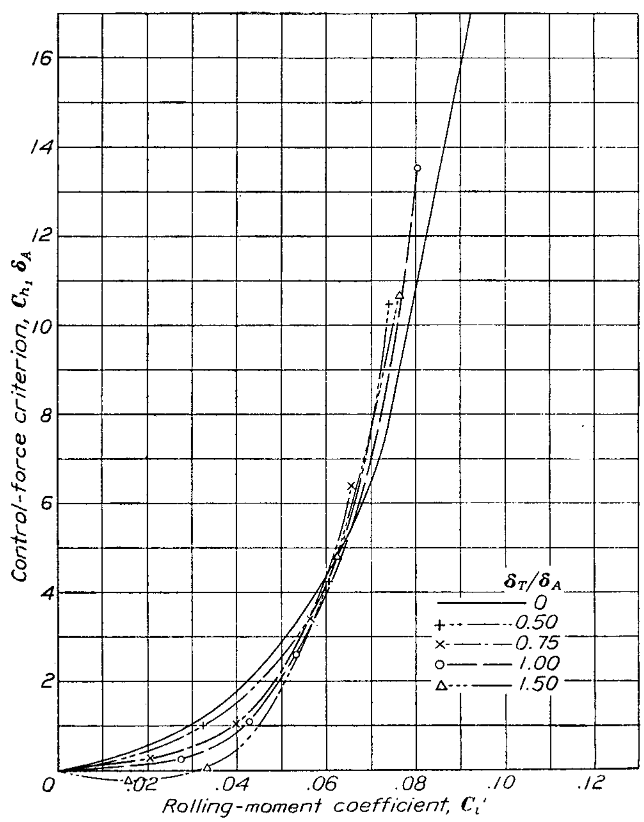


FIGURE 13.—Effect of tab-aileron deflection ratios on the control-force criterion. Short wide ailerons with equal up-and-down deflection. 10 percent c_A full-span inset tab. $\alpha=0°$.

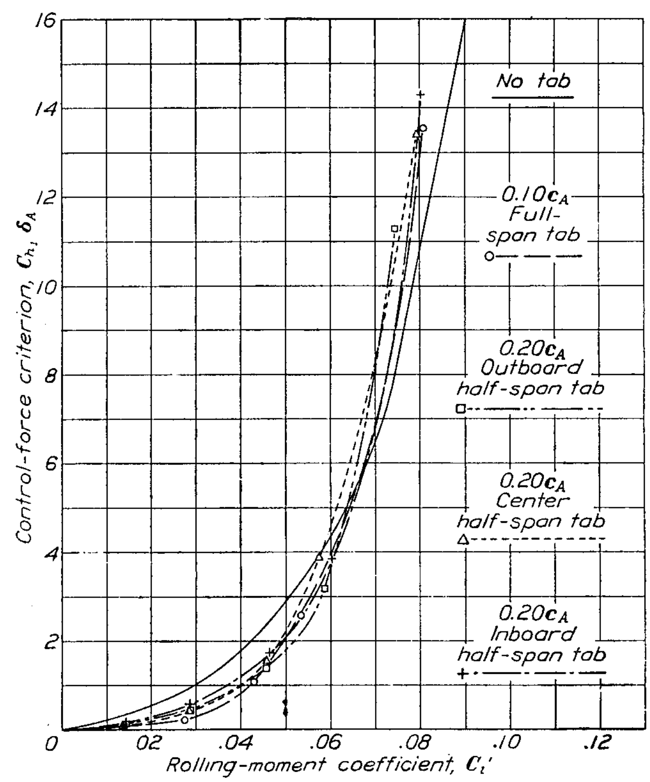


FIGURE 15.—Effect on of tab location on the control-force criterion. Short wide ailerons with equal up-and-down deflection. $\delta_T/\delta_A=1.0$. $\alpha=0°$.

trol. (See reference 12.) If a value of $C_l'=0.075$ is necessary for satisfactory control, none of the tabs are beneficial for the extreme control-surface movements. For the high-speed condition of flight the tab is quite satisfactory, however, as a means of balance. For the ratio of $\delta_T/\delta_A=1.0$ overbalance would probably occur in flight owing to the reduction of hinge moment caused by the rolling velocity; for the ratio 1.5 overbalance occurs in the wind-tunnel tests.

Effect of variation of tab size on control force.—A comparison of the effect on the control force of the variation in tab chord, for a given ratio of tab to aileron deflection ($\delta_T/\delta_A=0.75$), is shown by figure 14. This figure shows that none of the tabs gave reduction in

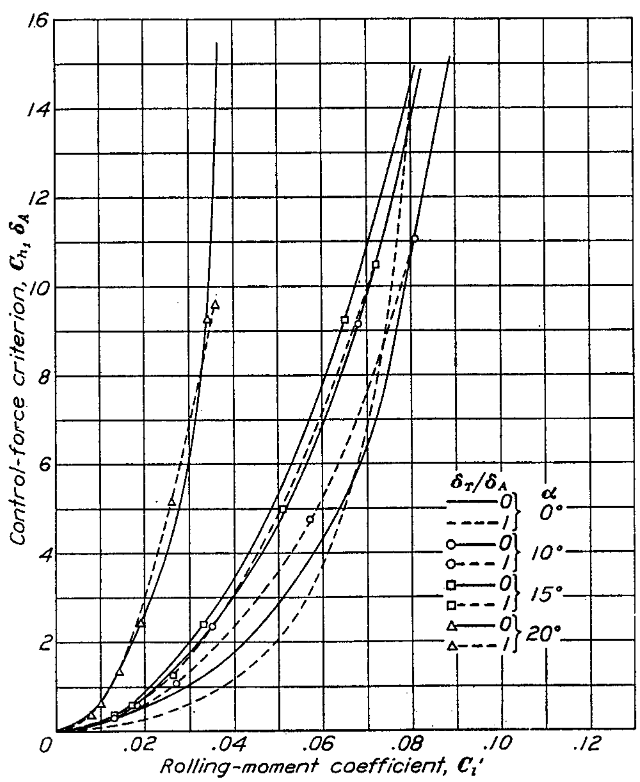


FIGURE 16.—Effect of angle of attack on the control-force criterion. Short wide ailerons with equal up-and-down deflection. 20 percent c_A half-span inboard inset tab.

control force for values of C_l' greater than 0.06. The 5 percent c_A tab requires a larger, and the 20 percent c_A tab a smaller, ratio of tab/aileron deflection to give satisfactory balance. The 5 percent c_A tab would probably be unsatisfactory as a balancing tab because of the decrease in the effectiveness of tabs in reducing the hinge moment when deflected through large angles.

Effect of tab location along aileron span on control force.—A comparison of the effect on the control force of locating a tab of the same size at different locations along the aileron span is shown in figure 15. As previously pointed out, the 10 percent c_A full-span tab at a ratio of tab/aileron deflection of 1 ($\delta_T/\delta_A=1.0$) would probably give overbalance. The 20 percent c_A half-span tabs, however, will probably not give overbalance. The outboard tab is slightly better than the center or inboard tab but, since in a majority of cases it is not practicable to use an outboard tab owing to the wing-tip shape, the inboard tab being next best would probably be used. The differences between the three locations of the 20 percent c_A half-span tabs are so slight that from the consideration of control-force and rolling-moment coefficient there is not much choice. From structural considerations, however, the inboard location is probably preferable.

Effect of angle of attack on control force.—The effect of angle of attack on the effectiveness of tabs in decreasing control force is shown in figure 16. It should be remembered that the curves for the different angles of attack should not be directly compared because of the difference in lift coefficients but that each pair of curves for the same angle of attack are comparable. From an inspection of these curves it will be noted that in all cases except at 20° angle of attack the tab gives

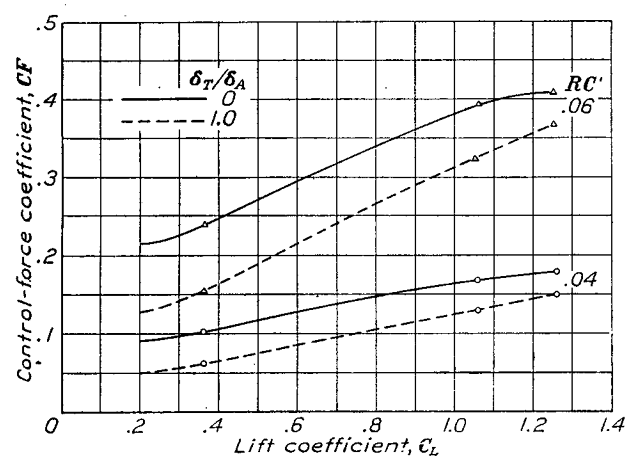


FIGURE 17.—Variation of control-force coefficient with lift coefficient for a given value of rolling-moment criterion. Short wide ailerons with equal up-and-down deflection; 20 percent c_A half-span inboard tab.

a reduction of control force, the greatest reduction occurring at 0° angle of attack. If no overbalance therefore occurs at 0° angle of attack, no overbalance will occur at other angles of attack.

In order to illustrate more accurately the effect of speed on control force with and without tabs, for a given rolling moment, the data from figure 16 have been plotted in figure 17 as a control-force coefficient CF against lift coefficient for two values of the rolling-moment criterion RC'. The control-force coefficient is based on a stick movement of ±25° to give the maximum aileron deflection for a specified value of RC' at maximum lift and is independent of air speed. The coefficient is defined as

$$CF=\frac{Fl}{qc_AS_AC_L}=\frac{C_{h_l}}{C_L}\frac{\delta_{A_{max}}}{25}$$

where F is the force applied at the end of a control lever of length l and $\frac{\delta_{A_{max}}}{25}$ is the gear ratio between aileron and control lever. The rolling-moment criterion is

$$RC = C_l'/C_L$$

which is proportional to the rolling moment in foot-pounds and is also independent of air speed.

Inspection of these curves shows that the control force is reduced by the use of tabs nearly the same absolute amount for any given RC', regardless of lift coefficient, and that the greatest percentage reduction occurs at the low values of RC' and at low lift coefficients.

Effect of variation of tab chord on trimming or servo control.—In figure 18(a) are plotted the rolling moments for various tab deflections of tabs of different chords to give complete balance of the aileron. For purposes of trimming the aircraft, it is possible to compensate for a calculated effect of 3° twist of the wing by deflecting the 5 percent c_A tabs ±7°. For smaller amounts of twist, the deflection required for trimming is directly proportional to the twist.

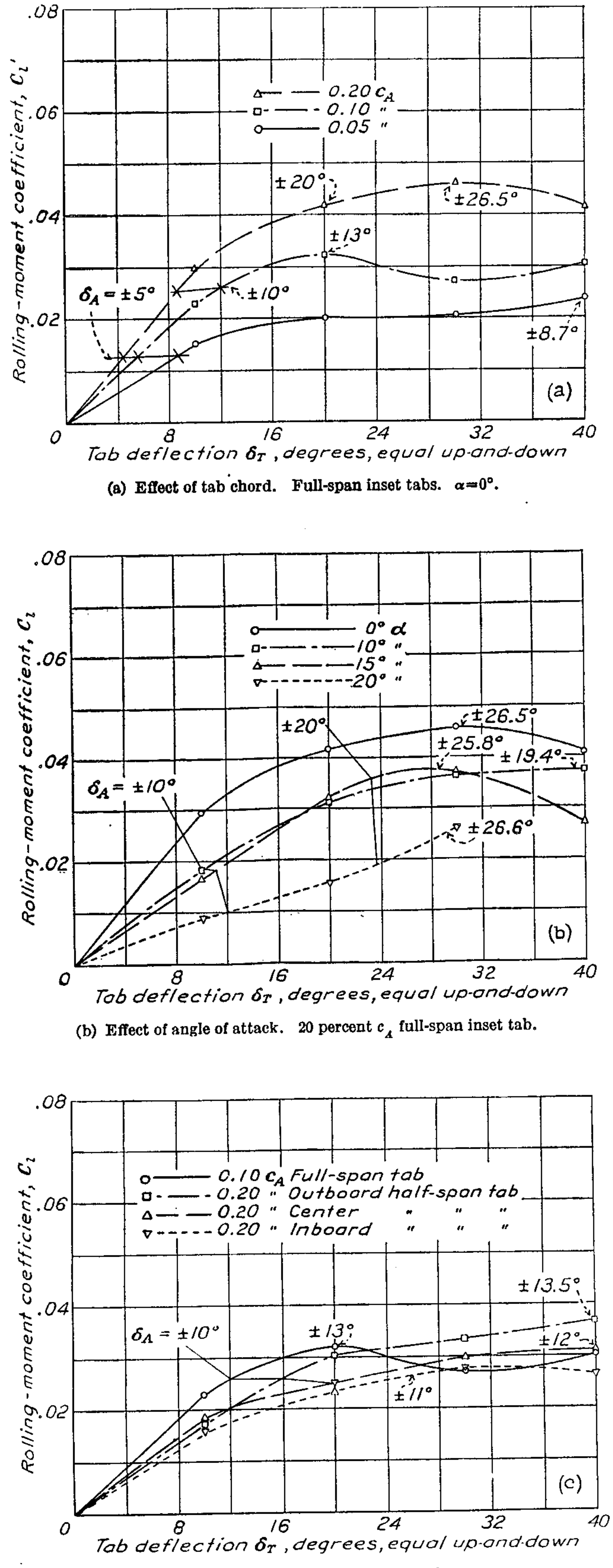
None of the tabs will give satisfactory control for servo operation unless the value $C_l'=0.04$ is satisfactory for rolling control, in which case the 20 percent c_A full-span tab may be used for complete servo operation of the ailerons. If it is desirable to use a tab for servo operation of the control, it probably should be used in conjunction with some other type of balance. The inset-hinge type of auxiliary balance would probably be the best because it is least affected by changes in angle of attack and yaw. As previously pointed out, it may be noted in figure 18 (a) that it is not, in general, beneficial to deflect the tabs from the neutral position more than 20°.

Effect of angle of attack on trimming or servo control.—Tabs as a means of trimming the aircraft or for servo operation of the controls become less effective at the higher angles of attack. Figure 18 (b) for the full-span 20 percent c_A tab shows that even if the tab were satisfactory for servo operation of the control at 0° angle of attack, it would not be satisfactory at 10°, 15°, and 20°.

Effect of tab location along aileron span on trimming or servo control.—The 20 percent c_A half-span tab at any of the locations along the span was inferior as a trimming or servo-control device to the 10 percent c_A full-span tab for tab deflections less than ±20°. (See fig. 18 (c).) The 20 percent c_A half-span tab at any of the locations gave a slight increase in effectiveness for deflections as great as 40°. The outboard location is slightly superior to the other locations for the larger deflections.

INSET TABS ON ELEVATOR

Effect of tab chord and angle of attack of tail surface on C_{h_1} and C_N.—It is not practicable to compare the control-force criterion for the tail-surface test results,

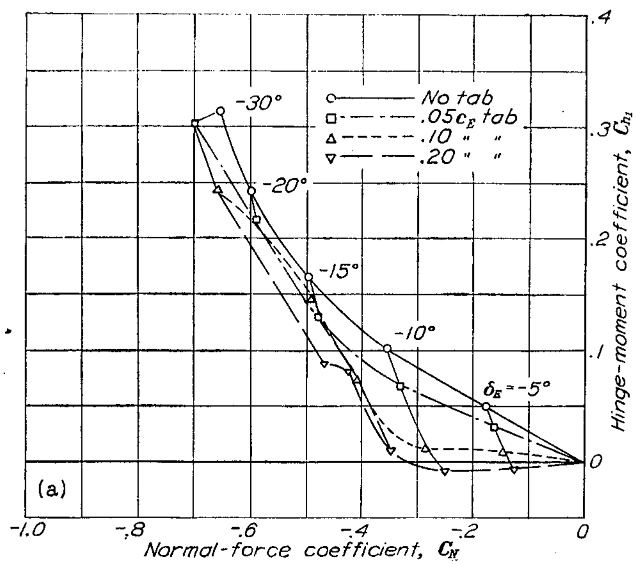


(a) Effect of tab chord. Full-span inset tabs. $\alpha=0°$.

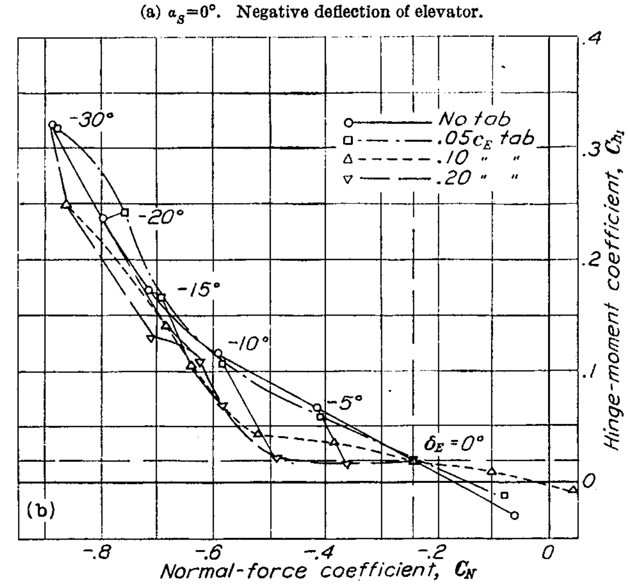
(b) Effect of angle of attack. 20 percent c_A full-span inset tab.

(c) Effect of tab location. $\alpha=0°$.

