REPORT No. 444

WIND-TUNNEL RESEARCH COMPARING LATERAL CONTROL DEVICES, PARTICULARLY AT HIGH ANGLES OF ATTACK

VI—SKEWED AILERONS ON RECTANGULAR WINGS

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SUMMARY

This report covers the sixth of a series of investigations in which various lateral control devices are compared with particular reference to their effectiveness at high angles of attack. The present report deals with flap-type ailerons hinged about axes having an angle with respect to the leading and trailing edges of the wing. Tests were made on four different skewed ailerons, including two different angles of skew and two sizes of ailerons. At the high angles of attack, all the skewed ailerons tested were slightly inferior with respect to rolling and yawing moments to straight ailerons having the same span and average chord. Computations indicate that the skewed ailerons are also inferior with respect to hinge moments.

INTRODUCTION

This report is the sixth of a series giving the results of an investigation in which it is hoped to compare all types of lateral control devices which have been satisfactorily used or which show reasonable promise of being effective. In this program it is planned first to test the various types of ailerons and other control devices on rectangular wings of aspect ratio 6. Later the best of these control devices are to be tested on wings of different shape. In the entire series the various devices are to be subjected to the same program of wind-tunnel tests which, it is thought, include all the factors directly connected with lateral control and stability that can be satisfactorily handled in a routine manner in a wind tunnel. The tests are designed to show the relative merits of the various control devices in regard to lateral controllability, lateral stability, and general usefulness. They include regular 6-component force tests with the control devices both neutral and deflected various amounts, rotation tests in which the model is rotated about the tunnel axis and the rolling moment measured, and free rotation tests showing the range and rate of autorotation. Because of the large effect of yaw on lateral stability, the tests are made not only at 0° yaw, but also with an angle of yaw of 20°, which represents the conditions in a fairly severe sideslip.

Part I of this series (reference 1) dealt with three different sizes of ordinary ailerons. One of these ailerons was of a medium size taken from the average of a number of conventional airplanes, one was extremely short and wide, and the other was extremely long and narrow. All the ailerons were proportioned to give approximately equal controllability at angles of attack below the stall and with equal up-and-down deflection. The results were analyzed to show the relative merits of the three sizes of ailerons when set in the above manner and also in accordance with two differential movements, and with upward movement only.

Other work that has been done in this series is reported in references 2, 3, 4, and 5.

The present report covers similar tests on skewed ailerons. Previous tests made by the Army Air Service on skewed ailerons had shown them to give higher rolling moments than straight ailerons at high angles of attack on a certain wing model. (Reference 6.) These tests indicated that the best angle of skew was about 8° or 10°, with 20° as the maximum giving beneficial results. The present tests included ailerons with 10° and 20° skew, both angles being tried on ailerons of two different sizes, one having the same span and average chord dimensions as the medium-sized ailerons of Part I and the others the same as the short, wide ailerons of Part I. These ailerons were tested on a rectangular wing only, but skewed ailerons will be later tested on wings with other plan forms.

APPARATUS AND METHODS

Wind tunnel.—The 7- by 10-foot wind tunnel of the National Advisory Committee for Aeronautics, which is being used throughout the entire investigation, has an open jet and a single closed return passage. The tunnel, together with the regular balance and associated apparatus, is described in detail in reference 7.

Models.—Inasmuch as previous tests (reference 1) had shown that the moments caused by both right and left ailerons could be found separately and added together to give the total effect of both with a satisfactory accuracy, the present tests were made with the right aileron only. All four ailerons were tested on one 10- by 60-inch laminated mahogany Clark Y wing model, which had a removable portion in the right rear corner as indicated in Figure 1. Four

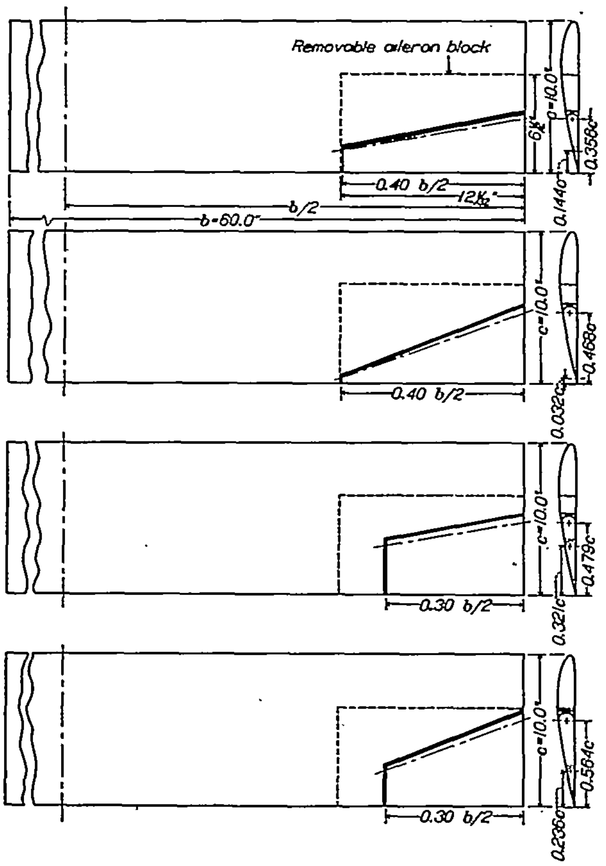

FIGURE 1.—Diagram of wings showing details of ailerons

different models of this portion of the wing were made, each containing one of the four ailerons.

Tests.—This series of tests was conducted in accordance with the standard procedure and at the dynamic pressure and Reynolds Number employed throughout the present research on lateral control. (See reference 1.) The dynamic pressure was 16.37 pounds per square foot, corresponding to a speed of 80 miles per hour at sea level under standard atmospheric conditions, and the Reynolds Number based on the 10-inch wing chord was 609,000.

Aileron movements.—From tests with the single ailerons deflected upward and downward various amounts, data were obtained from which the results were computed for four aileron movements: The equal up-and-down, average differential, extreme differential, and up-only movements. These movements were the same as those used in Part I. (Reference 1.) The relative up-and-down displacements with the two differential movements are given in Table I and the assumed linkages to obtain all of the movements in Figure 2. The deflection of the skewed ailerons was measured in a plane perpendicular to the hinge axis, and is slightly greater than the projected angle of deflection in a longitudinal plane.

Accuracy.—The accuracy of the results presented in this report is the same as that obtained in Part I. It is considered satisfactory at all angles of attack except in the burbled region between 20° and 25° when the rolling and yawing moments are relatively unreliable due to the critical, and often unsymmetrical, condition of the burbled air flow around the wing.

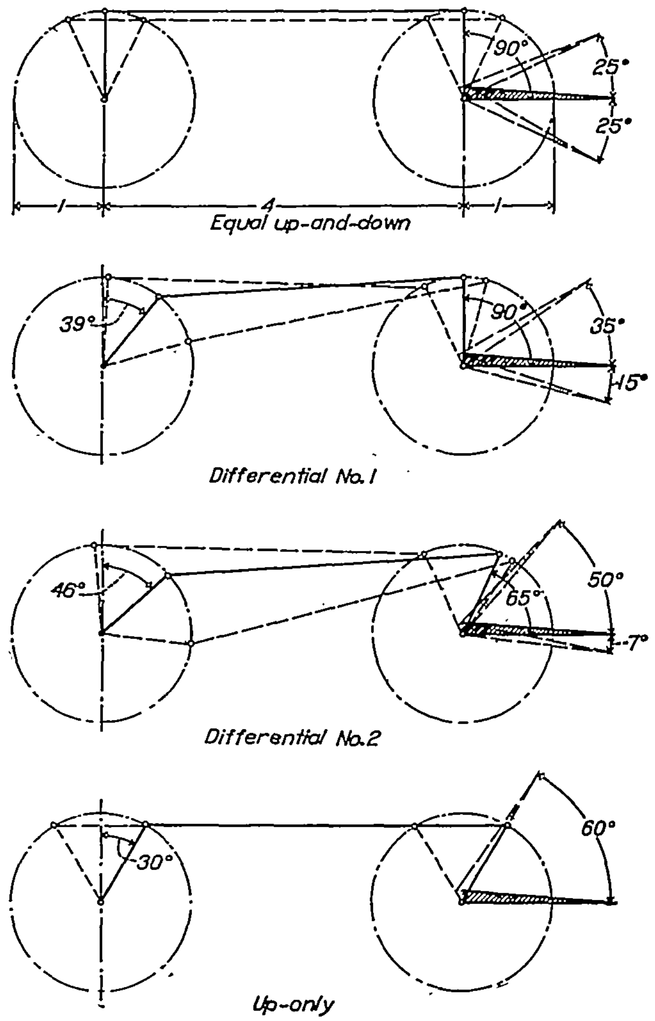

FIGURE 2.—Aileron linkage systems. Assumed maximum deflections

RESULTS

Coefficients.—The results are given in the form of absolute coefficients of lift and drag and of rolling and yawing moments:

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

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

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

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

where S is the total wing area, b is the wing span, and q is the dynamic pressure. The coefficients as given above are obtained directly from the balance and refer to the wind (or tunnel) axes. In special cases in the discussion where the moments are used with reference to body axes the coefficients are not primed. Thus the symbols for the rolling and yawing moment coefficients about the body axes are C_l and C_n.

Tables.—The complete detailed results of the present tests are given in Tables II to XIII.

Table II contains the following data for the unyawed wing with the 40 per cent semispan ailerons having a 10° angle of skew:

1. C_L and C_D with zero aileron deflection.
2. C_l' and C_n' for each aileron setting. Table III gives similar data for the same aileron with the wing at −20° yaw, and Table IV with the wing at +20° yaw.

Tables V, VI, and VII are similar to Tables II, III, and IV, respectively, but cover the results for the 40 per cent semispan aileron having 20° skew; Tables VIII, IX, and X cover the wider 30 per cent semispan ailerons with 10° skew, and Tables XI, XII, and XIII the 30 per cent semispan ailerons with 20° skew.

DISCUSSION IN TERMS OF CRITERIONS

For a comparison of the different lateral control arrangements, the results of the tests are discussed in terms of criterions, which are explained in detail in Part I and briefly in the following paragraphs. By use of these criterions a comparison of the effect of the different control devices on the general performance, the lateral controllability, and the lateral stability may be made. The values of the criterions summarizing the results of the present tests are given in Table XIV, and the values for the standard and the short, wide ailerons of Part I (no skew) are included for comparison.

GENERAL PERFORMANCE

The values of the three criterions used in connection with the general performance of the wing, the maximum lift coefficient, the speed-range ratio $\frac{C_{L max}}{C_{D min}}$, and the climb criterion $\frac{L}{D}$ at $C_L = 0.70$, are not appreciably affected by ordinary ailerons, so these values are approximately the same for the various cases tested.

LATERAL CONTROLLABILITY

Rolling criterion.—The rolling criterion upon which the effectiveness of each of the aileron arrangements is judged is a figure of merit that is designed to be proportional to the initial acceleration of the wing tip that follows a deflection of the ailerons from neutral, regardless of the air speed or the plan form of the wing. Expressed in coefficient form for a rectangular monoplane wing, the criterion is

$$RC = \frac{C_l}{C_L}$$

where C_l is the rolling-moment coefficient about the body axis due to the lateral controls. The value of this expression that has been found to represent satisfactory control is approximately 0.075. A more detailed explanation of the derivation of RC and of its more general form, which is applicable to any wing plan form, is given in Part I.

The comparison of the various ailerons and movements is given in Table XIV for four representative angles of attack: 0°, 10°, 20°, and 30°. The 0° angle represents the high-speed attitude; $\alpha = 10°$ represents the highest angle of attack at which entirely satisfactory control with ordinary ailerons can be obtained; $\alpha = 20°$ is the condition of greatest lateral instability and is probably about the greatest obtainable angle of attack in a steady glide with most present-day airplanes; and finally, $\alpha = 30°$ is given only for a comparison with controls for possible future types of airplanes.

At $\alpha = 0°$, all the ailerons gave values of RC greatly in excess of that considered necessary.

At $\alpha = 10°$, the ailerons with 10° skew gave slightly higher values of RC for most of the assumed aileron movements than the straight ailerons having the same average chord, but the ailerons with 20° skew gave lower values.

At $\alpha = 20°$, the 40 per cent semispan ailerons, both with 10° and with 20° skew, gave substantially lower values of RC than the straight ailerons of the same span and average chord. The same is true for the 30 per cent semispan aileron with 20° skew, but the 30 per cent semispan aileron with 10° skew gave values nearly as high as the straight ailerons of the same span and average chord.[1]

At $\alpha = 30°$, none of the ailerons gave values of RC approaching the assumed satisfactory one.

Lateral control with sideslip.—If a wing is yawed appreciably, a rolling moment is set up that tends to raise the forward tip. The magnitude of this rolling moment is always greater at very high angles of attack than the available rolling moment due to ordinary ailerons. The highest angle of attack at which the aileron can balance the rolling moment due to 20° yaw is tabulated for all the arrangements tested as a criterion of control with sideslip. As previously men-

[1] Owing to the fact that the wing with 40 per cent chord by 30 per cent semispan straight ailerons (reference 1) had a lift coefficient at an angle of attack of 20° that was about 9 per cent lower than the other Clark Y wings of this series of tests, the values of RC are correspondingly higher for that condition. A rigorous comparison of the results at an angle of attack of 20° can not, therefore, be made with this wing, but on the basis of later tests with the same size aileron on another wing, it seems that a reasonable comparison can be made with the present data on skewed ailerons if the values of RC for the short, wide, straight aileron given in Table XIV are reduced by 9 per cent. If that is done the values will be very slightly higher than those for the 30 per cent semispan aileron with 10° skew.

tioned, 20° yaw represents the conditions in a fairly severe sideslip. Table XIV shows that the lateral control against the effect of 20° sideslip is maintained up to approximately the same angle of attack with all of the combinations tested.

Yawing moment due to ailerons.—The desirable yawing moment due to ailerons depends to some extent upon the type of airplane that is being considered. For highly maneuverable military or acrobatic machines complete independence of the controls as they affect turning moments about the various body axes is a desirable feature. On the other hand, for large transport airplanes or for machines to be operated by relatively inexperienced pilots, a favorable yawing moment of proper magnitude would be an appreciable aid to safe flying at high angles of attack. Finally, it is obvious that a yawing moment tending to retard the high wing when the airplane is banked is never desirable.

The yawing moments obtained with the skewed ailerons follow closely those for the straight ailerons having the same span and average chord, the adverse values being slightly higher in general for the skewed ailerons at angles of attack above the stall. The maximum adverse yawing moments for the equal up-and-down movement and for both differential movements were greater with all of the skewed ailerons tested, but could be overcome by an average rudder.