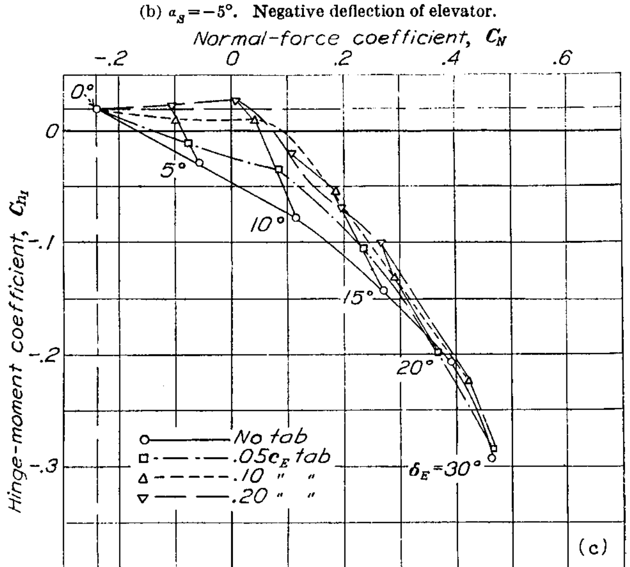
FIGURE 18.—Variation of rolling-moment coefficients with tab deflection for complete servo operation. Short wide aileron.



(a) $\alpha_S=0°$. Negative deflection of elevator.



(b) $\alpha_S=-5°$. Negative deflection of elevator.



(c) $\alpha_S=-5°$. Postive deflection of elevator.

FIGURE 19.—Effect of tab chord on hinge-moment coefficients for ratio of tab deflection to elevator deflection of 1 ($\delta_T/\delta_E=1$). Elevator 40 percent of area of horizontal tail. Reflection plane in place.

except at 0° setting of the fixed tail, because there is no similar control surface moving in the opposite direction and the control surface tends to deflect from neutral as soon as the tail setting is changed from 0°.

The effects of tab size and of stabilizer setting on the elevator hinge moment and on the normal-force coefficients are shown in figure 19. At 0° stabilizer setting the 5 percent c_E tab gave an appreciable reduction in hinge moment. With the 10 percent c_E tab the hinge moment became so small that there is a possibility of overbalance in flight owing to pitching velocity. The curves (fig. 19 (a)) show that with the 20 percent c_E tab the control surface was overbalanced for small elevator deflections with the ratio of tab to elevator deflection of 1. The increase in C_N with the 5 and 10 percent

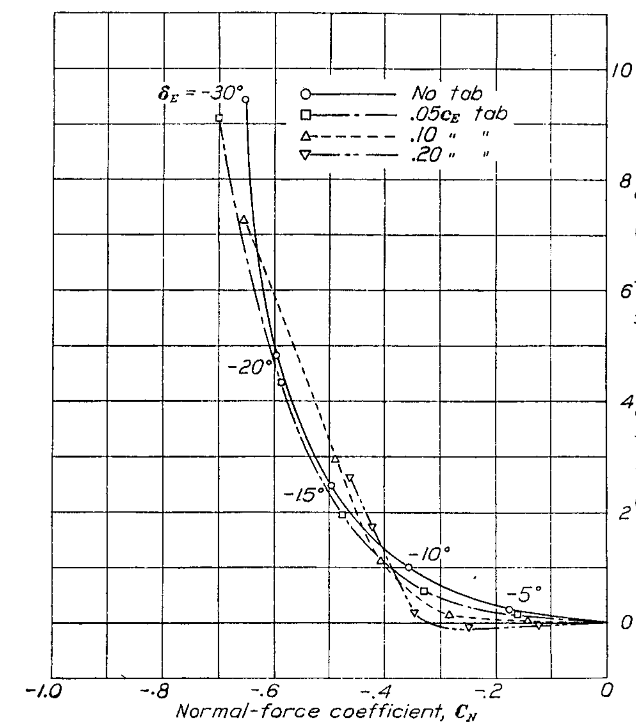


FIGURE 20.—Effect of tab chord on the control-force criterion for ratio of tab deflection to elevator deflection of 1 ($\delta_T/\delta_E=1$). Elevator 40 percent of area of horizontal tail. $\alpha_S=0°$. Reflection plane in place.

c_E tabs over C_N with no tab $\delta_T=0°$, at $\delta_E=-30°$ is unusual. For the tests at $\alpha_S=-5°$ (shown in figs. 19 (b) and 19 (c)), using the broken lines as reference axes, the curves for the various sized tabs are about the same as for the curves at $\alpha_S=0°$ of figure 19 (a). For positive elevator deflections there was more tendency to overbalance at $\alpha_S=-5°$ than for the same elevator deflection at $\alpha_S=0°$, although this tendency was very slight. Since the change in the reduction of hinge moment with different fixed tail settings was slight, the remainder of the discussion on control force of tail surfaces will be for the 0° fixed tail setting.

Effect of tab chord on the control force ($\delta_T/\delta_E=1$).—The control-force criterion used for the tail-surface test results is the same as the one used for the ailerons. The 5 percent c_E tab gave some reduction in control force for all values of the normal-force coefficient. (See fig. 20.) The 10 percent c_E tab gave reduction in control force only for normal-force coefficients less than 0.44, although it will probably give overbalance for small elevator deflections as pointed out previously. The 20 percent c_E tab gave overbalance in the static-force tests.

Effect of various ratios of δ_T/δ_E on control force.—It may be seen (fig. 21) that the 20 percent c_E tab with a deflection ratio of 2/3 gave approximately the same reduction as the 10 percent c_E tab (fig. 20) with a deflection ratio of 1. None of the arrangements gave satisfactory balance for normal-force coefficients greater than about 0.40.

Trimming or servo-control tab.—The results that may be expected by using these tabs for trimming or servo operation of the elevator are shown in figure 22. In this figure the normal-force coefficient and elevator deflection are plotted for the condition of the elevator completely balanced by the tab. These data may be used to determine the tab size and setting necessary to balance the airplane if the angle of attack of the tail is known. It should be noted that no benefit would be obtained by deflecting the tab to angles greater than 20° to the elevator. As the maximum change in C_N that could be obtained with the 0.20 c_E tab as a servo control is small, being equivalent to that obtained with only a 10° deflection of the elevator without tab, probably none of these tabs would be satisfactory as a servo control unless used in conjunction with some other type of auxiliary balance.

INSET TABS ON RUDDER

The rudder, as previously mentioned, was tested with only the 20 percent c_R tab both with and without the reflection plane. The vertical tail of most airplanes is probably most nearly represented by the arrangement without the reflection plane, although some vertical tails would be approximated by the conditions represented with the reflection plane. The effect of the change in fixed tail setting on the results having been discussed for the horizontal tail, the discussion for the vertical tail will be limited to the 0° fin setting ($\psi_F=0$), except for trimming and servo-control tabs.

Reduction of control force.—With the reflection plane in place, the ratio of $\delta_T/\delta_R=2/3$ gave very satisfactory reduction in control force for small rudder deflections, and some reduction for all values of C_N less than 0.63 (fig. 23 (a)). This tab/rudder deflection ratio probably will not give any overbalance on an airplane due to yawing velocity in flight. For all values of C_N greater than 0.63 it would be better to use the control without the tab. For higher tab/rudder deflection ratios overbalance will occur at the low deflections.

Without the reflection plane (fig. 23 (b)) the control force was higher for all values of the normal-force coefficient than with the reflection plane. This increased control force was probably due to the smaller effective aspect ratio of the model, which is accompanied by a lower slope of the lift curve, and also to the large tip loads on the rectangular tip of the rudder. Insofar as balance is concerned, the tab/rudder deflection ratio of 2/3 is probably the largest that can be used without overbalance. The tab in this case was effective in reducing the control force only for values of normal-force coefficient less than 0.60, which is approximately the same as for the model with the reflection plane.

Trimming or servo-control tab.—For trimming or servo control the tab was about equally effective either

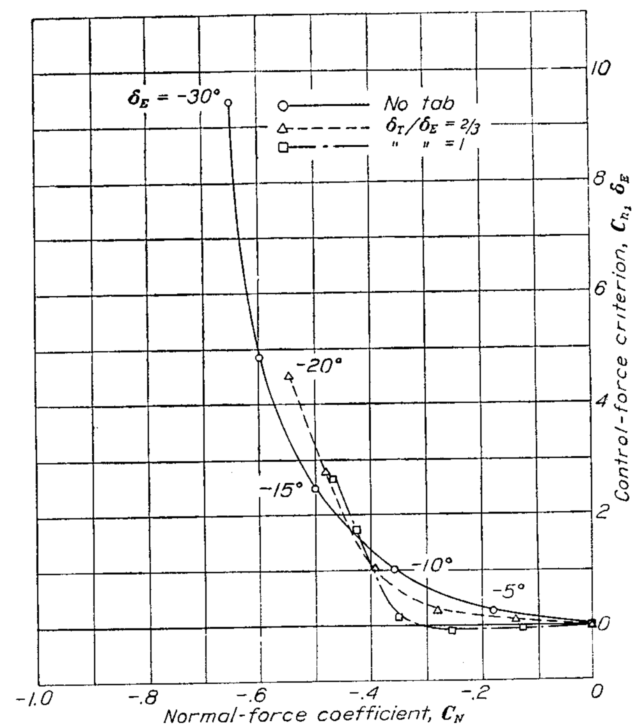
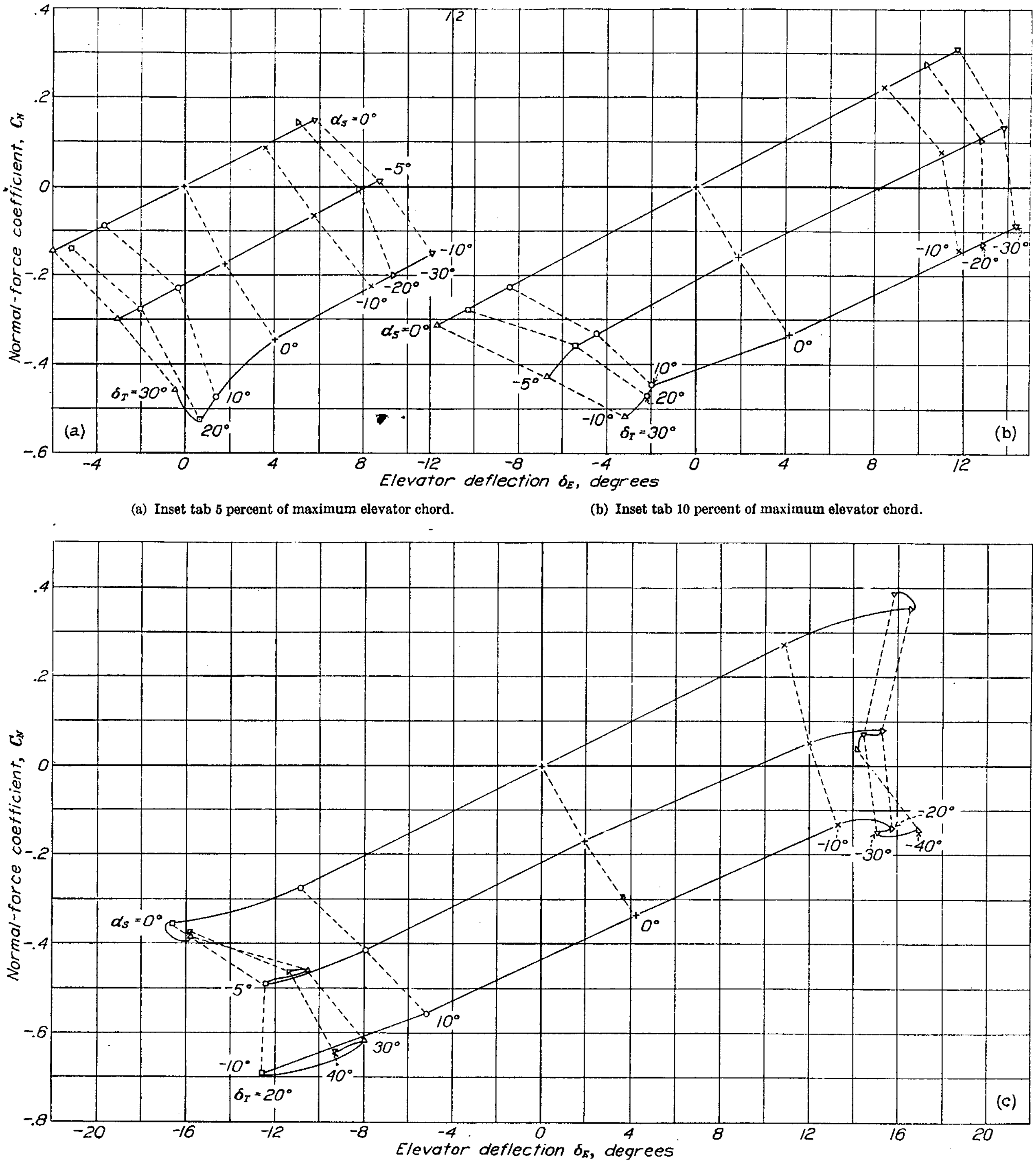


FIGURE 21.—Effect of tab-elevator deflection ratios on the control-force criterion. Elevator 40 percent of area of horizontal tail. Inset tab 20 percent of maximum elevator chord. $\alpha_S=0°$. Reflection plane in place.

with or without the reflection plane. (See fig. 24.) The maximum value of C_N was obtained with the tab deflected only 20° and was 0.39 with the reflection plane and 0.38 without it for the fin set at 0°, ($\psi_F=0°$). This value of C_N corresponds to a rudder displacement of about 10° without tab. The 20° tab deflection is probably greater than necessary for trimming but is not satisfactory for servo operation of the control. For servo operation of the control, the tab would have to be used in conjunction with some other type of auxiliary balance.

INSET TABS IN COMBINATION WITH OTHER TYPES OF BALANCE

A comparison of the actual reduction in hinge moment for a tab on the aileron alone and on the aileron with the auxiliary types of balance is shown in figure 25. The curves are typical for 0° angle of



(a) Inset tab 5 percent of maximum elevator chord.

(b) Inset tab 10 percent of maximum elevator chord.

(c) Inset tab 20 percent of maximum elevator chord.

FIGURE 22.—Variation of normal-force coefficients with elevator deflection for complete servo operation. Elevator 40 percent of area of horizontal tail. Reflection plane in place.

attack; for the other angles of attack the change is about the same. It is evident from these results that the reduction in hinge moment due to the tab is approximately independent of the auxiliary balance or, in other words, if the hinge moment is known for a control surface with either a paddle, horn, or Frise balance, the data reported herein may be used to calculate directly the further reduction in hinge moment that may be expected by the addition of a tab.

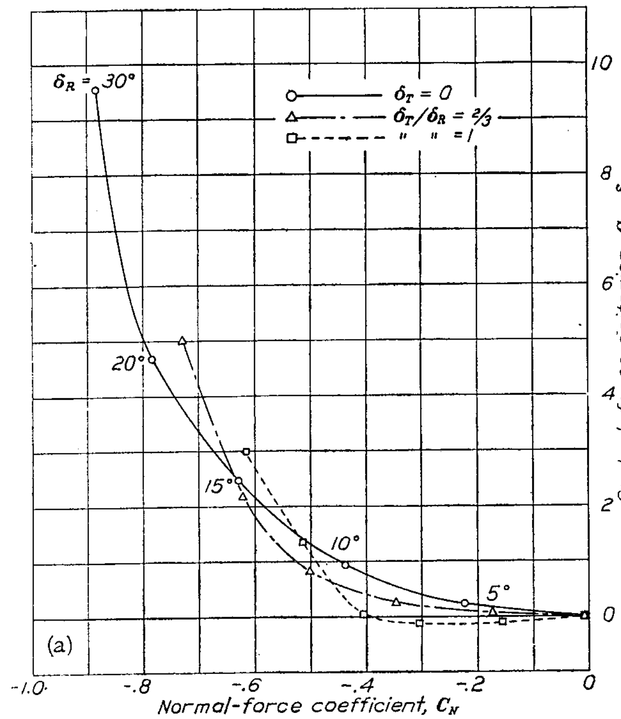
Previous tests (reference 13) have shown that the horn type of balance is ineffective at large angles of attack and tends to overbalance when yawed. The subject tests on the aileron with horn balance did not include the yawed condition but substantiated the conclusion that the horn balance is ineffective at large angles of attack. (See table VII.)

The tests with the Frise aileron yawed showed that the reduction of hinge moment due to a tab was the same either yawed or unyawed (fig. 26). In this figure the change in hinge-moment coefficient caused by the deflection of the tab is plotted against tab angle. Since the change in hinge-moment coefficient on this type of aileron caused by a deflection of the tab is unaffected by yaw, it is reasonable to assume that any other type of similarly balanced aileron and tab combination would be unaffected by yaw. If an aileron-tab combination is therefore not overbalanced at zero yaw it will not be overbalanced by the tab when yawed with the controls undeflected. It should be remembered, however, that all ailerons tend to be overbalanced when the wing is sideslipped because of the unsymmetrical wing span load distribution under these conditions. This overbalance was observed in the subject tests on the Frise aileron when yawed and the amount of overbalance was considerable at the high angles of attack. (See table VII.) When a balancing tab is attached to an aileron in a conventional manner so as to start moving at the same time as the aileron and in the opposite direction, the degree of overbalance when yawed will be greater than for the aileron without tab if the ailerons are allowed to deflect a small amount. It would be desirable to design the linkage of a balancing tab so that the aileron and tab would move together over the first 4° or 5° deflection and then differentially to reduce the hinge moment. This arrangement would also be desirable because of the fact that most aerodynamic balancing devices tend to give overbalance at low angles of control-surface deflection.