LATERAL STABILITY

Inasmuch as the skewed ailerons do not affect the shape of the wing to an appreciable extent when neutral, they have no appreciable influence on the lateral stability, and the values of the criterions on this subject are considered the same as those for the wings with the straight ailerons. The criterions for lateral stability are given in Table XIV and explained in reference 1. The rolling moments tending to make the wings autorotate (C_λ) depend in a very critical manner on the exact profile of the airfoils and are sometimes quite different for two airfoils made to the same design. The two examples given in Table XIV represent the extremes of this variation.

CONTROL FORCE REQUIRED

The hinge moments were not measured for the skewed ailerons, the rolling and yawing moment tests having shown them inferior to straight ailerons. Since it is approximately true that the hinge moment of an aileron varies as the square of the chord, however, it is to be expected that the hinge moments would be slightly higher for skewed than for straight ailerons of the same span and average chord. This condition has been substantiated by computations made by integrating values of the hinge moment for different unit chords obtained from data given in reference 8. These approximate computations showed that for equal up-and-down deflection of 25°, the total hinge moment of the 40 per cent semispan ailerons with 10° skew should be about 9 per cent higher and with 20° skew about 18 per cent higher than the values for the straight ailerons.

CONCLUSIONS

At the high angles of attack, all the skewed ailerons tested were slightly inferior to the straight ailerons having the same span and average chord with respect to both the rolling and yawing moments produced. Computations indicate that they are also inferior with respect to the control force required.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS,
LANGLEY FIELD, VA., *July 12, 1932.*

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TABLE I

SIMULTANEOUS AILERON DISPLACEMENTS WITH ASSUMED DIFFERENTIAL ARRANGEMENTS

Angles measured about aileron axis

Average differential (No. 1)		Extreme differential (No. 2)	
Upward displacement	Downward displacement	Upward displacement	Downward displacement
Degrees	*Degrees*	*Degrees*	*Degrees*
0	0	0	0
10	8.5	10	7
20	13	20	12
30	15	30	14
35	15	40	11.5
		50	7

TABLE II

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 10° SKEWED AILERONS 25 PER CENT AVERAGE c BY 40 PER CENT $b/2$. YAW=0°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	−3°	0°	4.5°	10°	12°	14°	15°	16°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																	
0°	0°	C_L	0.004	0.143	0.354	0.700	1.061	1.180	1.256	1.278	1.246	1.245	1.198	1.132	0.827	0.862	0.802	0.718	0.598
0°	0°	C_D	.018	.017	.022	.045	.089	.108	.131	.145	.171	.201	.247	.283	.426	.531	.714	.879	1.050
		UP ONLY																	
10°	------	C_l'	------	------	0.020	------	0.021	------	------	------	------	------	0.006	------	------	0.006	0.003	------	------
10°	------	C_n'	------	------	−.001	------	−.004	------	------	------	------	------	−.006	------	------	−.004	−.004	------	------
20°	------	C_l'	------	------	.036	------	.042	------	------	------	------	------	.021	------	------	.015	.007	------	------
20°	------	C_n'	------	------	.001	------	−.005	------	------	------	------	------	−.011	------	------	−.009	−.007	------	------
25°	------	C_l'	------	------	.044	------	.049	0.048	0.048	------	0.046	0.045	.030	0.024	0.006	.015	.011	------	------
25°	------	C_n'	------	------	.003	------	−.004	−.006	−.007	------	−.009	−.012	−.013	−.013	−.008	−.009	−.009	------	------
30°	------	C_l'	------	------	.048	------	.051	------	------	------	------	------	.033	------	------	.025	.015	------	------
30°	------	C_n'	------	------	.004	------	−.004	------	------	------	------	------	−.012	------	------	−.011	−.010	------	------
35°	------	C_l'	------	------	.053	------	.057	.055	.054	------	.051	.050	.036	.031	.011	.022	.019	------	------
35°	------	C_n'	------	------	.006	------	−.002	−.004	−.006	------	−.007	−.009	−.011	−.012	−.006	−.009	−.012	------	------
40°	------	C_l'	------	------	.059	------	.061	------	------	------	------	------	.039	------	------	.023	.021	------	------
40°	------	C_n'	------	------	.008	------	−.001	------	------	------	------	------	−.010	------	------	−.007	−.011	------	------
50°	------	C_l'	------	------	.063	------	.069	.067	.066	------	.064	.060	.044	.036	.008	.013	.011	------	------
50°	------	C_n'	------	------	.012	------	.002	.000	−.002	------	−.004	−.006	−.008	−.008	−.002	−.004	−.006	------	------
60°	------	C_l'	------	------	.069	------	.075	.075	.074	------	.071	.069	.053	.042	.008	.012	.011	------	------
60°	------	C_n'	------	------	.015	------	.005	.003	.000	------	−.002	−.005	−.006	−.006	−.001	−.004	−.005	------	------
80°	------	C_l'	------	------	.076	------	.084	------	------	------	------	------	.062	------	------	.018	.010	------	------
80°	------	C_n'	------	------	.019	------	.009	------	------	------	------	------	−.003	------	------	−.005	−.007	------	------
		DOWN ONLY																	
------	7°	C_l'	------	------	−0.015	------	−0.012	−0.012	−0.011	------	−0.007	−0.010	−0.003	−0.001	−0.007	−0.001	−0.001	------	------
------	7°	C_n'	------	------	.001	------	.003	.003	.004	------	.004	.004	.005	.004	.004	.002	.003	------	------
------	8½°	C_l'	------	------	−.018	------	−.015	------	------	------	------	------	−.005	------	------	.001	−.001	------	------
------	8½°	C_n'	------	------	.002	------	.004	------	------	------	------	------	.006	------	------	.003	.004	------	------
------	10°	C_l'	------	------	−.021	------	−.017	------	------	------	------	------	−.007	------	------	−.002	−.001	------	------
------	10°	C_n'	------	------	.003	------	.005	------	------	------	------	------	.007	------	------	.004	.004	------	------
------	11½°	C_l'	------	------	−.025	------	−.019	------	------	------	------	------	−.009	------	------	−.004	−.002	------	------
------	11½°	C_n'	------	------	.003	------	.006	------	------	------	------	------	.008	------	------	.005	.005	------	------
------	12°	C_l'	------	------	−.025	------	−.019	------	------	------	------	------	−.007	------	------	−.004	−.001	------	------
------	12°	C_n'	------	------	.004	------	.007	------	------	------	------	------	.008	------	------	.005	.006	------	------
------	13°	C_l'	------	------	−.027	------	−.021	------	------	------	------	------	−.007	------	------	−.002	−.002	------	------
------	13°	C_n'	------	------	.004	------	.007	------	------	------	------	------	.009	------	------	.003	.006	------	------
------	14°	C_l'	------	------	−.029	------	−.024	------	------	------	------	------	−.006	------	------	−.001	−.002	------	------
------	14°	C_n'	------	------	.005	------	.008	------	------	------	------	------	.010	------	------	.006	.007	------	------
------	15°	C_l'	------	------	−.031	------	−.024	−.023	−.021	------	−.017	−.012	−.006	.001	−.038	−.001	−.002	------	------
------	15°	C_n'	------	------	.005	------	.008	.009	.009	------	.010	.010	.010	.007	.037	.006	.007	------	------
------	20°	C_l'	------	------	−.037	------	−.030	------	------	------	------	------	−.005	------	------	−.001	−.001	------	------
------	20°	C_n'	------	------	.007	------	.013	------	------	------	------	------	.013	------	------	.008	.010	------	------
------	25°	C_l'	------	------	−.041	------	−.036	−.035	−.033	------	−.028	−.020	−.005	.007	−.006	−.001	−.001	------	------
------	25°	C_n'	------	------	.009	------	.015	.016	.017	------	.018	.017	.014	.009	.011	.010	.011	------	------
------	35°	C_l'	------	------	−.046	------	−.044	------	------	------	------	------	−.010	------	------	.003	.002	------	------
------	35°	C_n'	------	------	.015	------	.021	------	------	------	------	------	.017	------	------	.014	.015	------	------

TABLE III

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 10° SKEWED AILERONS 25 PER CENT AVERAGE c BY 40 PER CENT $b/2$. YAW=−20°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	0°	5°	10°	12°	14°	15°	16°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																
0°	0°	C_L	−0.014	0.305	0.635	0.946	1.044	1.123	1.145	1.162	1.179	1.178	0.972	0.912	0.914	0.817	0.758	0.642
0°	0°	C_D	.020	.022	.042	.078	.094	.114	.123	.133	.163	.218	.350	.421	.545	.681	.882	1.045
0°	0°	C_l'	−.002	−.006	−.006	−.006	−.015	−.020	−.026	−.032	−.055	−.078	−.102	−.104	−.035	−.057	−.048	−.044
0°	0°	C_n'	.001	.001	.002	.004	.006	.008	.010	.011	.014	.016	.023	.039	.049	.042	.046	.054
		UP ONLY																
25°	------	C_l'	------	0.046	------	0.042	0.048	0.048	------	0.048	0.061	0.050	0.039	0.031	0.013	−0.002	------	------
25°	------	C_n'	------	.003	------	−.005	−.007	−.008	------	−.010	−.011	−.014	−.023	−.022	−.017	−.006	------	------
35°	------	C_l'	------	.057	------	.054	.061	.061	------	.062	.064	.065	.091	.075	.019	.012	------	------
35°	------	C_n'	------	.007	------	−.003	−.005	−.007	------	−.010	−.012	−.015	−.018	−.037	−.025	−.010	------	------
50°	------	C_l'	------	.067	------	.068	.075	.075	------	.076	.079	.076	.071	.092	.031	.026	------	------
50°	------	C_n'	------	.015	------	−.003	.000	−.003	------	−.006	−.008	−.011	−.028	−.036	−.024	−.008	------	------
60°	------	C_l'	------	.064	------	.074	.082	.085	------	.085	.089	.083	.098	.090	.035	.026	------	------
60°	------	C_n'	------	.015	------	.007	.004	.001	------	−.002	−.004	−.008	−.027	−.035	−.023	−.013	------	------

TABLE IV

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 10° SKEWED AILERONS 25 PER CENT AVERAGE c BY 40 PER CENT $b/2$. YAW=20°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	0°	5°	10°	12°	14°	15°	16°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																
0°	0°	C_L	0.003	0.318	0.646	0.956	1.057	1.130	1.148	1.166	1.181	1.176	0.942	0.914	0.903	0.815	0.752	0.629
0°	0°	C_D	.019	.022	.043	.080	.096	.116	.125	.136	.171	.222	.353	.424	.523	.679	.872	1.021
0°	0°	C_l'	.008	.012	.013	.017	.021	.027	.032	.039	.063	.081	.106	.107	.097	.060	.052	.047
0°	0°	C_n'	−.001	−.002	−.003	−.006	−.008	−.011	−.012	−.014	−.017	−.022	−.031	−.045	−.055	−.048	−.054	−.063
		DOWN ONLY																
	7°	C_l'		−0.013		−0.010	−0.009	−0.009		−0.007	−0.008	−0.006	−0.003	−0.003	−0.001	−0.002		
	7°	C_n'		.002		.003	.003	.004		.003	.003	.004	.003	.004	.003	.004		
	15°	C_l'		−.026		−.020	−.020	−.019		−.016	−.013	−.013	−.006	−.007	−.003	−.004		
	15°	C_n'		.004		.007	.007	.008		.007	.006	.007	.008	.008	.007	.008		
	25°	C_l'		−.036		−.033	−.033	−.030		−.027	−.025	−.019	−.009	−.010	−.006	−.004		
	25°	C_n'		.007		.013	.014	.015		.014	.012	.013	.013	.014	.012	.013		

TABLE V

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 20° SKEWED AILERONS 25 PER CENT AVERAGE c BY 40 PER CENT $b/2$. YAW=0°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	−4°	−3°	0°	4 5°	10°	12°	14°	15°	16°	18°	20°	23°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																		
0°	0°	C_L	0.005	0.076	0.151	0.360	0.700	1.060	1.173	1.250	1.253	1.244	1.243	1.170	1.117	0.803	0.858	0.790	0.713	0.000
0°	0°	C_D	.018	.016	.017	.023	.045	.088	.108	.130	.146	.165	.201	.245	.283	.418	.540	.706	.890	1.053
		UP ONLY																		
10°		C_l'				0.015		0.015						0.003			0.001	0.000		
10°		C_n'				−.001		−.003						−.005			−.004	−.003		
20°		C_l'				.030		.031						.015			.008	.005		
20°		C_n'				.000		−.004						−.010			−.007	−.007		
25°		C_l'				.038		.038	0.040	0.038		0.036	0.036	.022	0.021	0.010	.013	.010		
25°		C_n'				.002		−.004	−.005	−.006		−.008	−.009	−.011	−.011	−.003	−.008	−.009		
30°		C_l'				.042		.044						.028			.015	.012		
30°		C_n'				.003		−.004						−.011			−.009	−.010		
35°		C_l'				.047		.049	.051	.050		.048	.048	.033	.032	.015	.018	.015		
35°		C_n'				.005		− 002	−.004	−.005		−.007	−.010	−.011	−.012	−.007	−.008	−.010		
40°		C_l'				.049		.052						.038			.016	.014		
40°		C_n'				.007		−.001						−.010			−.007	−.008		
50°		C_l'				.052		.058	.058	.056		.055	.056	.050	.037	.020	.019	.016		
50°		C_n'				.010		.003	.001	−.001		−.003	−.005	−.007	−.008	−.004	−.005	−.006		
60°		C_l'				.056		.063	.065	.065		.064	.065	.048	.037	.020	.019	.012		
60°		C_n'				.013		.006	.005	.003		.001	−.001	−.003	−.004	−.001	−.002	−.006		
80°		C_l'																		
80°		C_n'																		
		DOWN ONLY																		
	7°	C_l'				−0.011		−0.013	−.011	−0.011		−0.009	−0.009	−0.005	−0.001	0.001	0.000	−0.001		
	7°	C_n'				.001		.003	.004	.004		.005	.005	.005	.004	.003	.002	.003		
	8½°	C_l'				−.016		−.014						−.009			−.007	−.005		
	8½°	C_n'				.002		.004						.006			.005	.005		
	10°	C_l'				−.018		−.017						−.009			−.006	−.005		
	10°	C_n'				.002		.005						.008			.005	.006		
	11½°	C_l'				−.021		−.020						−.010			−.006	−.005		
	11½°	C_n'				.003		.006						.009			.006	.006		
	12°	C_l'				−.022		−.020						−.010			−.006	.002		
	12°	C_n'				.003		.006						.009			.006	.007		
	13°	C_l'				−.023		−.023						−.012			−.007	−.006		
	13°	C_n'				.003		.007						.010			.006	.007		
	14°	C_l'				−.024		−.023						−.012			−.007	−.006		
	14°	C_n'				.004		.007						.010			.007	.007		
	15°	C_l'				−.026		−.025	−.023	−.024		−.021	−.008	−.010	.000	−.003	−.006	−.005		
	15°	C_n'				.004		.008	.009	.010		.011	.011	.010	.007	.006	.007	.007		
	20°	C_l'				−.032		−.032						−.008			−.007	−.006		
	20°	C_n'				.006		.012						.013			.009	.010		
	25°	C_l'				−.035		−.035	−.034	−.032		−.028	−.015	−.008	.004	−.002	−.006	−.005		
	25°	C_n'				.008		.014	.015	.016		.018	.018	.015	.009	.010	.011	.013		
	35°	C_l'				−.041		−.040						−.014			−.005	−.005		
	35°	C_n'				.010		.017						.016			.014	.015		