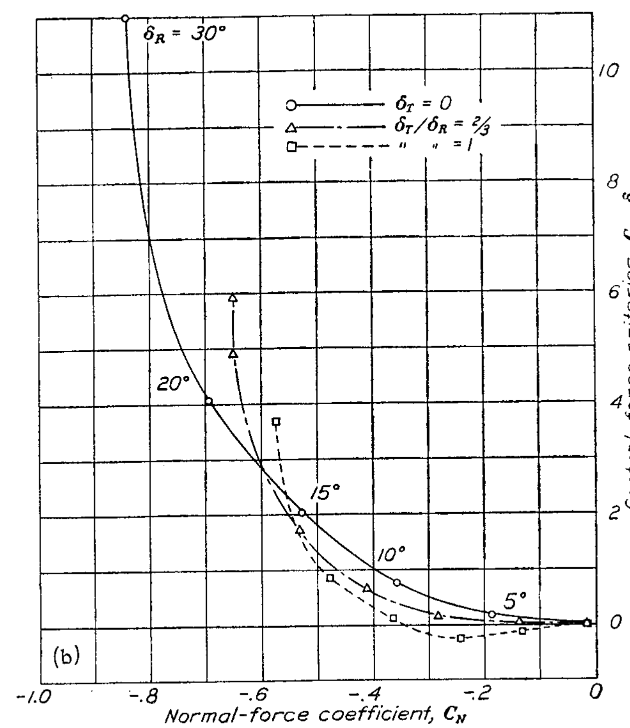
FACTORS AFFECTING APPLICATION OF STATIC-FORCE TEST RESULTS TO AIRPLANES IN FLIGHT

METHOD OF MEASURING THE HINGE MOMENTS

In the wind-tunnel force tests where the tab was part of the control surface, the measured hinge moment was the combined moment of the control surface and the tab. On an actual airplane, however, the arrangement would be more like that shown



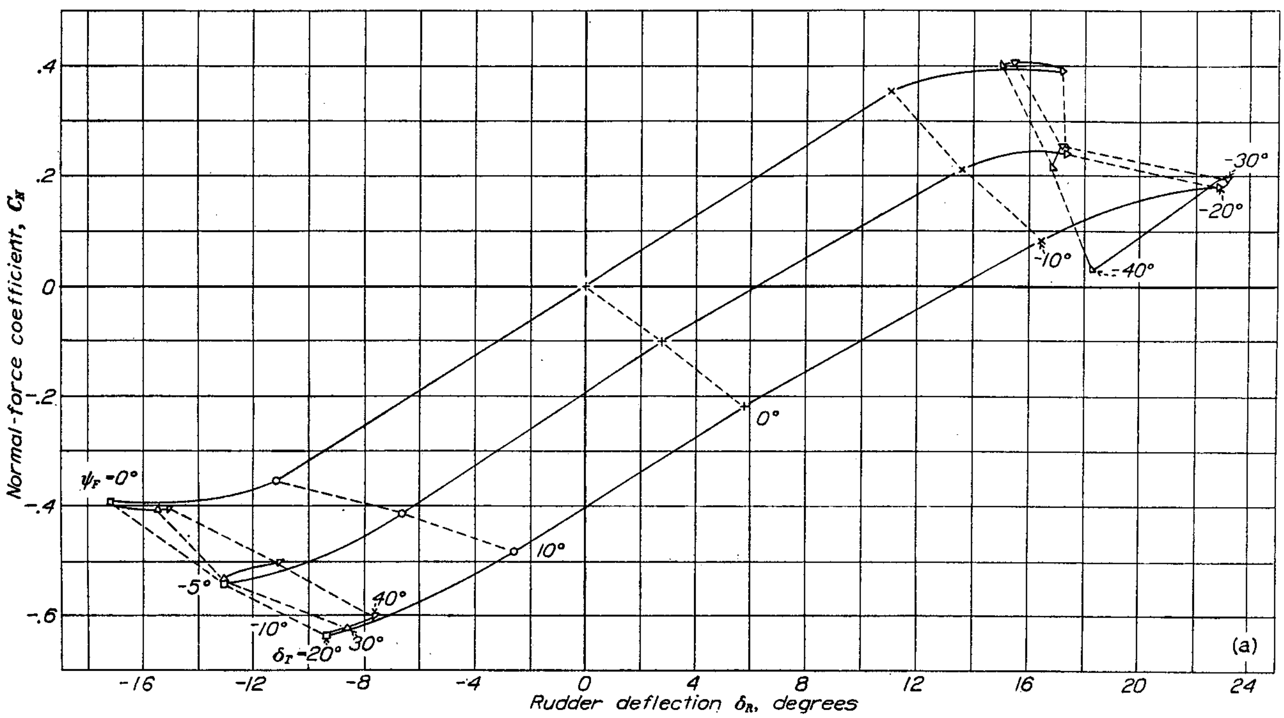
(a) Reflection plane in place.



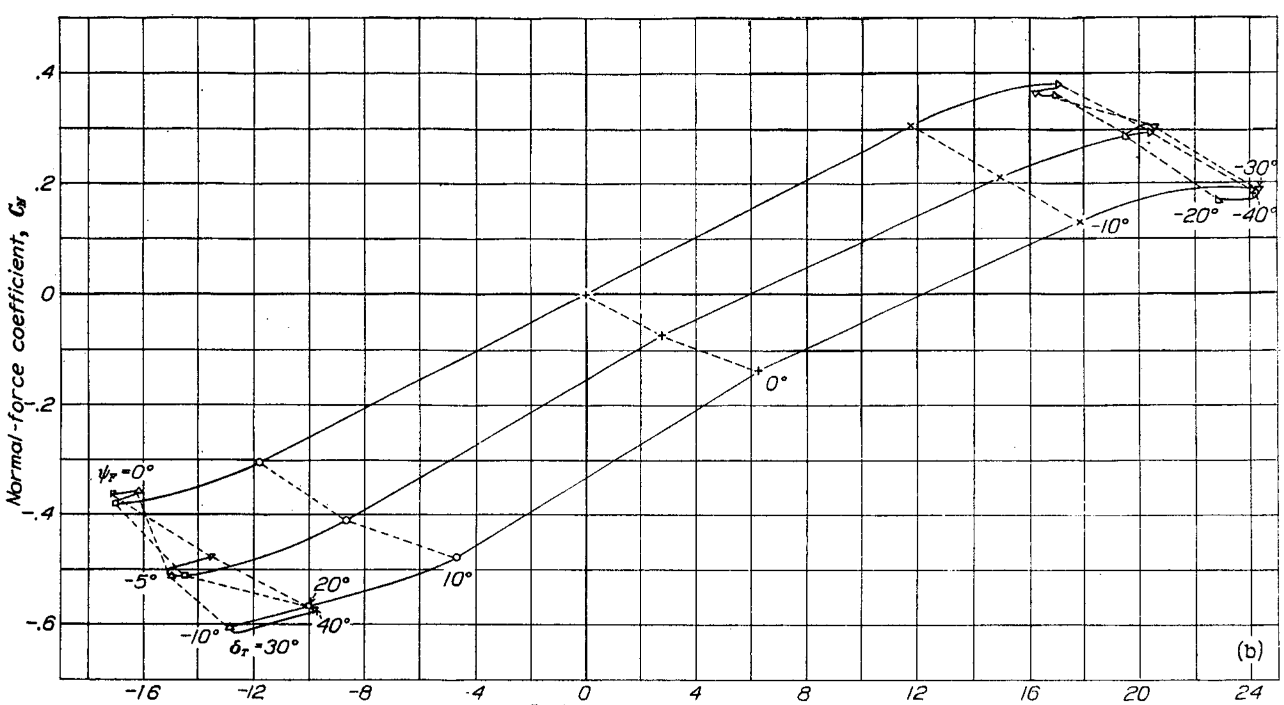
(b) Reflection plane removed.

FIGURE 23.—Effect of tab-rudder deflection ratios on the control-force criterion. Rudder 60 percent of area of vertical tail. Inset tab 20 percent of maximum rudder chord. $\psi_F=0°$.

in figure 27. The following discussion applies to any control surface, but an aileron will be treated for simplicity. In the sketch the ratio of 1:1 between



(a) Reflection plane in place.



(b) Reflection plane removed.

FIGURE 24.—Variation of normal-force coefficient with rudder deflection for complete servo operation. Rudder 60 percent of area of vertical tail. Inset tab 20 percent of maximum rudder chord.

tab and aileron deflection is assumed. If F_A is the force on the aileron control horn, F_T that on the tab control horn, a summation of the moments about the aileron axis gives,

$$F_A a + xe = yc + F_T b$$

or, solving for $F_A a$

$$F_A a = yc + F_T b - xe$$

In the force tests, $yc - xe$ was actually measured. For the case of $\delta_T/\delta_A = 1.0$ under consideration

$$b = f \text{ and } F_T f = xd = F_T b$$

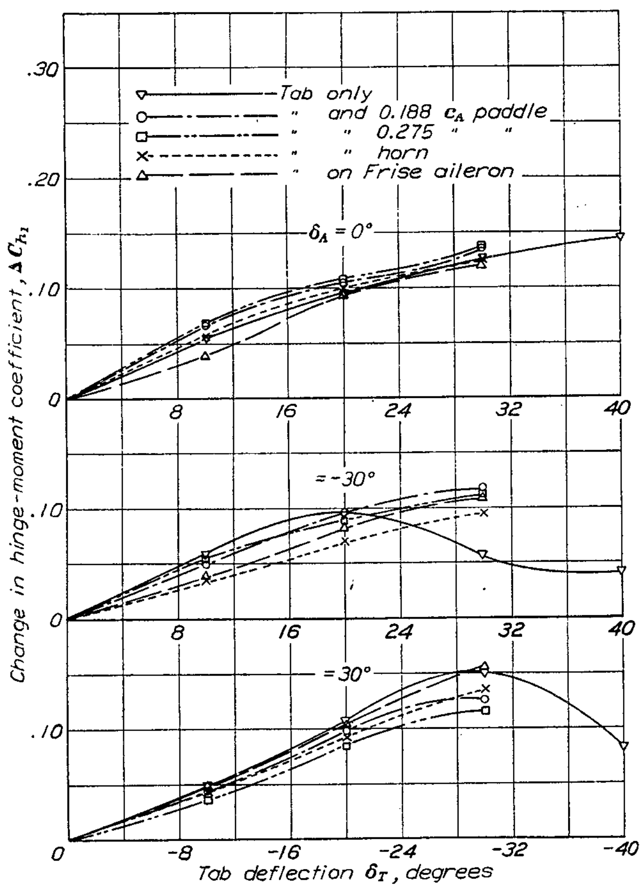


FIGURE 25.—Comparison of reduction of hinge-moment coefficients of inset tabs alone and in combination with other types of balancing surfaces. Short wide aileron. 20 percent c_A half-span center inset tab. $\alpha = 0°$.

therefore

$$F_A a = yc + xd - xe$$

If for the 10 percent c_A tab it be assumed that the center of pressure on the tab is 20 percent of the tab chord from the leading edge, it follows that

$$xd = \frac{2}{92} xe$$

therefore

$$F_A a = yc + \frac{2}{92} xe - xe = yc - 0.98\, xe$$

From the preceding equation it is apparent that the actual aileron hinge moment would be slightly larger for the flight conditions than it was for the force-test conditions. The actual difference in moment, how-

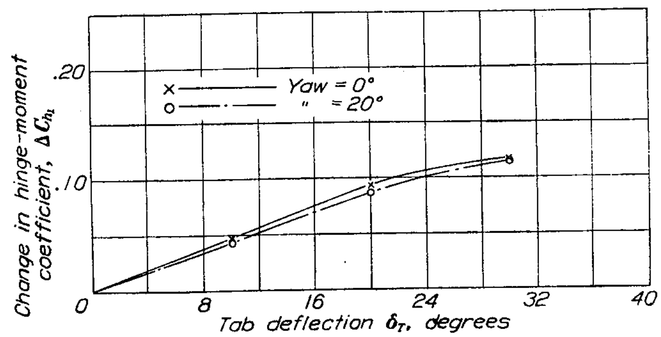


FIGURE 26.—Comparison of reduction of hinge-moment coefficients of inset tabs at 0° and 20° yaw. Frise aileron. 20 percent c_A half-span center inset tab. $\alpha = 0°$.

ever, is only 2 percent of the moment of the tab about the aileron axis for the 10 percent c_A tab.

EFFECT OF ROTATIONAL VELOCITIES

When a control surface is deflected on an airplane in flight, an angular velocity is obtained that changes the angle of attack of the control surface in such a manner as to decrease the hinge moment. As in the static-force tests no angular velocity accompanied the control-surface deflection, the hinge moments as measured should be decreased by an amount equal to

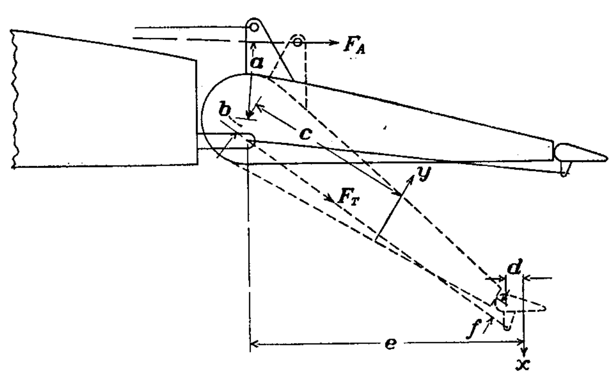


FIGURE 27.—Diagram of a balancing-tab arrangement for an airplane.

the reduction caused by the angle-of-attack change that would be expected in flight. An analytical determination of the reduction that would be expected with the short wide ailerons (40 percent c by 30 percent $b/2$) is therefore given.

From the data of the force tests it was found that for the ailerons, regardless of deflection, and for angles of attack below the stall, the change in hinge moment with angle of attack was:

$$\frac{\Delta C_{h_1}}{\Delta \alpha} = 0.0164 \text{ or } \Delta C_{h_1} = 0.0164 \Delta \alpha$$

This expression is for 2 ailerons, 1 on each wing tip, and $\Delta\alpha$ is in degrees. The value of $\Delta\alpha$ is one-half the difference between the average angle of attack over the portions of the wing containing the two ailerons and may be found in the following manner:

$$\Delta\alpha_1=\tan^{-1}\frac{p'b}{2V}$$

where p' is the rate of rotation in radians about the wind axis. This expression is for the change in angle of attack at the wing tip. For the inboard end of the aileron the expression is

$$\Delta\alpha_2=\tan^{-1}\frac{p'b_1}{2V}$$

where b_1 is the span of the wing between the ailerons. The average change is

$$\Delta\alpha=\frac{\Delta\alpha_1+\Delta\alpha_2}{2}=\frac{\tan^{-1}\frac{p'b}{2V}+\tan^{-1}\frac{p'b_1}{2V}}{2}$$

or

$$\Delta\alpha=\tan^{-1}\frac{p'b}{2V}\left(\frac{1+\frac{b_1}{b}}{2}\right)$$

A value of $\frac{p'b}{2V}=0.05$ gives for this wing and aileron arrangement $\Delta\alpha=\tan^{-1}0.0425=2.43°$; or the change in hinge moment due to a rate of rotation corresponding to this $\frac{p'b}{2V}$ is

$\Delta C_{h_1}=0.0164\times2.43=0.0398$, or 0.04 approximately.

This result shows that for $\frac{p'b}{2V}=0.05$ the reduction of the hinge-moment coefficient is about 0.04.

From a large number of wind-tunnel tests on wings alone, it has been found that for a rate of rotation corresponding to $\frac{p'b}{2V}=0.05$ the value of the damping-moment coefficient C_λ' below the stall is approximately 0.02. Recent tests (to be published) have shown, furthermore, that at low angles of attack the aileron deflection necessary to give a rolling velocity corresponding to $\frac{p'b}{2V}=0.05$ would give a static rolling-moment coefficient of 0.02 ($C_l'=0.02$). For the wing alone it follows that if the ailerons are deflected to give a $C_l'=0.02$ the resultant rolling velocity will correspond to $\frac{p'b}{2V}=0.05$ and therefore will give a reduction in the hinge-moment coefficient of 0.04. Available test data indicate that the rolling-moment coefficient required to produce a given rolling velocity with a complete airplane is about 25 percent greater than that required for the wing alone. Statements in the discussion relative to the effect of rolling velocity on the hinge moments in flight are based on this difference between results of the wing alone and those for a complete airplane. A similar analysis for the medium-size aileron shows that the reduction in hinge-moment coefficient is 0.008 for a rolling velocity corresponding to $\frac{p'b}{2V}=0.05$. It is evident therefore that the change in hinge moment due to rolling velocity depends to a large extent upon the size of the aileron.

Angular velocities in pitch and yaw affect the moments on the horizontal and vertical tail surfaces in a similar manner but no computations have been made for these effects.

CONCLUSIONS

The conclusions are based on static-force test results and as applied to ailerons are for an equal up-and-down movement. Such factors as angular velocities in roll and methods of operating the tab may have larger effects than those assumed.