TABLE VI

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 20° SKEWED AILERONS 25 PER CENT AVERAGE c BY 40 PER CENT $b/2$. YAW=−20°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	0°	5°	10°	12°	14°	15°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																	
0°	0°	C_L	−0.002	0.312	0.637	0.944	1.040	1.118	1.144	1.167	-------	1.178	1.168	0.966	0.917	0.912	0.818	0.759	0.642
0°	0°	C_D	.019	.021	.042	.079	.096	.115	.125	.137	-------	.169	.221	.348	.422	.525	.687	.886	1.053
0°	0°	C_l'	−.001	−.003	−.004	−.008	−.012	−.018	−.024	−.030	-------	−.052	−.076	−.102	−.104	−.091	−.056	−.048	−.044
0°	0°	C_n'	.002	.002	.002	.005	.006	.008	.010	.012	-------	.014	.016	.022	.040	.049	.044	.048	.055
		UP ONLY																	
25°	-------	C_l'	-------	0.035	-------	0.036	0.036	0.037	-------	0.037	-------	0.038	0.038	0.033	0.027	0.011	0.006	-------	-------
25°	-------	C_n'	-------	.002	-------	−.005	−.007	−.009	-------	−.011	-------	−.011	−.014	−.019	−.022	−.016	−.010	-------	-------
35°	-------	C_l'	-------	.046	-------	.048	.049	.051	-------	.051	-------	.052	.052	.046	.040	.023	.012	-------	-------
35°	-------	C_n'	-------	.005	-------	−.004	−.006	−.008	-------	−.011	-------	−.012	−.015	−.024	−.027	−.023	−.013	-------	-------
50°	-------	C_l'	-------	.058	-------	.064	.065	.067	-------	.068	-------	.069	.070	.063	.055	.038	.021	-------	-------
50°	-------	C_n'	-------	.013	-------	.001	−.002	−.004	-------	−.008	-------	−.009	−.014	−.025	−.027	−.025	−.015	-------	-------
60°	-------	C_l'	-------	.062	-------	.071	.073	.075	-------	.076	-------	.078	.077	.069	.061	.044	.028	-------	-------
60°	-------	C_n'	-------	.020	-------	.006	.004	.000	-------	−.004	-------	−.005	.010	−.020	−.025	−.023	−.016	-------	-------

TABLE VII

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 20° SKEWED AILERONS 25 PER CENT AVERAGE c BY 40 PER CENT $b/2$. YAW=20°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	0°	5°	10°	12°	14°	15°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																	
0°	0°	C_L	0.000	0.328	0.699	0.955	1.053	1.130	1.153	1.168	-------	1.181	1.174	0.936	0.912	0.901	.0812	0.747	0.631
0°	0°	C_D	.018	.021	.043	.080	.096	.115	.125	.138	-------	.172	.224	.356	.422	.520	.677	.871	1.035
0°	0°	C_l'	.010	.013	.015	.019	.023	.028	.034	.042	-------	.065	.082	.107	.109	.097	.060	.052	0.047
0°	0°	C_n'	−.001	−.001	−.003	−.006	−.008	−.011	−.012	−.014	-------	−.017	−.022	−.031	−.044	−.055	−.048	−.053	−.063
		DOWN ONLY																	
-------	7°	C_l'	-------	−0.010	-------	−0.011	−0.010	−0.009	-------	−0.008	-------	−0.008	−0.005	−0.003	−0.004	−0.002	−0.003	-------	-------
-------	7°	C_n'	-------	.001	-------	.003	.003	.004	-------	.003	-------	.003	.003	.003	.003	.002	.004	-------	-------
-------	15°	C_l'	-------	−.021	-------	−.021	−.020	−.019	-------	−.019	-------	−.016	−.012	−.007	−.009	−.004	−.005	-------	-------
-------	15°	C_n'	-------	.003	-------	.007	.008	.009	-------	.008	-------	.007	.008	.007	.007	.006	.008	-------	-------
-------	25°	C_l'	-------	−.031	-------	−.033	−.033	−.032	-------	−.031	-------	−.027	−.021	−.011	−.012	−.005	−.007	-------	-------
-------	25°	C_n'	-------	.007	-------	.014	.015	.017	-------	.016	-------	.013	.014	.012	.013	.012	.013	-------	-------

TABLE VIII

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 10° SKEWED AILERONS 40 PER CENT AVERAGE c BY 30 PER CENT $b/2$. YAW=0°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	−3°	0°	4.5°	10°	12°	14°	15°	16°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																	
0°	0°	C_L	0.008	0.149	0.383	0.700	1.058	1.176	1.250	1.255	1.240	1.241	1.163	1.117	0.793	0.845	0.808	0.716	0.600
0°	0°	C_D	.016	.016	.020	.043	.087	.108	.130	.148	.166	.199	.246	.281	.419	.538	.727	.881	1.045
		UP ONLY																	
10°	-----	C_l'	-----	-----	0.018	-----	0.020	-----	-----	-----	-----	-----	0.006	-----	-----	0.001	0.000	-----	-----
10°	-----	C_n'	-----	-----	−.001	-----	−.004	-----	-----	-----	-----	-----	−.006	-----	-----	−.003	−.003	-----	-----
20°	-----	C_l'	-----	-----	.037	-----	.040	-----	-----	-----	-----	-----	.025	-----	-----	.002	.004	-----	-----
20°	-----	C_n'	-----	-----	.002	-----	−.005	-----	-----	-----	-----	-----	−.011	-----	-----	−.005	−.007	-----	-----
25°	-----	C_l'	-----	-----	.044	-----	.048	.048	.047	.046	.046	.047	.034	.020	.009	.007	.008	-----	-----
25°	-----	C_n'	-----	-----	.004	-----	−.004	-----	-----	−.008	-----	−.011	−.012	−.013	−.008	−.007	−.008	-----	-----
30°	-----	C_l'	-----	-----	.048	-----	.055	-----	-----	-----	-----	-----	.042	-----	-----	.009	.011	-----	-----
30°	-----	C_n'	-----	-----	.006	-----	−.002	-----	-----	-----	-----	-----	−.012	-----	-----	−.008	−.009	-----	-----
35°	-----	C_l'	-----	-----	.053	-----	.065	.065	.054	-----	.064	.064	.052	.037	.018	.016	.016	-----	-----
35°	-----	C_n'	-----	-----	.009	-----	.000	−.003	−.005	-----	−.007	−.009	−.012	−.014	−.009	−.009	−.012	-----	-----
40°	-----	C_l'	-----	-----	.059	-----	.071	-----	-----	-----	-----	-----	.059	-----	-----	.019	.019	-----	-----
40°	-----	C_n'	-----	-----	.012	-----	.002	-----	-----	-----	-----	-----	−.010	-----	-----	−.009	−.012	-----	-----
50°	-----	C_l'	-----	-----	.065	-----	.081	.083	.082	-----	.082	.083	.070	.050	.034	.018	.027	-----	-----
50°	-----	C_n'	-----	-----	.016	-----	.007	.005	.003	-----	.000	−.003	−.008	−.008	−.007	−.005	−.011	-----	-----
60°	-----	C_l'	-----	-----	.072	-----	.087	.089	.091	-----	.092	.094	.079	.053	.043	.026	.017	-----	-----
60°	-----	C_n'	-----	-----	.021	-----	.012	.010	.008	-----	.006	.004	.001	−.001	−.003	−.003	−.008	-----	-----
80°	-----	C_l'	-----	-----	.062	-----	.071	-----	-----	-----	-----	-----	.054	-----	-----	.014	.010	-----	-----
80°	-----	C_n'	-----	-----	.018	-----	.009	-----	-----	-----	-----	-----	.001	-----	-----	.001	−.005	-----	-----
		DOWN ONLY																	
-----	7°	C_l'	-----	-----	−0.014	-----	−0.012	−0.011	−0.009	-----	−0.007	−0.007	−0.005	−0.013	−0.000	−0.001	−0.001	-----	-----
-----	7°	C_n'	-----	-----	.002	-----	.004	.004	.004	-----	.005	.005	.005	.005	.003	.003	.003	-----	-----
-----	8½°	C_l'	-----	-----	−.017	-----	−.014	-----	-----	-----	-----	-----	−.005	-----	-----	.001	.003	-----	-----
-----	8½°	C_n'	-----	-----	.002	-----	.004	-----	-----	-----	-----	-----	.006	-----	-----	.003	.005	-----	-----
-----	10°	C_l'	-----	-----	−.020	-----	−.016	-----	-----	-----	-----	-----	−.004	-----	-----	.001	.000	-----	-----
-----	10°	C_n'	-----	-----	.003	-----	.005	-----	-----	-----	-----	-----	.007	-----	-----	.004	.005	-----	-----
-----	11½°	C_l'	-----	-----	−.022	-----	−.017	-----	-----	-----	-----	-----	−.005	-----	-----	.002	.000	-----	-----
-----	11½°	C_n'	-----	-----	.003	-----	.006	-----	-----	-----	-----	-----	.007	-----	-----	.004	.005	-----	-----
-----	12°	C_l'	-----	-----	−.023	-----	−.018	-----	-----	-----	-----	-----	−.004	-----	-----	.002	.000	-----	-----
-----	12°	C_n'	-----	-----	.003	-----	.006	-----	-----	-----	-----	-----	.008	-----	-----	.004	.005	-----	-----
-----	13°	C_l'	-----	-----	−.025	-----	−.021	-----	-----	-----	-----	-----	−.005	-----	-----	.003	.000	-----	-----
-----	13°	C_n'	-----	-----	.004	-----	.008	-----	-----	-----	-----	-----	.009	-----	-----	.005	.006	-----	-----
-----	14°	C_l'	-----	-----	−.026	-----	−.022	-----	-----	-----	-----	-----	−.002	-----	-----	.002	.000	-----	-----
-----	14°	C_n'	-----	-----	.004	-----	.008	-----	-----	-----	-----	-----	.009	-----	-----	.005	.007	-----	-----
-----	15°	C_l'	-----	-----	−.027	-----	−.023	−.023	−.022	-----	−.018	−.003	−.006	−.010	.001	.001	000	-----	-----
-----	15°	C_n'	-----	-----	.005	-----	.009	.010	.011	-----	.012	.012	.010	.008	.007	.006	.008	-----	-----
-----	20°	C_l'	-----	-----	−.033	-----	−.029	-----	-----	-----	-----	-----	.002	-----	-----	004	.001	-----	-----
-----	20°	C_n'	-----	-----	.007	-----	.013	-----	-----	-----	-----	-----	.011	-----	-----	.007	.010	-----	-----
-----	25°	C_l'	-----	-----	−.039	-----	−.033	−.033	−.030	-----	−.027	−.007	−.004	−.004	.004	.005	.001	-----	-----
-----	25°	C_n'	-----	-----	.012	-----	.016	.018	.018	-----	.020	.018	.014	.010	.010	.009	.013	-----	-----
-----	35°	C_l'	-----	-----	−.044	-----	−.037	-----	-----	-----	-----	-----	−.005	-----	-----	.010	.004	-----	-----
-----	35°	C_n'	-----	-----	.016	-----	.022	-----	-----	-----	-----	-----	.017	-----	-----	.012	.017	-----	-----

TABLE IX

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 10° SKEWED AILERONS 40 PER CENT AVERAGE c BY 30 PER CENT $b/2$. YAW=−20°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	0°	5°	10°	12°	14°	15°	16°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																
0°	0°	C_L	−0.008	0.311	0.639	0.938	1.043	1.114	1.139	1.155	1.174	1.175	0.934	0.922	0.908	0.816	0.760	0.042
0°	0°	C_D	.019	.022	.042	.078	.095	.111	.124	.134	.166	.214	.346	.413	.525	.681	.879	1.057
0°	0°	C_l'	−.001	−.003	−.005	−.009	−.013	−.019	−.024	−.030	−.053	−.075	−.103	−.105	−.093	−.057	−.047	−.044
0°	0°	C_n'	.002	.002	.002	.005	.006	.008	.010	.011	.013	.016	.021	.038	.048	.042	.047	.055
		UP ONLY																
25°	-----	C_l'	-----	0.042	-----	0.042	0.043	0.042	0.042	0.042	0.045	0.043	0.039	0.032	0.021	0.005	-----	-----
25°	-----	C_n'	-----	.004	-----	−.005	−.006	−.008	−.009	−.010	−.011	−.014	−.021	−.024	−.022	−.010	-----	-----
35°	-----	C_l'	-----	.060	-----	.061	-----	-----	.061	-----	.063	.062	.057	.049	.037	.011	-----	-----
35°	-----	C_n'	-----	.010	-----	−.001	-----	-----	−.008	-----	−.011	−.015	−.025	−.028	−.027	−.015	-----	-----
50°	-----	C_l'	-----	.070	-----	.088	.090	.090	-----	.090	.094	.093	.086	.074	.060	.020	-----	-----
50°	-----	C_n'	-----	.021	-----	.009	.005	.002	-----	−.001	−.005	−.010	−.021	−.029	−.030	−.018	-----	-----
60°	-----	C_l'	-----	.069	-----	.103	.104	.106	-----	.108	.113	.110	.102	.089	.074	.032	-----	-----
60°	-----	C_n'	-----	.024	-----	.019	.015	.011	-----	.007	.004	−.002	−.015	−.024	−.028	−.019	-----	-----