1. Inset tabs were superior to attached tabs for the same tab/aileron deflection ratios.
2. The reduction in control force with a tab was greater at an angle of attack of 0° than at 10°, 15°, and 20°.
3. The 20 percent c_A half-span inset tab was probably the best for use as a balancing tab for ailerons.
4. The 20 percent c_A full-span inset tab was satisfactory as a servo control for values of rolling-moment coefficient as great as those obtained by deflecting the unbalanced control surface about 11°.
5. For ordinary trimming purposes the 5 percent c_A full-span tab was satisfactory.
6. The reduction in hinge-moment coefficient due to tabs could be added directly to the reduction due to paddle, horn, or Frise types of balance.
7. There was no advantage in using tabs for control moments greater than those ordinarily obtained by deflecting the control surfaces more than about 15°.
8. The reduction of hinge moment due to tabs was independent of angle of yaw for the Frise type aileron.
9. It appeared that tabs would be more effective when used with large control surfaces that would require small angular displacement.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., *February 5, 1935.*

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TABLE I.—FORCE TESTS, CLARK Y WING WITH PLAIN SHORT WIDE AILERON ON RIGHT WING TIP ONLY

[R. N.=609,000. Velocity=80 m. p. h. Yaw=0°]

α	Model									
	Wing with or without tabs		0.1875 c_A by 0.445 b_A paddle		0.275 c_A by 0.445 b_A paddle		Horn aileron balance		Frise aileron balance	
	C_L	C_D	C_L	C_D	C_L	C_D	C_L	C_D	C_L	C_D
°										
0	0.361	0.021	0.395	0.023	0.381	0.037	0.429	0.033	0.367	0.026
10	1.060	.092	1.068	.098	1.054	.102	1.186	.114	1.040	.094
15	1.260	.147	1.260	.157	1.254	.159	1.360	.179	1.254	.148
20	1.194	.265	1.128	.276	1.126	.270	1.212	.275	1.194	.246

TABLE II

FORCE TESTS, CLARK Y WING WITH PLAIN SHORT WIDE AILERON ON RIGHT WING TIP ONLY—FULL-SPAN ATTACHED TAB

[R. N.=609,000. Velocity=80 m. p. h. Yaw=0°]

δ_T	−40°			−30°			−20°			−10°			0°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
(a) $0.05c_A$															
$\delta_A=0°$															
0	0.032	0.003	0	0.019	0.002	0	0.009	0.001	0	−0.001	0.002	0	−0.047	0	0
10	−.083	.003	0	−.088	.003	0	−.104	.002	0	−.097	.003	−.001	−.177	0	0
15	−.162	.002	−.001	−.180	.002	−.001	−.182	.001	−.001	−.173	.003	−.001	−.239	0	0
20	−.278	.002	−.001	−.290	.003	−.001	.304	−.001	−.001	−.284	.003	−.001	−.338	0	0
$\delta_A=15°$															
0	−0.246	−0.023	0.005	−0.246	−0.022	0.005	−0.240	−0.024	0.005	−0.238	−0.022	0.005	−0.301	−0.024	0.006
10	−.407	−.020	.010	−.378	−.016	.009	−.382	−.021	.009	−.382	−.020	.009	−.436	−.022	.011
15	−.444	−.017	.012	−.415	−.016	.011	−.420	−.018	.011	−.413	−.017	.011	−.472	−.020	.012
20	−.468	−.001	.009	−.441	−.002	.008	−.454	−.003	.008	−.439	−.002	.008	−.494	−.003	.009
$\delta_A=30°$															
0	−0.418	−0.039	0.013	−0.407	−0.037	0.013	−0.378	−0.037	0.013	−0.393	−0.036	0.012	−0.454	−0.039	0.014
10	−.514	−.032	.019	−.508	−.030	.019	−.492	−.030	.019	−.522	−.030	.019	−.576	−.035	.022
15	−.551	−.025	.022	−.538	−.023	.021	−.529	−.024	.021	−.558	−.024	.021	−.599	−.029	.023
20	−.516	.002	.014	−.510	.003	.014	−.508	.002	.014	−.516	.003	.014	−.550	−.001	.015
(b) $0.10c_A$															
$\delta_A=0°$															
0	0.121	0.009	0	0.089	0.006	0	0.083	0.007	0	0.048	0.004	0	−0.029	0	0
10	−.003	.009	−.001	−.034	.006	−.001	−.034	.007	−.001	−.050	.005	−.001	−.135	0	0
15	−.104	.007	−.001	−.128	.005	−.001	−.122	.006	−.001	−.134	.005	−.002	−.206	0	0
20	−.223	.006	−.001	−.229	.005	−.001	−.219	.005	−.002	−.242	.004	−.002	−.318	0	0
$\delta_A=15°$															
0	−0.217	−0.017	0.005	−0.229	−0.027	0.005	−0.173	−0.020	0.005	−0.206	−0.023	0.005	−0.274	−0.028	0.006
10	−.387	−.021	.009	−.398	−.023	.010	−.282	−.017	.008	−.346	−.020	.009	−.438	−.025	.011
15	−.433	−.019	.011	−.429	−.019	.011	−.297	−.011	.008	−.383	−.017	.011	−.474	−.021	.012
20	−.454	−.001	.009	−.463	−.001	.009	−.335	.002	.007	−.418	−.001	.008	−.489	−.002	.010
$\delta_A=30°$															
0	−0.401	−0.043	0.013	−0.404	−0.040	0.013	−0.268	−0.033	0.011	−0.368	−0.038	0.013	−0.472	−0.043	0.016
10	−.433	−.025	.019	−.483	−.032	.018	−.397	−.028	.017	−.505	−.031	.020	−.612	−.038	.024
15	−.521	−.024	.021	−.521	−.025	.020	−.443	−.020	.019	−.552	−.026	.022	−.640	−.030	.025
20	−.487	.004	.015	−.495	.006	.014	−.408	.006	.013	−.494	.003	.014	−.566	−.005	.016

δ_T	0°			10°			20°			30°			40°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
(a) $0.05c_A$															
$\delta_A=0°$															
0	−0.047	0	0	−0.109	−0.004	0	−0.160	−0.008	0.001	−0.201	−0.010	0.001	−0.226	0.011	0.001
10	−.177	0	0	−.229	−.003	.001	−.292	−.008	.002	−.339	−.009	.002	−.366	−.011	.003
15	−.239	0	0	−.298	−.003	.001	−.346	−.007	.002	−.387	−.010	.003	−.411	−.010	.003
20	−.338	0	0	−.397	−.002	0	−.446	−.004	.002	−.487	−.006	.002	−.516	−.005	.003
$\delta_A=-15°$															
0	0.101	0.032	0.001	0.037	0.029	0	−0.005	0.027	0	−0.022	0.026	0	−0.020	0.026	0
10	.042	.035	−.005	−.024	.032	−.005	−.081	.029	−.005	−.111	.028	−.004	−.125	.027	−.004
15	.004	.032	−.007	−.070	.029	−.008	−.125	.026	−.007	−.157	.026	−.007	−.176	.024	−.006
20	−.034	.025	−.009	−.103	.023	−.011	−.161	.021	−.010	−.197	.019	−.010	−.226	.018	−.010
$\delta_A=-30°$															
0	0.394	0.057	0.009	0.320	0.053	0.008	0.264	0.050	0.007	0.218	0.047	0.007	0.268	0.050	0.007
10	.216	.065	−.002	.165	.063	−.002	.120	.059	−.003	.104	.058	−.003	.126	.060	−.002
15	.187	.062	−.007	.117	.060	−.008	.059	.058	−.008	.047	.056	−.008	.047	.057	−.008
20	.175	.041	−.014	.106	.040	−.015	.051	.035	−.015	.024	.035	−.014	.031	.049	−.014
(b) $0.10c_A$															
$\delta_A=0°$															
0	−0.029	0	0	−0.141	−0.006	0	−0.225	−0.011	0.001	−0.279	−0.014	0.002	−0.358	−0.017	0.002
10	−.135	0	0	−.249	−.005	.001	−.338	−.010	.002	−.411	−.014	.004	−.493	−.016	.004
15	−.206	0	0	−.309	−.005	.001	−.384	−.008	.002	−.451	−.012	.004	−.537	−.016	.005
20	−.318	0	0	−.414	−.002	.001	−.494	−.003	.003	−.551	−.004	.004	−.627	−.005	.005
$\delta_A=-15°$															
0	0.129	0.033	0.001	0.031	0.027	0	−0.042	0.024	0	−0.077	0.022	0	−0.093	0.020	0
10	.065	.035	−.005	−.047	.029	−.005	−.136	.026	−.004	−.191	.023	−.004	−.229	.021	−.004
15	.026	.033	−.008	−.091	.027	−.007	−.182	.024	−.007	−.247	.021	−.006	−.291	.019	−.006
20	−.015	.027	−.011	−.126	.021	−.010	−.230	.018	−.009	−.295	.015	−.008	−.350	.018	−.008
$\delta_A=-30°$															
0	0.444	0.064	0.011	0.342	0.055	0.009	0.258	0.099	0.007	0.178	0.043	0.006	0.183	0.048	0.007
10	.247	.068	−.002	.158	.063	−.003	.116	.059	−.003	.086	.055	−.003	.061	.056	−.002
15	.208	.064	−.007	.125	.060	−.008	.042	.056	−.008	−.006	.053	−.008	−.029	.053	−.008
20	.194	.058	−.014	.119	.053	−.015	.026	.047	−.014	−.030	.046	−.014	−.075	.035	−.013

(c) $0.20c_A$

α°															
	$\delta_A=0°$														
0	0.240	0.017	0.001	0.226	0.014	0	0.183	0.010	0.001	0.130	0.008	0	-0.009	0	0
10	.125	.018	-.001	.123	.015	-.002	.083	.012	-.002	-.014	.008	-.002	-.160	0	0
15	.025	.015	-.002	.012	.013	-.002	-.021	.011	-.002	-.121	.007	-.002	-.263	0	0
20	-.128	.010	-.003	-.139	.007	-.003	-.162	.006	-.003	-.253	.002	-.003	-.389	0	0
	$\delta_A=15°$														
0	-0.166	-0.019	0.005	-0.159	-0.019	0.005	-0.137	-0.017	0.005	-0.228	-0.019	0.005	-0.355	-0.031	0.006
10	-.366	-.021	.009	-.348	-.020	.009	-.299	-.016	.008	-.452	-.023	.010	-.555	-.030	.012
15	-.436	-.019	.012	-.373	-.015	.010	-.343	-.013	.009	-.511	-.020	.012	-.608	-.027	.015
20	-.465	.007	.010	-.385	0	.007	-.372	0	.006	-.537	-.004	.009	-.580	-.005	.011
	$\delta_A=30°$														
0	-0.442	-0.040	0.014	-0.295	-0.029	0.011	-0.309	-0.034	0.012	-0.493	-0.040	0.015	-0.569	-0.048	0.017
10	-.503	-.031	.020	-.357	-.024	.016	-.489	-.029	.019	-.697	-.038	.024	-.817	-.045	.027
15	-.520	-.023	.021	-.389	-.016	.017	-.539	-.023	.021	-.745	-.031	.026	-.840	-.036	.029
20	-.499	.003	.014	-.374	.006	.011	-.497	.002	.013	-.639	-.002	.016	-.718	-.008	.019

α°															
	$\delta_A=0°$														
0	-0.009	0	0	-0.270	-0.007	0.001	-0.376	-0.017	0.002	-0.477	-0.022	0.004	-0.541	-0.025	0.004
10	-.160	0	0	-.348	-.007	.002	-.510	-.017	.005	-.616	-.021	.007	-.699	-.025	.009
15	-.263	0	0	-.440	-.006	.003	-.558	-.016	.006	-.661	-.019	.008	-.740	-.023	.010
20	-.189	0	0	-.576	-.008	.003	-.675	-.009	.005	-.732	-.009	.007	-.804	-.010	.009
	$\delta_A=-15°$														
0	0.197	0.038	0.001	0.040	0.029	0	-0.115	0.019	0	-0.196	0.017	0	-0.202	0.016	0.006
10	.108	.040	-.005	-.067	.031	-.005	-.261	.021	-.004	-.394	.018	-.002	-.447	.014	-.002
15	.060	.038	-.008	-.130	.029	-.007	-.331	.019	-.006	-.461	.015	-.005	-.516	.013	-.003
20	.010	.029	-.013	-.184	.021	-.011	-.385	.012	-.009	-.512	.011	-.007	-.566	.006	-.005
	$\delta_A=-30°$														
0	0.569	0.070	0.012	0.438	0.061	0.010	0.273	0.050	0.007	0.149	0.042	0.006	0.144	0.043	0.007
10	.343	.072	-.001	.198	.064	-.002	.075	.056	-.003	.029	.054	-.003	.004	.051	-.003
15	.308	.070	-.007	.125	.062	-.007	-.031	.054	-.008	-.088	.051	-.008	.114	.050	-.008
20	.285	.046	-.015	.111	.040	-.014	-.061	{.044, .031}	-.015	-.171	{.042, .030}	-.014	{.192, .212}	{.039, .025}	-.013

(d) $0.30c_A$

α°															
	$\delta_A=0°$														
0	0.389	0.024	0.002	0.371	0.018	0.001	0.336	0.016	0	0.210	0.010	0	0.007	0	0
10	.261	.024	-.002	.265	.021	-.003	.204	.018	-.003	.051	.010	-.002	-.166	0	0
15	.150	.024	-.003	.149	.020	-.004	.074	.016	-.004	-.072	.009	-.003	-.278	0	0
20	.027	.017	-.004	.015	.015	-.005	-.056	.011	-.005	-.202	.006	-.003	-.412	0	0
	$\delta_A=15°$														
0	-0.030	-0.014	0.005	-0.034	-0.015	0.004	-0.063	-0.016	0.003	-0.208	-0.023	0.004	-0.366	-0.033	0.007
10	-.234	-.015	.008	-.262	-.017	.008	-.282	-.017	.007	-.444	-.024	.010	-.612	-.032	.014
15	-.316	-.012	.010	-.298	-.012	.008	-.352	-.014	.009	-.516	-.021	.012	-.668	-.028	.017
20	-.353	.001	.007	-.270	.006	.005	-.420	.001	.006	-.559	0	.008	-.675	-.001	.011
	$\delta_A=30°$														
0	-0.401	-0.042	0.015	-0.152	-0.027	0.010	-0.334	-0.036	0.011	-0.542	-0.045	0.015	-0.769	-0.055	0.021
10	-.419	-.027	.019	-.350	-.025	.016	-.587	-.036	.021	-.783	-.044	.026	-.972	-.051	.032
15	-.410	-.015	.019	-.385	-.015	.016	-.642	-.026	.023	-.825	-.035	.029	-1.006	-.042	.035
20	-.400	.009	.013	-.334	.012	.010	-.535	.006	.013	-.672	.002	.017	-.801	-.006	.020

α°															
	$\delta_A=0°$														
0	0.007	0	0	-0.205	-0.010	0.001	-0.431	-0.020	0.002	-0.598	-0.028	0.004	-0.713	-0.034	0.007
10	-.166	0	0	-.384	-.010	.002	-.597	-.020	.006	-.771	-.027	.009	-.891	-.034	.013
15	-.278	0	0	-.469	-.009	.003	-.665	-.016	.007	-.821	-.024	.011	-.930	-.029	.015
20	-.412	0	0	-.625	.004	.003	-.796	-.005	.007	-.911	-.009	.010	-.975	-.010	.012
	$\delta_A=-15°$														
0	0.248	0.038	0.002	0.026	0.027	0	-0.157	0.020	0	-0.290	0.013	0	-0.318	0.009	0.001
10	.143	.039	-.005	-.090	.030	-.005	-.325	.020	-.004	-.520	.011	-.003	-.623	.006	0
15	.087	.039	-.009	-.159	.028	-.007	-.398	.019	-.006	-.590	.011	-.003	-.700	.005	0
20	.031	.033	-.013	-.218	.021	-.011	-.456	.015	-.008	-.643	.007	-.005	-.757	.001	-.001
	$\delta_A=-30°$														
0	0.612	0.074	0.014	0.491	0.065	0.011	0.306	0.051	0.007	0.100	0.040	0.005	-0.015	0.035	0.005
10	.414	.074	0	.202	.065	-.002	.079	.056	-.003	-.042	.049	-.003	-.095	045	-.002
15	.371	.073	-.007	.148	.063	-.008	-.074	.054	-.009	-.218	.046	-.009	-.274	.043	-.007
20	{.352, .344}	{.051, .067}	-.015	.113	.043	-.016	-.111	.047	-.015	-.297	.038	-.014	-.397	{.025, .042}	-.012

TABLE III

FORCE TESTS, CLARK Y WING WITH PLAIN SHORT WIDE AILERON ON RIGHT WING TIP ONLY—0.20c_A HALF-SPAN ATTACHED TAB

[R. N.=609,000. Velocity=80 m. p. h. Yaw=0°]