TABLE X

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 10° SKEWED AILERONS 40 PER CENT AVERAGE c BY 30 PER CENT $b/2$. YAW=20°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	0°	5°	10°	12°	14°	15°	16°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																
0°	0°	C_L	0.002	0.326	0.653	0.962	1.059	1.128	1.157	1.175	1.188	1.178	0.980	0.915	0.890	0.808	0.750	0.630
0°	0°	C_D	.017	.022	.043	.080	.098	.115	.125	.138	.172	222	.357	.421	.521	.673	.869	1.037
0°	0°	C_l'	.010	.013	.015	.019	.024	.028	.034	.043	.064	.083	.095	.109	.096	.061	.053	.048
0°	0°	C_n'	−.001	−.001	−.003	−.006	−.008	−.011	−.012	−.014	−.017	−.021	−.030	−.045	−.054	−.048	−.054	−.064
		DOWN ONLY																
	7°	C_l'		−0.012		−0.011	−0.011	−0.010		−0.010	−0.007	−0.005	0.010	−0.004	−0.003	−0.004		
	7°	C_n'		.001		.003	.003	.004		.004	.003	.003	.002	.004	.003	.006		
	15°	C_l'		−.025		−.022	−.024	−.022		−.021	−.016	−.013	.008	−.007	−.003	−.005		
	15°	C_n'		.004		.008	.009	.010		.010	.008	.008	.006	.009	.007	.009		
	25°	C_l'		−.039		−.038	−.040	−.036		−.034	−.026	−.016	.004	−.010	−.003	−.005		
	25°	C_n'		.011		.019	.020	.021		.020	.015	.015	.012	.015	.012	.014		

TABLE XI

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 20° SKEWED AILERONS 40 PER CENT AVERAGE c BY 30 PER CENT $b/2$. YAW=0°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	−3°	0°	4.5°	10°	12°	14°	15°	16°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																	
0°	0°	C_L	0.022	0.164	0.372	0.700	1.069	1.178	1.249	1.247	1.244	1.243	1.164	1.102	0.795	0.838	0.804	0.707	0.589
0°	0°	C_D	.017	.016	.022	.046	.093	.112	.134	.152	.171	.207	.248	.281	.424	.535	.721	.887	1.053
		UP ONLY																	
10°		C_l'			0.017		0.016	0.016	0.016		0.013	0.013	0.003	0.004	0.002	0.001	0.000		
10°		C_n'			.000		−.003	−.004	−.004		−.005	−.005	−.005	−.005	−.003	−.003	−.004		
20°		C_l'			.033		.035		.034	.031	.033	.033	.023	.021	.008	.010	.005		
20°		C_n'			.001		−.005		−.007	−.007	−.008	−.010	−.010	−.012	−.007	−.007	−.008		
25°		C_l'			.041		.043	.041	.041		.039	.039	.028	.025	.008	.009	.006		
25°		C_n'			.003		−.004	−.005	−.006		−.008	−.010	−.011	−.012	−.007	−.008	−.009		
30°		C_l'			.049		.051	.051	.050		.050	.050	.041	.037	.015	.015	.012		
30°		C_n'			.006		−.002	−.004	−.006		−.008	−.010	−.012	−.013	−.009	−.010	−.011		
35°		C_l'			.053		.059	.059	.057		.056	.055	.043	.040	.015	.016	.014		
35°		C_n'			.003		−.002	−.003	−.005		−.007	−.010	−.011	−.013	−.009	−.010	−.012		
40°		C_l'			.058		.067	.066	.066		.066	.066	.057	.049	.023	.021	.020		
40°		C_n'			.011		.001	−.002	−.003		−.006	−.008	−.011	−.012	−.010	−.010	−.014		
50°		C_l'			.069		.079	.078	.078		.077	.077	.062	.054	.030	.024	.026		
50°		C_n'			.017		.006	.004	.001		−.002	−.004	−.006	−.008	−.007	−.008	−.013		
60°		C_l'			.070		.087	.087	.088		.087	.087	.070	.061	.036	.029	.024		
60°		C_n'			.020		.013	.010	.008		.005	.002	.000	−.002	−.002	−.004	−.011		
80°		C_l'																	
80°		C_n'																	
		DOWN ONLY																	
	7°	C_l'			−0.011		−0.008	−0.009	−0.009		−0.009	−0.008	−0.001	0.000	0.002	0.001	0.000		
	7°	C_n'			.002		.004	.004	.005		.005	.006	.006	.005	.004	.004	.004		
	8½°	C_l'			−.013		−.011	−.012	−.011		−.009	−.011	−.009	.000	.001	.001	−.001		
	8½°	C_n'			.003		.004	.005	.006		.006	.007	.006	.005	.004	.003	.004		
	10°	C_l'			−.015		−.013	−.014	−.014		−.012	−.001	−.003	.000	.002	.002	.000		
	10°	C_n'			.003		.006	.006	.007		.007	.008	.007	.008	.004	.004	.004		
	11½°	C_l'			−.016		−.016	−.017	−.016		−.015	−.002	.000	.001	.002	.002	.000		
	11½°	C_n'			.003		.006	.007	.008		.009	.009	.008	.006	.004	.005	.005		
	12°	C_l'			−.018		−.017	−.018	−.017		−.015	−.003	−.004	.001	.002	.002	.000		
	12°	C_n'			.004		.007	.007	.009		.009	.009	.008	.006	.005	.005	.005		
	13°	C_l'			−.019		−.020	−.021	−.019		−.016	−.004	.004	.001	.003	.002	−.001		
	13°	C_n'			.004		.008	.009	.009		.010	.010	.009	.007	.005	.005	.006		
	14°	C_l'			−.020		−.020	−.021	−.020		−.016	−.004	−.003	.001	.002	.002	.000		
	14°	C_n'			.004		.008	.009	.010		.011	.011	.009	.007	.005	.005	.007		
	15°	C_l'			−.022		−.023	−.023	−.022		−.018	−.005	−.003	.002	.002	.003	.000		
	15°	C_n'			.005		.009	.010	.011		.012	.012	.010	.007	.006	.006	.007		
	20°	C_l'			−.027		−.028	−.028	−.027		−.022	−.005	−.003	.005	.004	.003	.000		
	20°	C_n'			.007		.013	.014	.015		.016	.015	.012	.009	.007	.008	.010		
	25°	C_l'			−.033		−.032		−.031	−.031	−.026	−.007	.001	.006	.005	.004	.001		
	25°	C_n'			.010		.016		.018	.019	.020	.017	.014	.010	.009	.009	.011		
	30°	C_l'			−.039		−.037	−.037	−.035		−.029	−.018	−.003	.006	.007	.007	.002		
	30°	C_n'			.013		.019	.020	.021		.023	.021	.016	.012	.011	.012	.015		

TABLE XII

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 20° SKEWED AILERONS 40 PER CENT AVERAGE c BY 30 PER CENT $b/2$. YAW=−20°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																
0°	0°	C_L	0.006	0.326	0.651	0.948	1.048	1.109	1.152	1.168	1.166	1.164	0.953	0.914	0.896	0.819	0.754	0.639
0°	0°	C_D	.018	.022	.044	.080	.097	.115	.137	.152	.172	.220	.350	.423	.526	.692	.881	1.048
0°	0°	C_l'	−.002	−.004	−.005	−.009	−.013	−.019	−.033	−.042	−.055	−.078	−.104	−.105	−.089	−.057	−.048	−.043
0°	0°	C_n'	.001	.001	.002	.005	.006	.009	.012	.013	.014	.017	.025	.041	.049	.044	.048	.055
		UP ONLY																
25°	-------	C_l'	-------	0.037	-------	0.036	0.037	0.036	0.038	-------	0.039	0.047	0.043	0.033	0.016	0.003	-------	-------
25°	-------	C_n'	-------	.003	-------	−.006	−.007	−.008	−.011	-------	−.012	−.015	−.020	−.025	−.020	−.012	-------	-------
35°	-------	C_l'	-------	.052	-------	.053	.053	.052	.053	-------	−.055	−.054	−.048	−.038	−.025	−.008	-------	-------
35°	-------	C_n'	-------	.007	-------	−.004	−.006	−.008	−.011	-------	−.013	−.016	−.025	−.029	−.026	−.016	-------	-------
50°	-------	C_l'	-------	.071	-------	.077	.076	.078	.080	-------	.079	.082	.072	.065	.046	.018	-------	-------
50°	-------	C_n'	-------	.019	-------	.003	.001	−.002	−.006	-------	−.009	−.013	−.026	−.031	−.030	−.021	-------	-------
60°	-------	C_l'	-------	.081	-------	.091	.092	.093	.096	-------	.097	.098	.089	.080	.061	.025	-------	-------
60°	-------	C_n'	-------	.029	-------	.012	.008	.005	.001	-------	−.003	−.009	−.022	−.029	−.029	−.019	-------	-------