(a) Outboard

δ_T	−40°			−30°			−20°			−10°			0°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
	$\delta_A=0°$														
0	0.111	0.008	0.001	0.099	0.008	0.000	0.074	0.005	0.000	0.024	0.002	0.000	−0.034	0	0
10	.043	.010	0	.039	.010	−.001	.005	.008	−.001	−.069	.003	−.001	−.138	0	0
15	−.010	.009	−.001	−.022	.009	−.002	−.064	.007	−.002	−.140	.002	−.001	−.208	0	0
20	−.100	.008	−.002	−.117	.007	−.003	−.151	.005	−.001	−.230	.001	−.001	−.296	0	0
	$\delta_A=15°$														
0	−0.109	−0.019	0.005	−0.116	−0.018	0.004	−0.153	−0.019	0.004	−0.184	−0.022	0.004	−0.293	−0.024	0.006
10	−.276	−.018	.009	−.294	−.018	.009	−.357	−.019	.009	−.375	−.019	.010	−.489	−.023	.011
15	−.377	−.019	.011	−.358	−.019	.011	−.408	−.016	.010	−.431	−.016	.012	−.531	−.024	.013
20	−.398	−.008	.009	−.403	−.004	.010	−.450	−.003	.008	−.463	−.008	.010	−.542	−.007	.010
	$\delta_A=30°$														
0	−0.387	−0.040	0.013	−0.300	−0.033	0.012	−0.316	−0.034	0.012	−0.398	−0.041	0.014	−0.466	−0.043	0.015
10	−.457	−.031	.019	−.392	−.027	.017	−.453	−.031	.018	−.540	−.038	.021	−.616	−.039	.023
15	−.473	−.026	.020	−.430	−.022	.019	−.488	−.027	.021	−.570	−.030	.023	−.634	−.032	.025
20	−.449	{−.004, −.007}	.015	−.413	−.001	.014	−.470	−.007	.015	−.531	−.007	.017	−.576	−.010	.018

δ_T	0°			10°			20°			30°			40°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
	$\delta_A=0°$														
0	0.034	0	0	−0.100	−0.004	0.000	−0.199	−0.007	0.001	−0.263	−0.011	0.001	−0.300	−0.013	0.002
10	−.138	0	0	−.214	−.003	.001	−.321	−.007	.003	−.389	−.011	.004	−.442	−.013	.005
15	−.208	0	0	−.282	−.004	.001	−.374	−.007	.003	−.439	−.010	.004	−.487	−.012	.006
20	−.296	0	0	−.369	−.002	.001	−.455	−.006	.003	−.522	{−.011, −.007}	.004	−.561	.007	.006
	$\delta_A=-15°$														
0	0.111	0.033	0.001	0.057	0.030	0.001	−0.029	0.029	0	−0.071	0.022	0	−0.087	0.022	0.001
10	.048	.035	−.005	−.014	.032	−.005	−.112	.030	−.005	−.176	.023	−.004	−.216	.023	−.003
15	.010	.032	−.008	−.059	.029	−.007	−.162	.027	−.007	−.234	.020	−.005	−.283	.019	−.004
20	−.027	.024	−.012	−.097	.023	−.010	−.210	.016	−.010	−.279	.014	−.008	−.329	.012	.007
	$\delta_A=-30°$														
0	0.462	0.059	0.011	0.394	0.057	0.009	0.281	0.052	0.008	0.198	0.047	0.006	0.164	0.047	0.007
10	.231	.066	−.002	.189	.063	−.002	.141	.060	−.002	.081	.055	−.002	.061	.055	−.002
15	.199	.063	−.006	.139	.061	−.007	.065	.058	−.007	.019	.053	−.007	.025	.053	−.006
20	.176	.042	−.014	.122	.039	−.014	.035	.037	−.015	−.029	.031	−.014	−.047	.031	−.013

(b) Center

δ_T	−40°			−30°			−20°			−10°			0°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
	$\delta_A=0°$														
0	0.106	0.009	.001	0.089	0.008	0.001	0.078	0.007	0	0.030	0.003	0	−0.024	0	0
10	−.004	.008	0	−.019	.011	−.001	−.022	.008	−.001	−.074	.003	0	−.104	0	0
15	−.089	.007	0	−.100	.010	0	−.102	.008	−.001	−.151	.004	0	−.164	0	0
20	−.202	.005	0	−.219	.003	0	−.223	.005	0	−.268	.002	.001	−.250	0	0
	$\delta_A=15°$														
0	−0.236	−0.024	0.005	−0.215	−0.024	0.005	−0.198	−0.017	0.005	−0.254	−0.023	0.006	−0.271	−0.027	0.006
10	−.402	−.022	.010	−.373	−.021	.009	−.353	−.016	.009	−.405	−.022	.010	−.456	−.026	.011
15	−.452	−.020	.019	−.409	−.015	.011	−.396	−.016	.011	−.455	−.019	.013	−.512	−.022	.015
20	−.469	−.004	.011	−.398	−.001	.009	−.416	−.001	.009	−.476	−.004	.010	−.539	−.003	.011
	$\delta_A=30°$														
0	−0.419	−0.038	0.014	−0.338	−0.031	0.013	−0.382	−0.033	0.013	−0.439	−0.038	0.014	−0.531	−0.042	0.016
10	−.459	−.030	.019	−.425	−.025	.018	−.504	−.033	.019	−.593	−.036	.022	−.661	−.040	.024
15	−.481	−.021	.021	−.468	−.017	.020	−.551	−.026	.023	−.636	−.028	.025	−.716	−.033	.028
20	−.494	.002	.016	−.440	.004	.015	−.496	.001	.015	−.564	0	.016	−.615	−.003	.018

δ_T	0°			10°			20°			30°			40°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
	$\delta_A=0°$														
0	−0.024	0	0	−0.115	−0.004	0.001	−0.190	−0.007	0	−0.256	−0.011	0.002	−0.295	−0.012	0.002
10	−.104	0	0	−.229	−.005	.002	−.316	−.003	.002	−.376	−.004	.004	−.431	−.013	.003
15	−.164	0	0	−.310	−.004	.003	−.376	{−.005, −.001}	.003	−.423	−.002	.005	−.479	−.012	.006
20	−.250	0	0	−.416	−.004	.003	−.483	−.001	.003	−.529	−.005	.005	−.560	−.005	.006
	$\delta_A=-15°$														
0	0.088	0.034	0.001	0.037	0.030	0.001	−0.018	0.027	0	−0.066	0.023	0	−0.084	0.023	0.001
10	.043	.035	−.005	−.030	.031	−.004	−.099	.027	−.005	−.168	.023	−.004	−.198	.022	−.003
15	.013	.033	−.007	−.076	.029	−.006	−.143	.032	−.006	−.212	.021	−.005	−.252	.021	−.004
20	−.013	.025	−.010	−.115	.022	−.009	−.186	.028	−.009	−.257	.016	−.007	−.307	.015	−.006
	$\delta_A=-30°$														
0	0.427	0.061	0.010	0.361	0.055	0.009	0.293	0.055	0.008	0.249	0.049	0.008	0.234	0.049	0.007
10	.232	.065	−.001	.162	.061	−.002	.123	.059	−.003	.121	.055	−.001	.077	.055	−.002
15	.193	.064	−.006	.113	.060	−.006	.048	.057	−.007	.001	.053	−.006	−.032	.052	−.007
20	.181	{.042, .057}	−.013	.102	.051	−.013	.028	.035	−.016	−.025	.033	−.012	−.059	.054	−.012

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(c) Inboard

$\delta_A=0°$

α (°)															
0	0.112	0.011	0.001	0.077	0.006	0	0.071	0.007	0	0.013	0.003	0	−0.035	0	0
10	−.040	.008	0	−.056	.006	0	−.056	.006	−.001	−.099	.002	0	−.137	0	0
15	−.148	.007	−.001	−.148	.004	−.001	−.131	.005	−.001	−.164	.003	.001	−.207	0	0
20	−.226	.003	−.001	−.236	.001	−.001	−.210	.002	−.001	−.245	.001	.001	−.289	0	0

$\delta_A=0°$

0	−0.035	0	0	−0.100	−0.003	0	−0.176	−0.007	0.001	−0.218	−0.009	0.001	−0.254	−0.012	0.002
10	−.137	0	0	−.197	−.003	.001	−.266	−.006	.002	−.308	−.009	.003	−.354	−.012	.003
15	−.207	0	0	−.250	−.003	.001	−.308	−.007	.002	−.354	−.008	.003	−.400	−.012	.004
20	−.289	0	0	−.338	−.001	.001	−.404	−.002	.002	−.441	−.003	.003	−.484	−.008	.003

$\delta_A=15°$

0	−0.182	−0.023	0.005	−0.185	−0.024	0.005	−0.141	−0.022	0.005	−0.208	−0.023	0.005	−0.230	−0.029	0.005
10	−.347	−.021	.009	−.342	−.019	.010	−.292	−.019	.009	−.364	−.021	.010	−.398	−.025	.010
15	−.393	−.019	.012	−.378	−.016	.011	−.338	−.017	.010	−.415	−.019	.011	−.463	−.022	.012
20	−.430	−.006	.010	−.385	−.005	.009	−.363	−.003	.008	−.445	−.007	.010	−.496	−.006	.010

$\delta_A=-15°$

0	0.110	0.033	0.001	0.052	0.031	0.001	−0.021	0.028	0.001	−0.064	0.026	0.001	−0.075	0.023	0.001
10	.052	.035	−.004	−.022	.032	−.005	−.101	.028	−.005	−.157	.026	−.004	−.187	.023	−.004
15	.018	.033	−.007	−.062	.030	−.007	−.137	.029	−.007	−.193	.025	−.006	−.226	.023	−.006
20	−.013	.026	−.011	−.094	.023	−.010	−.164	.020	−.010	−.222	.019	−.009	−.260	{.017 .014}	−.009

$\delta_A=30°$

0	−0.368	−0.037	0.014	−0.340	−0.038	0.013	−0.335	−0.036	0.013	−0.410	−0.037	0.014	−0.481	−0.041	0.015
10	−.455	−.030	.019	−.445	−.028	.019	−.463	−.030	.019	−.535	−.034	.022	−.586	−.038	.023
15	−.487	−.025	.022	−.465	−.021	.020	−.504	−.024	.021	−.590	−.029	.024	−.644	−.032	.025
20	−.459	−.003	.013	−.422	−.001	.014	−.461	−.005	.015	−.532	−.010	.016	−.578	−.010	.018

$\delta_A=-30°$

0	0.430	0.066	0.011	0.372	0.060	0.009	0.292	0.051	0.008	0.227	0.050	0.007	0.234	0.049	0.007
10	.252	.067	−.002	.201	.064	−.001	.144	.060	−.002	.104	.059	−.002	.060	.055	−.001
15	.221	.065	−.007	.134	.061	−.007	.052	.058	−.008	−.004	.057	−.008	−.042	.054	−.007
20	.206	.042	−.014	.121	.039	−.014	.031	.034	−.014	−.029	.031	−.014	−.070	.029	−.014

TABLE IV

FORCE TESTS, CLARK Y WING WITH PLAIN SHORT WIDE AILERON ON RIGHT WING TIP ONLY—FULL-SPAN INSET TAB

[R. N.=609,000. Velocity=80 m. p. h. Yaw=0°]

(a) $0.05c_A$

$\delta_A=0°$

δ_T	−40°			−30°			−20°			−10°			0°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
0	0.019	0.005	−0.001	−0.001	0.004	0	−0.008	0.002	0	−0.022	0.002	0	−0.070	0	0
10	−.083	.003	−.001	−.095	.003	−.001	−.097	.001	0	−.098	.002	−.001	−.143	0	0
15	−.145	.002	−.001	−.148	.002	−.001	−.149	.002	−.001	−.151	.003	−.001	−.185	0	0
20	−.234	0	−.001	−.239	.001	−.001	−.232	0	−.001	−.239	.001	−.001	−.266	0	0

$\delta_A=0°$

δ_T	0°			10°			20°			30°			40°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
0	−0.070	0	0	−0.123	−0.004	0.001	−0.153	−0.007	0.001	−0.182	−0.008	0.001	−0.212	−0.010	0.001
10	−.143	0	0	−.202	−.004	.001	−.236	−.007	.001	−.278	−.010	.002	−.314	−.011	.003
15	−.185	0	0	−.244	−.004	.001	−.280	−.006	.002	−.319	−.008	.002	−.351	−.010	.003
20	−.266	0	0	−.328	−.003	.001	−.368	−.004	.002	−.405	−.004	.003	−.439	−.005	.003

$\delta_A=15°$

δ_T	−40°			−30°			−20°			−10°			0°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
0	−0.194	−0.023	0.005	−0.197	−0.023	0.005	−0.178	−0.022	0.004	−0.178	−0.021	0.004	−0.233	−0.026	0.005
10	−.315	−.020	.008	−.317	−.020	.009	−.302	−.020	.008	−.302	−.019	.008	−.351	−.021	.009
15	−.346	−.016	.010	−.355	−.017	.010	−.334	−.015	.010	−.334	−.014	.010	−.386	−.018	.011
20	−.376	−.004	.008	−.316	−.004	.009	−.302	−.004	.008	−.370	−.003	.008	−.415	−.004	.008

$\delta_A=-15°$

δ_T	0°			10°			20°			30°			40°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
0	0.033	0.032	0	−0.008	0.028	0	−0.010	0.028	0	−0.015	0.027	0	−0.031	0.026	0
10	0	.033	−.006	−.054	.030	−.005	−.074	.028	−.005	−.101	.028	−.004	−.127	.026	−.004
15	−.027	.032	−.008	−.086	.028	−.007	−.113	.025	−.007	−.142	.023	−.006	−.171	.022	−.006
20	−.052	.025	−.011	−.113	.020	−.010	−.145	.018	−.010	−.176	.017	−.009	−.209	.015	−.009

$\delta_A=30°$

δ_T	−40°			−30°			−20°			−10°			0°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
0	−0.340	−0.036	0.013	−0.337	−0.036	0.013	−0.264	−0.032	0.011	−0.318	−0.035	0.013	−0.386	−0.036	0.013
10	−.455	−.029	.019	−.415	−.030	.018	−.371	−.028	.016	−.413	−.029	.018	−.473	−.028	.019
15	−.444	−.020	.020	−.441	−.020	.020	−.401	−.019	.018	−.445	−.020	.020	−.504	−.028	.021
20	−.488	.003	.013	−.422	.003	.014	−.394	.003	.013	−.425	.003	.013	−.466	−.001	.014

$\delta_A=-30°$

δ_T	0°			10°			20°			30°			40°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
0	0.266	0.061	0.007	0.218	0.049	0.006	0.211	0.049	0.007	0.226	0.050	0.007	0.224	0.051	0.007
10	.157	.062	−.003	.136	.056	−.002	.134	.058	−.002	.114	.059	−.003	.100	.059	−.003
15	.113	.061	−.003	.071	.056	−.008	.066	.057	−.008	.056	.055	−.008	.042	.055	−.008
20	.111	.636	−.014	.064	.038	−.014	.051	.038	−.014	.035	.037	−.014	.018	.036	−.014

TABLE IV—Continued

FORCE TESTS, CLARK Y WING WITH PLAIN SHORT WIDE AILERON ON RIGHT WING TIP ONLY—FULL-SPAN INSET TAB—Continued

[R. N.=609,000. Velocity=80 m. p. h. Yaw=0°]

δ_T	−40°			−30°			−20°			−10°			0°		
	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
	(b) $0.10c_A$														
α	$\delta_A=0°$														
°															
0	0.086	0.011	0	0.054	0.009	0.001	0.039	0.007	0	0.004	0.004	0	-0.070	0	0
10	-.015	.008	-.001	-.045	.005	-.001	-.045	.007	-.002	-.072	.004	-.001	-.143	0	0
15	-.084	.004	-.001	-.107	.004	-.001	-.088	.008	-.002	-.120	.004	-.001	-.185	0	0
20	-.177	.009	-.002	-.194	.008	-.002	-.184	.009	-.002	-.188	.008	-.001	-.266	0	0
	$\delta_A=15°$														
0	-0.169	-0.021	0.005	-0.172	-0.021	0.005	-0.078	-0.013	0.004	-0.153	-0.018	0.004	-0.233	-0.026	0.005
10	-.297	-.018	.009	-.284	-.018	.008	-.176	-.009	.006	-.272	-.017	.007	-.351	-.021	.009
15	-.326	-.016	.010	-.308	-.015	.009	-.210	-.008	.007	-.312	-.015	.009	-.386	-.018	.011
20	-.359	.004	.008	-.340	.004	.007	-.266	.006	.006	-.349	.002	.007	-.415	-.004	.008
	$\delta_A=30°$														
0	-0.302	-0.033	0.012	-0.280	-0.031	0.012	-0.190	-0.026	0.009	-0.300	-0.031	0.011	-0.386	-0.036	0.013
10	-.364	-.025	.017	-.346	-.026	.016	-.304	-.024	.015	-.398	-.028	.017	-.473	-.028	.019
15	-.384	-.019	.018	-.360	-.019	.017	-.340	-.017	.016	-.430	-.022	.019	-.504	-.028	.021
20	-.379	.008	.013	-.360	.007	.013	-.332	.007	.012	-.407	.005	.013	-.466	-.001	.014
	(c) $0.20c_A$														
	$\delta_A=0°$														
°															
0	0.187	0.020	0.001	0.144	0.016	0	-0.133	0.016	-0.001	0.036	0.008	0	-0.070	0	0
10	.092	.018	-.004	.075	.016	-.002	.081	.019	-.002	-.024	.009	-.002	-.143	0	0
15	.022	.014	-.003	0	.014	-.003	.026	.016	-.004	-.077	.007	-.002	-.185	0	0
20	-.055	.008	-.004	-.081	.010	-.004	-.057	.010	-.005	-.153	.003	-.003	-.266	0	0
	$\delta_A=15°$														
0	-0.069	-0.013	0.004	-0.075	-0.013	0.004	-0.033	-0.007	0.003	-0.129	-0.017	0.004	-0.233	-0.026	0.005
10	-.186	-.011	.006	-.157	-.008	.005	-.138	-.004	.005	-.241	-.014	.008	-.351	-.021	.009
15	-.246	-.011	.008	-.075	-.007	.004	-.183	-.006	.005	-.291	-.013	.009	-.386	-.018	.011
20	-.262	-.001	.007	-.141	.003	.003	-.244	-.001	.005	-.341	-.002	.008	-.415	-.004	.008
	$\delta_A=30°$														
0	-0.228	-0.028	0.010	-0.043	-0.015	0.006	-0.154	-0.022	0.008	-0.273	-0.029	0.011	-0.386	-0.036	0.013
10	-.242	-.019	.013	-.155	-.014	.011	-.271	-.021	.013	-.380	-.026	.017	-.473	-.028	.019
15	-.204	-.010	.013	-.200	-.010	.012	-.315	-.017	.015	-.418	-.021	.019	-.504	-.028	.021
20	-.114	.008	.006	-.211	.004	.008	-.312	.003	.011	-.392	-.002	.013	-.466	-.001	.014

δ_T	0°			10°			20°			30°			40°		
	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
	(b) $0.10c_A$														
α	$\delta_A=0°$														
°															
0	-0.070	0	0	-0.152	-0.005	0.001	-0.205	-0.008	0.001	-0.241	-0.010	0.001	-0.275	-0.014	0.002
10	-.143	0	0	-.230	-.007	.001	-.297	-.010	.002	-.341	-.012	.003	-.379	-.015	.004
15	-.185	0	0	-.270	-.006	.001	-.330	-.010	.003	-.376	-.011	.004	-.416	-.013	.005
20	-.266	0	0	-.352	-.002	.001	-.414	-.003	.002	-.456	.001	.003	-.491	-.001	.004
	$\delta_A=-15°$														
0	0.033	0.032	0	-0.042	0.028	0	-0.041	0.026	0	-0.060	0.026	0	-0.079	0.023	0
10	0	.033	-.006	-.091	.028	-.005	-.126	.025	-.005	-.160	.023	-.004	-.203	.021	-.004
15	-.027	.032	-.008	-.124	.023	-.007	-.166	.021	-.007	-.208	.020	-.006	-.247	.019	-.005
20	-.052	.025	-.011	-.151	.019	-.010	-.199	.017	-.010	-.244	.021	-.008	-.286	.019	-.007
	$\delta_A=-30°$														
0	0.266	0.061	0.007	0.176	0.048	0.006	0.104	0.043	0.005	0.171	0.049	0.006	0.175	0.049	0.006
10	.157	.062	-.003	.106	.056	-.002	.084	.054	-.002	.065	.056	-.003	.065	.055	-.003
15	.113	.061	-.008	.033	.053	-.008	.013	.054	-.008	0	.053	-.008	-.017	.052	-.007
20	.111	.036	-.014	.020	.037	-.015	.001	.052	-.014	-.026	.051	-.014	-.045	.050	-.014
	(c) $0.20c_A$														
	$\delta_A=0°$														
°															
0	-0.070	0	0	-0.177	-0.007	0.001	-0.266	-0.014	0.002	-0.320	-0.018	0.003	-0.372	-0.021	0.004
10	-.143	0	0	-.254	-.007	.002	-.342	-.013	.005	-.414	-.018	.006	-.461	-.021	.008
15	-.185	0	0	-.282	-.006	.002	-.367	-.012	.005	-.439	-.017	.007	-.490	-.026	.009
20	-.266	0	0	-.364	-.002	.002	-.450	-.006	.005	-.513	-.007	.006	-.550	-.007	.008
	$\delta_A=-15°$														
0	0.033	0.032	0	-0.072	0.025	0	-0.124	0.021	0	-0.133	0.020	0.001	-0.132	0.019	0
10	0	.033	-.006	-.123	.026	-.004	-.216	.020	-.003	-.262	.017	-.002	-.306	.014	-.001
15	-.027	.032	-.008	-.153	.024	-.006	-.250	.018	-.005	-.308	.013	-.003	-.344	.012	-.002
20	-.052	.025	-.011	-.182	.018	-.008	-.280	.012	-.007	-.343	.010	-.005	-.376	.007	-.004
	$\delta_A=-30°$														
0	0.266	0.061	0.007	0.148	0.044	0.005	0.037	0.038	0.004	-0.033	0.033	0.003	0.093	0.045	0.005
10	.157	.062	-.003	.084	.055	-.003	.006	.048	-.003	.012	.051	-.003	.029	.052	-.003
15	.113	.061	-.008	0	.053	-.007	-.082	.047	-.008	-.034	.046	-.007	-.079	.046	-.007
20	.111	.036	-.014	-.006	.045	-.014	-.105	.038	-.014	-.145	.036	-.013	-.149	.034	-.012

TABLE V

FORCE TESTS, CLARK Y WING WITH PLAIN SHORT WIDE AILERON ON RIGHT WING TIP ONLY—0.20c_A HALF-SPAN INSET TAB

[R. N=609,000. Velocity=80 m. p. h. Yaw=0°]

δ_T	−40°			−30°			−20°			−10°			0°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
(a) Outboard															
δ_A=0°															
0	0.059	0.008	0	0.035	0.007	0	0.026	0.006	0	−0.012	0.004	−0.001	−0.070	0	0
10	.007	.009	−.002	−.008	.008	−.001	−.012	.007	−.001	.069	.004	−.001	−.143	0	0
15	−.025	.009	−.002	−.043	.009	−.002	−.056	.007	−.002	.126	.004	−.001	−.185	0	0
20	−.100	.007	−.003	−.131	.007	−.002	−.145	.006	−.002	.198	.003	−.002	−.266	0	0
δ_A=15°															
0	−0.087	−0.018	0.003	−0.102	−0.019	0.004	−0.105	−0.018	0.003	−0.143	−0.021	0.005	−0.233	−0.026	0.005
10	−.227	−.017	.007	−.246	−.015	.007	−.232	−.014	.007	−.281	−.017	.008	−.351	−.021	.009
15	−.292	−.016	.008	−.286	−.012	.008	−.287	−.012	.008	−.328	−.015	.009	−.386	−.018	.011
20	−.316	−.004	.007	−.336	−.001	.008	−.334	0	.008	−.376	−.004	.008	−.415	−.004	.008
δ_A=30°															
0	−0.308	−0.035	0.011	−0.229	−0.025	0.010	−0.280	−0.029	0.011	−0.323	−0.033	0.011	−0.386	−0.036	0.013
10	−.344	−.027	.015	−.323	−.023	.015	−.366	−.026	.016	−.415	−.029	.018	−.473	−.028	.019
15	−.378	−.021	.017	−.361	−.018	.017	−.400	−.020	.018	−.448	−.024	.019	−.504	−.028	.021
20	−.362	−.001	.012	−.346	.005	.012	−.389	.003	.013	−.422	.002	.014	−.466	−.001	.014
(b) Center															
δ_A=0°															
0	0.068	0.008	0.001	0.051	0.007	0	0.022	0.007	0	−0.006	0.004	0	−0.070	0	0
10	−.026	.006	−.001	−.044	.005	−.001	−.045	.006	−.001	−.081	.002	−.001	−.143	0	0
15	−.081	.004	−.001	−.098	.002	−.001	−.091	.004	−.002	−.122	0	−.001	−.185	0	0
20	−.160	.002	−.002	−.178	.002	−.002	−.164	.003	−.002	−.199	.001	−.002	−.266	0	0
δ_A=15°															
0	−0.140	−0.023	0.005	−0.147	−0.026	0.005	−0.124	−0.018	0.004	−0.145	−0.024	0.004	−0.233	−0.026	0.005
10	−.291	−.020	.009	−.292	−.020	.009	−.252	−.015	.008	−.296	−.020	.008	−.351	−.021	.009
15	−.337	−.020	.010	−.304	−.017	.009	−.290	−.014	.009	−.327	−.019	.009	−.386	−.018	.011
20	−.353	−.005	.009	−.341	−.005	.009	−.338	−.003	.008	−.376	−.005	.008	−.415	−.004	.008
δ_A=30°															
0	−0.303	−0.036	0.013	−0.235	−0.030	0.011	−0.279	−0.033	0.011	−0.336	−0.038	0.013	−0.386	−0.036	0.013
10	−.332	−.027	.017	−.308	−.025	.016	−.357	−.029	.016	−.412	−.031	.018	−.473	−.028	.019
15	−.360	−.021	.018	−.344	−.019	.017	−.395	−.023	.018	−.445	−.026	.020	−.504	−.028	.021
20	−.315	.002	.014	−.341	.005	.013	−.384	.003	.013	−.418	.001	.014	−.466	−.001	.014

δ_T	0°			10°			20°			30°			40°		
α (°)	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
(a) Outboard															
δ_A=0°															
0	−0.070	0	0	−0.124	−0.004	0	−0.180	−0.006	0.001	−0.216	−0.009	0.002	−0.221	−0.010	0.003
10	−.143	0	0	−.206	−.004	.001	−.260	−.007	.002	−.300	−.010	.004	−.318	−.010	.005
15	−.185	0	0	−.240	−.003	.001	−.289	−.006	.001	−.335	−.008	.004	−.350	−.008	.005
20	−.266	0	0	−.315	−.001	.006	−.372	−.005	.003	−.408	−.005	.004	−.434	−.002	.005
δ_A=−15°															
0	0.033	0.032	0	−0.017	0.026	0	−0.047	0.026	0	−0.047	0.026	0	−0.052	0.025	0.001
10	0	.032	−.006	−.061	.028	−.005	−.115	.026	−.005	−.134	.025	−.003	−.150	.024	−.002
15	−.027	.032	−.008	−.091	.025	−.007	−.146	.024	−.007	−.174	.023	−.005	−.192	.023	−.004
20	−.052	.025	−.011	−.116	.020	−.010	−.174	.018	−.009	−.207	.017	−.007	−.225	.016	−.006
δ_A=−30°															
0	0.266	0.061	0.007	0.196	0.050	0.006	0.142	0.048	0.005	0.146	0.050	0.006	0.128	0.047	0.006
10	.157	.062	−.003	.082	.057	−.003	.069	.054	−.003	.096	.058	−.003	.090	.056	−.003
15	.113	.061	−.008	.060	.055	−.008	.019	.053	−.008	.036	.055	−.008	.051	.055	−.007
20	.111	.036	−.014	.053	.046	−.014	.001	.043	−.014	.008	.046	−.014	−.004	.046	−.013
(b) Center															
δ_A=0°															
0	−0.070	0	0	−0.125	−0.007	0	−0.164	−0.008	0.001	−0.196	−0.011	0.002	−0.214	−0.013	0.002
10	−.143	0	0	−.197	−.007	.001	−.242	−.009	.002	−.273	−.012	.003	−.305	−.014	.004
15	−.185	0	0	−.234	−.007	.001	−.282	−.010	.002	−.318	−.013	.003	−.346	−.015	.005
20	−.266	0	0	−.314	.003	.001	−.362	−.003	.002	−.382	−.004	.003	−.376	−.005	.004
δ_A=−15°															
0	0.033	0.032	0	−0.022	0.025	0	−0.032	0.025	0	−0.050	0.023	0.001	−0.065	0.021	0
10	0	.032	−.006	−.067	.026	−.004	−.099	.025	−.004	−.130	.023	−.003	−.152	.021	−.003
15	−.027	.032	−.008	−.098	.023	−.006	−.150	.021	−.006	−.165	.019	−.005	−.189	.017	−.005
20	−.052	.025	−.011	−.120	.018	−.009	−.159	.017	−.009	−.196	.014	−.008	−.218	.013	−.007
δ_A=−30°															
0	0.266	0.061	0.007	0.206	0.046	0.006	0.170	0.044	0.006	0.210	0.049	0.007	0.224	0.050	0.006
10	.157	.062	−.003	.100	.055	−.002	.105	.053	−.002	.109	.055	.002	.088	.052	−.002
15	.113	.061	−.008	.049	.051	−.008	.031	.050	−.007	.027	.050	−.008	.006	.047	−.007
20	.111	.036	−.014	.043	.045	−.018	.011	.043	−.013	.001	.042	−.013	−.022	.041	−.013

TABLE V—Continued

FORCE TESTS, CLARK Y WING WITH PLAIN SHORT WIDE AILERON ON RIGHT WING TIP ONLY—0.20c_A HALF-SPAN INSET TAB—Continued

[R. N=609,000. Velocity=80 m. p. h. Yaw=0°]

(c) Inboard

δ_T	−40°			−30°			−20°			−10°			0°		
	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
α (°)	$\delta_A=0°$														
0	0.054	0.011	0	0.044	0.009	0	0.024	0.007	−0.001	−0.015	0.005	0	−0.070	0	0
10	−.059	.008	−.001	−.063	.006	−.001	−.060	.007	−.001	−.090	.005	−.001	−.143	0	0
15	−.130	.005	−.002	−.130	.005	−.001	−.105	.006	−.002	−.135	.004	−.001	−.185	0	0
20	−.195	.004	−.001	−.193	.004	−.002	−.179	.004	−.002	−.212	.004	−.001	−.266	0	0
	$\delta_A=15°$														
0	−0.150	−0.019	0.004	−0.142	−0.020	0.004	−0.125	−0.018	0.004	−0.152	−0.020	0.004	−0.233	−0.026	0.005
10	−.276	−.016	.007	−.194	−.010	.006	−.236	−.013	.007	−.276	−.015	.008	−.351	−.021	.009
15	−.313	−.015	.009	−.228	−.007	.007	−.276	−.011	.008	−.322	−.014	.009	−.386	−.018	.011
20	−.348	−.001	.008	−.282	0	.007	−.321	−.001	.007	−.359	−.001	.008	−.415	−.004	.008
	$\delta_A=30°$														
0	−0.301	−0.033	0.012	−0.238	−0.029	0.010	−0.284	−0.033	0.012	−0.330	−0.035	0.012	−0.386	−0.036	0.013
10	−.366	−.027	.016	−.322	−.024	.015	−.377	−.028	.017	−.425	−.029	.019	−.473	−.028	.019
15	−.392	−.020	.018	−.356	−.017	.016	−.415	−.020	.018	−.457	−.023	.021	−.504	−.028	.021
20	−.384	.004	.013	−.340	.005	.012	−.387	.004	.013	−.423	.004	.013	−.466	−.001	.014

δ_T	0°			10°			20°			30°			40°		
	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
α (°)	$\delta_A=0°$														
0	−0.070	0	0	−0.124	−0.005	0	−0.157	−0.008	0.001	−0.183	−0.009	0.001	−0.194	−0.010	0.001
10	−.143	0	0	−.195	−.004	.001	−.235	−.007	.002	−.264	−.009	.003	−.282	−.011	.003
15	−.185	0	0	−.228	−.003	.001	−.270	−.006	.002	−.302	−.008	.003	−.318	−.010	.004
20	−.266	0	0	−.312	.001	.001	−.360	0	.002	−.383	−.001	.003	−.394	0	.003
	$\delta_A=-15°$														
0	0.033	0.032	0	−0.015	0.028	0	−0.033	0.027	0	−0.051	0.025	0	−0.059	0.025	0
10	0	.032	−.006	−.061	.030	−.005	−.096	.028	−.004	−.121	.026	−.004	−.141	.024	−.002
15	−.027	.032	−.008	−.087	.028	−.007	−.126	.026	−.007	−.154	.024	−.006	−.171	.022	−.004
20	−.052	.025	−.011	−.111	.022	−.010	−.152	.018	−.009	−.187	.017	−.008	−.204	.016	−.007
	$\delta_A=-30°$														
0	0.266	0.061	0.007	0.210	.048	0.006	0.160	0.046	0.006	0.238	0.051	0.007	0.252	0.053	0.007
10	.157	.062	−.003	.075	.059	−.004	.042	.057	−.004	.045	.057	−.003	.050	.057	−.003
15	.113	.061	−.008	.049	.057	−.009	.009	.054	−.009	−.007	.055	−.008	−.018	.057	−.008
20	.111	.036	−.014	.048	.049	−.014	−.007	.044	−.014	−.020	.041	−.013	−.036	.040	−.013

TABLE VI

FORCE TESTS, CLARK Y WING WITH PLAIN MEDIUM-SIZE AILERON ON RIGHT WING TIP ONLY—0.10c_A FULL-SPAN INSET TAB

[R. N.=609,000. Velocity=80 m. p. h. Yaw=0°]

δ_T	−40°			−30°			−20°			−10°			0°		
	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
α (°)	$\delta_A=0°$														
0	0.094	0.010	0	0.065	0.008	0	0.049	0.006	0	0.028	0.005	0	−0.042	0	0
10	−.039	.003	−.001	−.049	.003	0	−.049	.002	0	−.055	.001	0	−.077	0	0
15	−.082	.001	−.001	−.080	0	0	−.086	.001	0	−.077	.001	0	−.112	0	0
20	−.150	−.005	−.001	−.150	−.005	0	−.144	−.003	0	−.146	−.002	0	−.189	0	0
	$\delta_A=15°$														
0	−0.137	−0.020	0.004	−0.146	−0.019	0.004	−0.071	−0.013	0.003	−0.129	−0.019	0.004	−0.177	−0.022	0.005
10	−.189	−.020	.006	−.186	−.019	.007	−.173	−.017	.007	−.171	−.020	.007	−.210	−.021	.008
15	−.202	−.018	.008	−.202	−.017	.008	−.173	−.016	.007	−.196	−.019	.008	−.226	−.019	.009
20	−.287	−.009	.008	−.274	−.009	.008	−.178	−.006	.007	−.288	−.009	.008	−.356	−.008	.009
	$\delta_A=30°$														
0	−0.262	−0.034	0.010	−0.237	−0.032	0.010	−0.151	−0.028	0.008	−0.262	−0.034	0.010	−0.316	−0.037	0.011
10	−.299	−.033	.015	−.287	−.033	.015	−.218	−.028	.013	−.318	−.034	.015	−.376	−.036	.016
15	−.310	−.032	.017	−.288	−.032	.016	−.246	−.029	.015	−.326	−.034	.011	−.387	−.036	.019
20	−.335	−.004	.013	−.316	−.003	.013	−.278	−.003	.012	−.358	−.004	.013	−.404	−.007	.015

δ_T	0°			10°			20°			30°			40°		
	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
α (°)	$\delta_A=0°$														
0	−0.042	0	0	−0.126	−0.006	0.001	−0.182	−0.007	0.001	−0.238	−0.011	0.002	−0.262	−0.013	0.003
10	−.077	0	0	−.147	−.005	.001	−.218	−.009	.002	−.268	−.013	.003	−.309	−.016	.004
15	−.112	0	0	−.182	−.006	.001	−.250	−.010	.002	−.303	−.012	.004	−.336	−.014	.005
20	−.181	0	0	−.252	−.008	.002	−.346	−.012	.003	−.388	−.013	.004	−.426	−.014	.005
	$\delta_A=-15°$														
0	0.068	0.026	0	0	0.023	0	0.009	0.022	0	0.031	0.024	−0.001	0.029	0.025	0
10	.043	.025	−.004	−.026	.023	−.003	−.050	.021	−.004	−.075	.019	−.004	−.104	.017	−.003
15	.026	.021	−.006	−.045	.017	−.005	−.090	.015	−.005	−.120	.012	−.005	−.162	.011	−.004
20	−.026	−0.001	−.008	−.088	−.007	−.007	−.137	−.010	−.007	−.195	−.013	−.006	−.234	−.014	−.005
	$\delta_A=-30°$														
0	0.224	0.044	0.004	0.177	0.041	0.004	0.097	0.036	0.003	0.177	0.041	0.004	0.194	0.042	0.004
10	.214	.045	−.003	.166	.042	−.003	.088	.038	−.004	.133	.040	−.003	.195	.044	−.003
15	.212	.042	.006	.152	.038	−.006	.086	.035	−.006	.128	.036	−.006	.193	.040	−.006
20	.156	.023	−.012	.129	.017	−.011	.077	.013	−.011	.102	.014	−.011	.136	.016	−.011

TABLE VII

FORCE TESTS, CLARK Y WING WITH PLAIN SHORT WIDE AILERON ON RIGHT WING TIP ONLY—0.20c_A HALF-SPAN CENTER INSET TAB AND AUXILIARY BALANCE

[R. N.=609,000. Velocity=80 m. p. h.]

δ_T	−30°			−20°			−10°			0°		
	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
	(a) 0.1875c_A by 0.445b_A paddle balance. Yaw=0°											
α, °	δ_A=0°											
0	0.036	0.009	0	0.018	0.007	−0.001	−0.015	0.003	−0.001	−0.065	0	0
10	−.028	.009	0	−.038	.007	−.001	−.073	.003	0	−.127	0	0
15	−.076	.006	−.001	−.083	.006	−.001	−.110	.003	−.001	−.164	0	0
20	−.141	.001	−.001	−.160	.001	−.002	−.191	−.001	−.001	−.242	0	0
	δ_A=15°											
0	−0.167	−0.019	0.005	−0.138	−0.016	0.004	−0.185	−0.019	0.005	−0.232	−0.022	0.005
10	−.204	−.012	.008	−.237	−.014	.009	−.300	−.019	.010	−.341	−.021	.010
15	−.234	−.010	.009	−.280	−.012	.010	−.330	−.015	.010	−.371	−.018	.011
20	−.275	−.003	.008	−.320	−.004	.008	−.362	−.004	.008	−.400	−.004	.009
	δ_A=30°											
0	−0.224	−0.028	0.011	−0.252	−0.030	0.011	−0.307	−0.031	0.012	−0.350	−0.035	0.013
10	−.316	−.022	.017	−.359	−.025	.017	−.417	−.027	.019	−.463	−.031	.020
15	−.336	−.017	.018	−.380	−.018	.018	−.437	−.020	.020	−.483	−.023	.021
20	−.338	.004	.013	−.374	.004	.013	−.420	.003	.014	−.456	.001	.015
	(b) 0.275c_A by 0.445b_A paddle balance. Yaw=0°											
	δ_A=0°											
0	0.050	0.008	0	0.019	0.006	0	−0.014	0.007	0	−0.062	0	0
10	−.029	.004	−.001	−.032	.002	−.001	−.067	.005	−.001	−.124	0	0
15	−.080	.003	−.001	−.072	.001	−.002	−.114	.005	0	−.157	0	0
20	−.096	.004	−.001	−.149	.002	−.002	−.186	.005	0	−.224	0	0
	δ_A=15°											
0	−0.151	−0.018	0.005	−0.127	−0.014	0.005	−0.163	−0.016	0.005	−0.222	−0.019	0.006
10	−.205	−.015	.007	−.241	−.014	.008	−.292	−.017	.009	−.337	−.019	.011
15	−.232	−.012	.008	−.274	−.010	.010	−.330	−.016	.011	−.371	−.016	.013
20	−.269	−.001	.007	−.317	.002	.008	−.362	−.001	.009	−.395	−.001	.010
	δ_A=30°											
0	−0.216	−0.026	0.011	−0.247	−0.027	0.011	−0.296	−0.031	0.013	−0.332	−0.032	0.013
10	−.320	−.026	.015	−.354	−.025	.017	−.410	−.029	.018	−.440	−.029	.020
15	−.351	−.019	.016	−.378	−.018	.017	−.440	−.022	.020	−.467	−.022	.021
20	−.345	.005	.012	−.376	.006	.013	−.424	.004	.013	−.446	.004	.016

δ_T	0°			10°			20°			30°		
	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
	(a) 0.1875c_A by 0.445b_A paddle balance. Yaw=0°											
α, °	δ_A=0°											
0	−0.065	0	0	−0.131	−0.005	0	−0.169	−0.007	0.001	−0.202	−0.009	0.001
10	−.127	0	0	−.193	−.004	.002	−.240	−.007	.003	−.274	−.009	.004
15	−.164	0	0	−.227	−.003	.002	−.270	−.006	.003	−.306	−.009	.004
20	−.242	0	0	−.303	.002	.001	−.343	−.004	.002	−.364	−.005	.003
	δ_A=−15°											
0	0.020	0.030	0	−0.038	0.027	0	−0.061	0.025	0	−0.073	0.023	0
10	−.021	.032	−.003	−.080	.029	−.003	−.122	.026	−.003	−.156	.024	−.002
15	−.045	.029	−.006	−.105	.026	−.006	−.149	.024	−.005	−.186	.021	−.004
20	−.063	.021	−.009	−.130	.018	−.009	−.169	.016	−.008	−.204	.015	−.008
	δ_A=−30°											
0	0.241	0.052	0.008	0.192	0.049	0.007	0.146	0.045	0.007	0.123	0.043	0.006
10	.127	.062	0	.085	.059	−.001	.059	.056	−.001	.048	.055	−.001
15	.105	.059	−.006	.049	.055	−.006	.021	.054	−.006	−.004	.050	−.006
20	.093	.038	−.012	.035	{.034 .042}	−.012	−.007	{.031 .037}	−.012	−.032	{.030 .038}	−.011
	(b) 0.275c_A by 0.445b_A paddle balance. Yaw=0°											
	δ_A=−0°											
0	−0.062	0	0	−0.129	−0.005	0.001	−0.169	−0.008	0.001	−0.200	−0.011	0.002
10	−.124	0	0	−.178	−.009	.001	−.234	−.012	.002	−.272	−.015	.003
15	−.157	0	0	−.222	−.008	0	−.266	−.012	.002	−.309	−.015	.004
20	−.224	0	0	−.292	−.004	.001	−.328	−.005	.002	−.357	−.007	.003
	δ_A=−15°											
0	0.010	0.030	0.001	−0.041	0.026	0	−0.082	0.023	0.001	−0.085	0.023	0.001
10	−.019	.028	−.005	−.080	.024	−.004	−.136	.019	−.004	−.155	.018	−.003
15	−.046	.025	−.007	−.105	.020	−.006	−.150	.016	−.006	−.181	.015	−.005
20	−.068	.022	−.010	−.127	.019	−.010	−.179	.014	−.008	−.206	.012	−.008
	δ_A=−30°											
0	0.244	0.052	0.009	0.189	0.048	0.008	0.155	0.045	0.008	0.131	0.042	0.007
10	.134	.056	−.001	.082	.053	−.002	.058	.050	−.002	.047	.049	−.002
15	.103	.053	−.006	.047	.050	−.007	.007	.046	−.006	−.002	.045	−.007
20	.094	.036	−.012	.026	.034	−.012	−.018	{.030 .040}	−.012	−.036	{.029 .037}	−.011

TABLE VII—Continued

FORCE TESTS, CLARK Y WING WITH PLAIN SHORT WIDE AILERON ON RIGHT WING TIP ONLY—0.20c_A HALF-SPAN CENTER INSET TAB AND AUXILIARY BALANCE—Continued

[R. N.=609,000. Velocity=m. p. h.]

δ_T	−30°			−20°			−10°			0°			0°			10°			20°			30°		
	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'	C_{h_1}	C_l'	C_n'
	(c) Horn balance. Yaw=0°																								
α	δ_A=0°												δ_A=0°											
°																								
0	0.073	0.012	0	0.056	0.010	−0.001	0.005	0.005	0.001	−0.067	0	0	−0.067	0	0	−0.123	−0.002	0.001	−0.166	−0.007	0.001	−0.190	−0.009	0.001
10	.016	.011	−.001	.028	.011	−.002	−.017	.007	−.001	−.087	0	0	−.087	0	0	−.139	−.001	.001	−.181	−.005	.002	−.221	−.008	.005
15	−.063	.010	−.001	−.031	.011	−.002	−.075	.007	−.001	−.133	0	0	−.133	0	0	−.170	.001	.002	−.204	−.005	.002	−.240	−.007	.003
20	−.180	.004	0	−.149	.005	−.002	−.212	.002	0	−.272	0	0	−.272	0	0	−.312	−.001	.002	−.338	−.004	.003	−.370	−.006	.004
	δ_A=15°												δ_A=−15°											
0	−0.146	−0.027	0.008	−0.118	−0.024	0.006	−0.153	−0.028	0.007	−0.198	−0.033	0.008	−0.005	0.044	0.001	−0.051	0.041	0	−0.087	0.037	0	−0.080	0.037	0
10	−.249	−.008	.013	−.247	−.006	.011	−.300	−.010	.013	−.345	−.014	.014	.003	.046	−.007	−.052	.043	−.006	−.100	.039	−.006	−.123	.037	.005
15	−.229	.006	.010	−.273	.001	.010	−.324	−.002	.012	−.366	−.004	.013	.003	.041	−.011	−.053	.039	−.010	−.101	.035	−.010	−.132	.032	.009
20	−.269	.005	.009	−.295	.003	.009	−.351	.004	.010	−.396	.003	.011	−.009	.022	−.014	−.065	.020	−.013	−.114	.017	−.012	−.144	.014	.012
	δ_A=30°												δ_A=−30°											
0	−0.264	−0.033	0.018	−0.308	−0.036	0.017	−0.357	−0.038	0.019	0.400	−0.040	0.020	0.194	0.075	0.011	0.160	0.072	0.011	0.125	0.070	0.010	0.099	0.069	0.010
10	−.314	−.008	.027	−.360	−.011	.022	−.414	−.013	.024	−.460	−.016	.025	.163	.086	−.003	.138	.083	−.003	.112	.079	−.003	.130	.081	−.002
15	−.352	.002	.020	−.390	.001	.020	−.451	−.003	.023	−.495	−.005	.025	.098	.084	−.011	.056	.080	−.011	.012	.076	−.011	.008	.076	−.012
20	−.392	.010	.019	−.429	.010	.019	−.488	.008	.021	−.545	.007	.023	.110	{.048, .059}	−.018	.063	{.059, .051}	−.018	.015	{.050, .056}	−.018	−.001	.052	−.01
	(d) Frise aileron. Yaw=0°																								
	δ_A=0°												δ_A=0°											
0	0.074	0.009	0	0.042	0.009	0	0.005	0.005	−0.001	−0.065	0	0	−0.065	0	0	−0.104	−0.004	0	−0.158	−0.006	0.001	−0.185	−0.011	0.001
10	−.006	.011	−.001	−.025	.007	−.001	−.047	.005	−.001	−.125	0	0	−.125	0	0	−.161	−.001	0	−.210	−.006	.002	−.246	−.009	.003
15	−.049	.016	−.001	−.063	.007	−.001	−.089	.005	−.001	−.173	0	0	−.173	0	0	−.195	−.002	.002	−.244	{−.005, −.007}	.002	−.275	−.005	.003
20	−.104	.003	−.008	−.106	.003	−.008	−.136	.021	−.003	−.219	0	0	−.219	0	0	−.247	−.003	−.005	−.286	{−.002, .002}	−.004	−.317	.002	−.003
	δ_A=15°												δ_A=−15°											
0	−0.078	−0.021	0.004	−0.076	−0.018	0.003	−0.111	−0.023	0.005	−0.176	−0.026	0.006	−0.046	0.030	0.001	−0.087	0.027	0	−0.141	0.024	0	−0.162	0.022	0
10	−.191	−.014	.007	−.175	−.014	.006	−.214	−.019	.008	−.264	−.022	.009	−.075	.031	−.004	−.117	.026	−.004	−.169	.023	−.004	−.193	.022	−.003
15	−.184	−.006	.008	−.211	−.011	.008	−.249	−.015	.009	−.294	−.018	.010	−.088	.029	−.006	−.141	.024	−.006	−.194	.023	−.006	−.221	.020	−.005
20	−.214	{.005, −.001}	.001	−.254	−.004	.001	−.312	.014	.011	−.335	−.005	.003	−.116	.014	−.015	−.164	.019	−.014	−.212	.010	−.013	−.241	.012	−.013
	δ_A=30°												δ_A=−30°											
0	−0.194	−0.030	0.011	−0.245	−0.033	0.012	−0.303	−0.036	0.010	−0.350	−0.038	0.014	0.135	0.034	0.009	0.097	0.032	0.008	0.055	0.030	0.007	0.026	0.028	0.007
10	−.254	−.013	.015	−.306	{−.017, −.027}	.017	−.363	−.031	.018	−.409	−.033	.019	.101	.054	0	.082	.048	−.001	.044	.043	.001	.024	.041	.001
15	−.285	−.015	.017	−.333	−.018	.018	−.391	−.025	.020	−.437	−.026	.021	.097	.054	−.003	.072	.050	−.005	.031	.049	−.004	.026	.049	−.003
20	−.291	.008	.007	−.335	−.002	.007	−.378	−.004	.009	−.415	−.005	.010	.062	.041	−.016	.038	.040	−.016	−.002	.039	−.016	.001	.036	−.015

(e)[1] Frise aileron. Yaw=20°

α												
	$\delta_A=0°$											
°												
0	0.085	0.007	0	0.048	0.005	0	0.022	0.005	0	−0.042	0.007	−0.001
10	.001	.003	−.002	.005	.004	−.001	−.013	.002	−.001	−.058	.015	−.006
15	−.002	.008	.004	−.005	.004	−.001	−.028	.002	−.001	−.073	.030	−.011
20	−.001	.003	−.011	−.048	.002	−.011	−.077	.001	−.011	−.128	.078	−.016
	$\delta_A=15°$											
0	−0.049	−0.017	0.003	−0.042	−0.017	0.003	−0.069	−0.020	0.004	−0.117	−0.023	0.004
10	−.117	−.014	.006	−.133	−.016	.006	−.165	−.020	.007	−.200	−.023	.008
15	−.119	−.011	.007	−.145	−.017	.030	−.176	−.019	.008	−.222	−.022	.010
20	−.100	.004	−.005	−.125	−.008	.085	−.173	.004	.007	−.204	−.010	−.003
	$\delta_A=30°$											
0	−0.203	−0.029	0.010	−0.238	{−0.026, −.031}	0.011	−0.296	−0.032	0.012	−0.331	−0.035	0.010
10	−.286	−.023	.016	−.337	−.029	.018	−.403	−.037	.021	−.438	−.037	.019
15	−.274	−.024	.018	−.328	−.031	.019	−.400	−.034	.023	−.442	{−.031, −.037}	.022
20	−.197	−.010	.002	−.237	−.012	.002	−.282	−.016	.006	−.307	−.015	.006

(f)[1] Frise aileron. Yaw=−20°

α												
	$\delta_A=0°$											
0	−0.078	−0.009	0.001	−0.120	−0.103	0.001	−0.156	−0.006	0.001	−0.206	−0.009	0.002
10	−.173	−.016	.006	−.223	−.005	.001	−.281	−.007	.002	−.309	−.009	.003
15	−.229	−.027	.012	−.275	−.007	.001	−.332	−.011	.002	−.359	−.012	.003
20	−.270	−.079	.009	−.347	−.003	.007	−.399	−.012	.008	−.414	−.014	.009
	$\delta_A=-15°$											
0	−0.037	0.029	0.001	−0.074	0.027	0.001	−0.126	0.023	0.001	−0.154	0.020	0.001
10	−.106	.030	−.005	−.150	.026	−.005	−.204	.024	−.005	−.238	.020	−.004
15	−.142	.027	−.009	−.189	.023	−.008	−.249	.020	−.007	−.279	.019	−.007
20	−.176	.028	−.009	−.231	.023	−.007	−.292	.018	−.005	−.325	.017	−.005
	$\delta_A=-30°$											
0	0.172	0.044	0.010	0.139	0.043	0.009	0.102	0.040	0.008	0.066	0.041	0.008
10	.109	.061	−.001	.070	.059	−.001	.025	.057	−.001	−.003	.056	−.001
15	.042	.061	−.008	.005	.059	−.007	−.033	.057	−.008	−.063	.057	−.008
20	−.046	.061	−.010	−.077	.058	−.009	−.111	.055	−.009	−.136	.053	−.009

[1] In these tables the rolling- and yawing-moment coefficients for $\delta_T=0°$ and $\delta_A=0°$ are those due to yaw; for (δ_T) and (δ_A) deflected they are due to tab and/or aileron.

TABLE VIII

FORCE TESTS, TAIL SURFACE. ELEVATOR=0.40 TAIL AREA. REFLECTION PLANE IN PLACE

[R. N.=1,218,000. Velocity=80 m. p. h. Yaw=0°]

(a) 0.05 c_E inset tab

δ_T	−30°		−20°		−10°		0°		0°		10°		20°		30°	
α_S	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}
	$\delta_E=0°$								$\delta_E=0°$							
° 0	−0.072	0.065	−0.049	0.062	−0.035	0.040	−0.003	0	0.003	0	0.035	−0.040	0.049	−0.062	0.072	−0.065
−5	−.320	.102	−.294	.087	−.277	.053	−.240	.019	−.240	.019	−.214	−.003	−.199	−.028	−.181	−.043
−10	−.576	.134	−.548	.118	−.524	.096	−.489	.040	−.489	.040	−.468	.013	−.461	.010	−.446	−.006
	$\delta_E=10°$								$\delta_E=-10°$							
0	0.310	−0.047	0.325	−0.060	0.330	−0.069	0.356	−0.101	−0.356	0.101	−0.330	0.069	−0.325	0.060	−0.310	0.047
−5	.059	−.010	.077	−.022	.082	−.035	.116	−.078	−.591	.116	−.582	.107	−.581	.107	−.573	.104
−10	−.196	.018	−.176	−.004	−.164	−.019	−.130	−.060	−.831	.122	−.818	.122	−.819	.131	−.821	.135
	$\delta_E=20°$								$\delta_E=-20°$							
0	0.610	−0.228	0.588	−0.216	0.572	−0.200	0.598	−0.242	−0.598	0.242	−0.572	0.200	−0.588	0.216	−0.610	0.228
−5	.389	−.197	.378	−.197	.345	−.175	.392	−.206	−.798	.237	−.763	.206	−.757	.243	−.801	.256
−10	.169	−.150	.169	−.144	.157	−.125	.200	−.144	−.991	.253	−.955	.216	−.986	.247	−1.000	.269
	$\delta_E=30°$								$\delta_E=-30°$							
0	0.700	−0.303	0.677	−0.284	0.662	−0.271	0.684	−0.314	−0.684	0.314	−0.662	0.271	−0.677	0.284	−0.700	0.303
−5	.468	−.284	.449	−.272	.423	−.244	.461	−.287	−.887	.321	−.859	.284	−.860	.293	−.884	.319
−10	.249	−.275	.233	−.256	.211	−.219	.244	−.256	−1.106	.309	−1.074	.278	−1.085	.300	−1.106	.319

(b) 0.10 c_E inset tab

δ_T	−30°		−20°		−10°		10°		20°		30°	
α_S	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}
	$\delta_E=0°$						$\delta_E=0°$					
° 0	−0.136	0.149	−0.106	0.118	−0.074	0.077	0.074	−0.077	0.106	−0.118	0.136	−0.149
−5	−.379	.171	−.346	.133	−.316	.090	−.183	−.037	−.149	−.074	−.119	−.093
−10	−.640	.196	−.607	.171	−.573	.121	−.429	−.021	−.416	−.031	−.391	−.046
	$\delta_E=10°$						$\delta_E=-10°$					
0	0.248	0.021	0.262	0.003	0.284	−0.013	−0.284	0.013	−0.262	−0.003	−0.248	−0.021
−5	−.003	.053	.017	.034	.043	.009	−.515	.044	−.534	.063	−.584	.044
−10	−.256	.074	−.231	.043	−.204	.024	−.746	.075	−.777	.103	−.776	.094
	$\delta_E=20°$						$\delta_E=-20°$					
0	0.569	−0.212	0.489	−0.147	0.528	−0.181	−0.528	0.181	−0.489	0.147	−0.569	0.212
−5	.340	−.172	.290	−.131	.320	−.157	−.734	.197	−.685	.141	−.759	.225
−10	.118	−.125	.090	−.116	.119	−.119	−.930	.197	−.875	.138	−.973	.228
	$\delta_E=30°$						$\delta_E=-30°$					
0	0.656	−0.243	0.595	−0.181	0.646	−0.250	−0.646	0.250	−0.595	0.181	−0.656	0.243
−5	.424	−.225	.360	−.150	.410	−.235	−.850	.262	−.800	.194	−.860	.250
−10	.197	−.212	.141	−.147	.192	−.200	−1.062	.262	−1.013	.212	−1.062	.250

TABLE VIII—Continued

FORCE TESTS, TAIL SURFACE. ELEVATOR=0.40 TAIL AREA. REFLECTION PLANE IN PLACE—Continued

[R. N.=1,218,000. Velocity=80 m. p. h. Yaw=0°]

(c) 0.20 c_E inset tab

δ_T	−40°		−30°		−20°		−10°		10°		20°		30°		40°	
α_S	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}
	$\delta_E=0°$								$\delta_E=0°$							
° 0	−0.263	0.246	−0.282	0.212	−0.206	0.199	−0.113	0.112	0.113	−0.112	0.206	−0.199	0.282	−0.212	0.263	−0.246
−5	−.508	.258	−.457	.230	−.472	.205	−.357	.121	−.122	−.087	−.044	−.171	−.030	−.174	.013	−.208
−10	−.766	.299	−.725	.261	−.683	.221	−.588	.130	−.371	−.059	−.308	−.127	−.303	−.127	−.265	−.159
	$\delta_E=10°$								$\delta_E=-10°$							
0	0.128	0.118	0.155	0.102	0.148	0.109	0.249	0.009	−0.249	−0.009	−0.148	−0.109	−0.155	−0.102	−0.128	−0.118
−5	−.130	.143	−.094	.121	−.088	.118	.009	.028	−.482	.022	−.427	−.040	−.437	−.009	−.409	−.028
−10	−.384	.171	−.348	.149	−.333	.130	−.238	.037	−.724	.054	−.626	−.028	−.694	.032	−.669	.013
	$\delta_E=20°$								$\delta_E=-20°$							
0	0.535	−0.188	0.513	−0.166	0.424	−0.082	0.509	−0.178	−0.509	0.178	−0.424	0.082	−0.513	0.166	−0.535	0.188
−5	.287	−.143	.279	−.141	.199	−.069	.284	−.153	−.720	.188	−.625	.110	−.706	.184	−.764	.210
−10	.036	−.085	.044	−.035	.005	−.066	.090	−.122	−.914	.191	−.841	.113	−.912	.175	−.971	.219
	$\delta_E=30°$								$\delta_E=-30°$							
0	0.628	−0.244	0.464	−0.088	0.541	−0.150	0.613	−0.250	−0.613	0.250	−0.541	0.150	−0.464	0.088	−0.628	0.244
−5	.416	−.234	.266	−.100	.302	−.125	.380	−.219	−.836	.262	−.769	.181	−.710	.132	−.832	.241
−10	.212	−.219	.074	−.088	.106	−.135	.187	−.216	−1.042	.256	−.973	.178	−.914	.122	−1.065	.253

TABLE IX

FORCE TESTS, TAIL SURFACE, RUDDER 0.60 TAIL AREA, 0.20c_R INSET TAB

[R.N.=1,218,000. Velocity=80 m. p. h. Yaw=0°]

δ_T	−40°		−30°		−20°		−10°		0°		0°		10°		20°		30°		40°	
	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}	C_N	C_{h_1}
ψ_F	(a) Reflection plane in place																			
	δ_R=0°										δ_R=0°									
° 0	−0.294	0.245	−0.239	0.215	−0.239	0.210	−0.116	0.111	0.011	0.003	−0.011	−0.003	0.116	−0.111	0.239	−0.210	0.239	−0.215	0.299	−0.245
−5	−.532	.284	−.479	.236	−.467	.221	−.348	.133	−.217	.025	−.261	.031	−.124	−.081	.017	−.182	.008	−.192	.029	−.193
−10	−.796	.313	−.757	.296	−.702	.243	−.585	.164	−.458	.057	−.509	.061	−.382	−.033	−.258	−.132	−.245	−.145	−.248	−.132
	δ_R=10°										δ_R=−10°									
0	0.155	0.111	0.123	0.095	0.101	0.114	0.304	0.013	0.438	−0.095	−0.438	0.095	−0.304	−0.013	−0.101	−0.114	−0.123	−0.095	−0.155	−0.111
−5	−.099	.153	−.057	.132	−.058	.122	.065	.044	.197	−.061	−.683	.129	−.554	.036	−.426	−.047	−.450	−.039	−.451	−.022
−10	−.345	.192	−.301	.170	−.295	.152	−.173	.068	−.045	−.039	−.892	.169	−.772	.093	−.660	.007	−.683	.022	−.720	.044
	δ_R=20°										δ_R=−20°									
0	0.652	−0.142	0.630	−0.118	0.513	−0.068	0.676	−0.160	0.782	−0.234	−0.782	0.234	−0.676	0.160	−0.513	0.068	−0.630	0.118	−0.652	0.142
−5	.375	−.049	.385	−.042	.342	−.021	.454	−.092	.579	−.161	−.909	.278	−.826	.195	−.724	.115	−.642	.053	−.867	.213
−10	.108	.038	.128	.038	.110	.044	.225	−.035	.345	−.119	−1.107	.306	−1.019	.222	−.926	.135	−.843	.072	−1.022	.210
	δ_R=30°										δ_R=−30°									
0	0.782	−0.250	0.615	−0.100	0.728	−0.167	0.816	−0.238	0.883	−0.318	−0.883	0.318	−0.816	0.238	−0.728	0.167	−0.615	0.100	−0.782	0.250
−5	.652	−.221	.405	−.070	.530	−.133	.623	−.212	.682	−.292	−1.046	.346	−.963	.272	−.844	.193	−.726	.106	−.965	.270
−10	.463	−.225	.266	−.075	.322	−.118	.447	−.200	.506	−.279	−1.115	.366	−1.038	.296	−.959	.220	−.887	.132	−1.028	.281
	(b) Reflection plane removed																			
	δ_R=0°										δ_R=0°									
0	−0.234	0.232	−0.210	0.213	−0.191	0.240	−0.089	0.101	0.015	0.004	−0.015	−0.004	0.089	−0.101	0.191	−0.240	0.210	−0.213	0.234	−0.232
−5	−.429	.270	−.396	.240	−.369	.231	−.269	.129	−.151	.018	−.210	.018	−.095	−.090	.005	−.182	.023	−.198	.034	−.203
−10	−.638	.312	−.604	.288	−.636	.268	−.465	.169	−.349	.057	−.418	.051	−.301	−.057	−.198	−.140	−.184	−.157	−.188	−.153
	δ_R=10°										δ_R=−10°									
0	0.110	0.126	0.133	0.112	0.143	0.101	0.243	0.025	0.354	−0.078	−0.354	0.078	−0.243	−0.025	−0.143	−0.101	−0.133	−0.112	−0.110	−0.126
−5	−.074	.157	−.056	.132	−.039	.128	.055	.049	.166	−.053	−.568	.121	−.454	.013	−.348	−.074	−.334	−.075	−.343	−.060
−10	−.267	.190	−.245	.178	−.219	.150	−.123	.063	−.018	−.032	−.791	.175	−.670	.068	−.563	−.001	−.518	−.041	−.572	.003
	δ_R=20°										δ_R=−20°									
0	0.489	−0.053	0.485	−0.054	0.479	−0.043	0.586	−0.122	0.692	−0.202	−0.692	0.202	−0.586	0.122	−0.479	0.043	−0.485	0.054	−0.489	0.053
−5	.294	−.009	.296	.003	.286	.006	.379	−.060	.490	−.148	−.891	.300	−.796	.216	−.703	.125	−.631	.079	−.726	.134
−10	.095	.047	.095	.054	.096	.054	.189	−.019	.292	−.100	−1.055	.345	−.981	.250	−.891	.176	−.802	.110	−.909	.191
	δ_R=30°										δ_R=−30°									
0	0.671	−0.198	0.571	−0.123	0.648	−0.197	0.780	−0.285	0.838	−0.366	−0.838	0.366	−0.780	0.285	−0.648	0.197	−0.571	0.123	−0.671	0.198
−5	.502	−.160	.412	−.090	.508	−.171	.598	−.240	.664	−.309	−1.017	.419	−.935	.318	−.854	.226	−.756	.166	−.865	.250
−10	.330	−.116	.259	−.066	.302	−.107	.431	−.200	.496	−.266	−1 119	.425	−1.066	.351	−.997	.266	−.913	.194	−1.022	.281

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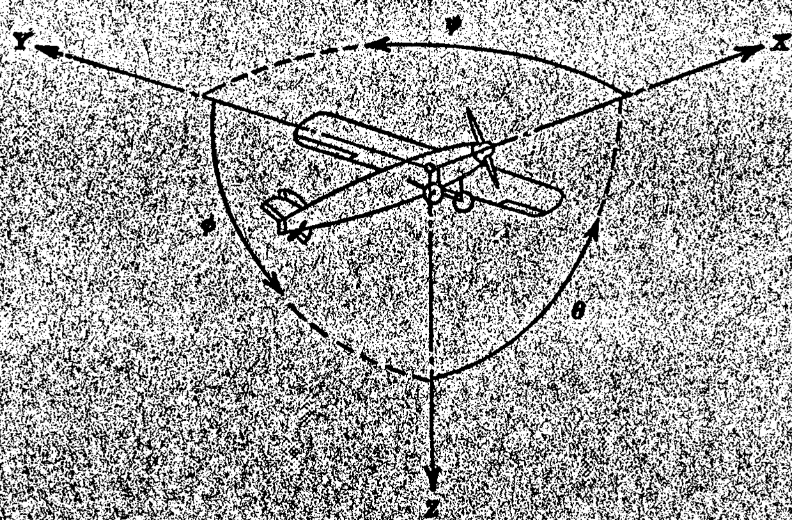

Positive directions of axes and angles (forces and moments) are shown by arrows

Axis		Force (parallel to axis) symbol	Moment about axis			Angle		Velocities	
Designation	Symbol		Designation	Symbol	Positive direction	Designation	Symbol	Linear (component along axis)	Angular
Longitudinal	X	X	Rolling	L	$Y \longrightarrow Z$	Roll	ϕ	u	p
Lateral	Y	Y	Pitching	M	$Z \longrightarrow X$	Pitch	θ	v	q
Normal	Z	Z	Yawing	N	$X \longrightarrow Y$	Yaw	ψ	w	r

Absolute coefficients of moment

$C_l = \frac{L}{qbS}$ (rolling) $C_m = \frac{M}{qcS}$ (pitching) $C_n = \frac{N}{qbS}$ (yawing)

Angle of set of control surface (relative to neutral position), δ. (Indicate surface by proper subscript.)

4. PROPELLER SYMBOLS

D, Diameter
p, Geometric pitch
p/D, Pitch ratio
V', Inflow velocity
V_s, Slipstream velocity
T, Thrust, absolute coefficient $C_T = \frac{T}{\rho n^2 D^4}$
Q, Torque, absolute coefficient $C_Q = \frac{Q}{\rho n^2 D^5}$
P, Power, absolute coefficient $C_P = \frac{P}{\rho n^3 D^5}$
C_s, Speed-power coefficient $= \sqrt[5]{\frac{\rho V^5}{P n^2}}$
η, Efficiency
n, Revolutions per second, r.p.s.
Φ, Effective helix angle $= \tan^{-1}\left(\frac{V}{2\pi rn}\right)$

5. NUMERICAL RELATIONS

1 hp. = 76.04 kg-m/s = 550 ft-lb./sec.
1 metric horsepower = 1.0132 hp.
1 m.p.h. = 0.4470 m.p.s.
1 m.p.s. = 2.2369 m.p.h.
1 lb. = 0.4536 kg.
1 kg = 2.2046 lb.
1 mi. = 1,609.35 m = 5,280 ft.
1 m = 3.2808 ft.