TABLE XIII

FORCE TEST. 10- BY 60-INCH CLARK Y WING WITH 20° SKEWED AILERONS 40 PER CENT AVERAGE c BY 30 PER CENT $b/2$. YAW=20°. R. N.=609,000. VELOCITY=80 M. P. H.

δ_A up	δ_A down	α	−5°	0°	5°	10°	12°	14°	16°	17°	18°	20°	22°	25°	30°	40°	50°	60°
		AILERONS LOCKED—NEUTRAL																
0°	0°	C_L	0.017	0.337	0.663	0.965	1.067	1.136	1.177	1.194	1.185	1.177	0.935	0.903	0.894	0.803	0.744	0.628
0°	0°	C_D	.017	.021	.044	.081	.098	.118	.141	.157	.175	.225	.353	.421	.523	.681	.879	1.042
0°	0°	C_l'	.009	.013	.015	.018	.022	.028	.042	.054	.035	.083	.107	.107	.096	.058	.052	.041
0°	0°	C_n'	−.001	−.002	−.003	−.006	−.008	−.010	−.014	−.015	−.017	−.022	−.031	−.050	−.054	−.046	−.052	−.061
		DOWN ONLY																
-------	7°	C_l'	-------	−0.010	-------	−0.009	−0.010	−0.010	−0.010	-------	−0.008	−0.006	−0.003	−0.003	−0.001	0.000	-------	-------
-------	7°	C_n'	-------	.002	-------	.003	.004	.004	.005	-------	.004	.005	.004	.006	.004	.004	-------	-------
-------	15°	C_l'	-------	−.021	-------	−.022	−.023	−.023	−.022	-------	−.019	−.016	−.007	−.007	−.003	−.002	-------	-------
-------	15°	C_n'	-------	.004	-------	.009	.010	.011	.011	-------	.010	.010	.008	.010	.008	.009	-------	-------
-------	25°	C_l'	-------	−.034	-------	−.036	-------	−.045	−.034	−.032	−.028	−.023	−.009	−.010	−.002	−.002	-------	-------
-------	25°	C_n'	-------	.009	-------	.017	-------	.019	.019	.018	.016	.016	.014	.016	.012	.012	-------	-------

TABLE XIV.—CRITERIONS SHOWING RELATIVE MERITS OF AILERONS

ASSUMED RIGHT AILERON UP AND LEFT AILERON DOWN

Subject	Criterion	Straight ailerons 25 per cent chord by 40 per cent semispan (assumed standard size)				10° skewed ailerons 25 per cent average chord by 40 per cent semispan				20° skewed ailerons 25 per cent average chord by 40 per cent semispan			
		Standard 25° up, 25° down	Differential No. 1 35° up, 15° down	Differential No. 2 50° up, 7° down	Up only 60°	Standard 25° up, 25° down	Differential No. 1 35° up, 15° down	Differential No. 2 50° up, 7° down	Up only 60°	Standard 25° up, 25° down	Differential No. 1 35° up, 15° down	Differential No. 2 50° up, 7° down	Up only 60°
Wing area or minimum speed.	Maximum C_L ($\delta_A=0°$)	1.270	1.270	1.270	1.270	1.278	1.278	1.278	1.278	1.253	1.253	1.253	1.253
Speed range	Maximum C_L/minimum C_D ($\delta_A=0°$)	79.4	79.4	79.4	79.4	74.7	74.7	74.7	74.7	76.4	76.4	76.4	76.4
Rate of climb	L/D at $C_L=0.70$ ($\delta_A=0°$)	15.9	15.9	15.9	15.9	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
Lateral controllability	RC $\alpha=0°$	.204	.202	.214	.196	.240	.238	.221	.194	.204	.204	.179	.155
	RC $\alpha=10°$	.076	.074	.074	.072	.082	.077	.075	.069	.071	.070	.065	.058
	RC $\alpha=20°$	.038	.051	.055	.054	.035	.039	.041	.044	.031	.041	.048	.040
	RC $\alpha=30°$	.017	.005	.002	.002	.026	.032	.018	.014	.031	.032	.024	.021
Lateral control with sideslip.	Maximum α at which ailerons will balance C_l' due to 20° yaw.	20°	20°	21°	22°	19°	20°	20°	21°	18°	19°	20°	20°
Yawing moments due to ailerons: (+) Favorable; (−) unfavorable.	C_{n_A} $\alpha=0°$	------- −.007	.002 [b]−.003	.010 [b]−.002	.016 -------	------- −.007	.001 [b]−.003	.010 [c]−.003	.015 [a]−.007	------- −.006	.002 [b]−.003	.009 [b]−.003	.013 [a]−.001
	C_{n_A} $\alpha=10°$	------- −.004	.004 [b]−.002	.013 [b]−.001	.018 -------	------- [a]−.005	.004 [a]−.002	.013 [b]−.001	.018 -------	------- −.005	.003 [b]−.002	.012 [b]−.002	.017 [a]−.001
	C_{n_A} $\alpha=20°$	------- −.010	------- [b]−.007	.008 [b]−.006	.013 [a]−.003	------- [a]−.013	------- [a]−.009	.005 [c]−.009	.012 [b]−.004	------- −.014	------- [c]−.009	.018 [a]−.009	.014 [b]−.004
	C_{n_A} $\alpha=30°$	------- −.008	------- −.008	------- [b]−.007	.002 [b]−.004	------- −.008	------- [a]−.004	[f].004 [c]−.002	[f].016 -------	------- [a]−.007	------- [c]−.004	.004 [a]−.005	.003 [b]−.003
Lateral stability ($\delta_A=0°$)	α for initial instability in rolling	18°	18°	18°	18°	-------	-------	-------	-------	-------	-------	-------	-------
	α for initial instability at $p'b/2V=0.05$: Yaw=0°.	17°	17°	17°	17°	-------	-------	-------	-------	-------	-------	-------	-------
	Ditto: Yaw=20°	11°	11°	11°	11°	-------	-------	-------	-------	-------	-------	-------	-------
	Maximum unstable C_λ at $p'b/2V=0.05$: Yaw=0°.	.048	.048	.048	.048	-------	-------	-------	-------	-------	-------	-------	-------
	Ditto: Yaw=20°	.093	.093	.093	.093	-------	-------	-------	-------	-------	-------	-------	-------

Subject	Criterion	Straight ailerons 40 per cent chord by 30 per cent semispan				10° skewed ailerons 40 per cent average chord by 30 per cent semispan				20° skewed ailerons 40 per cent average chord by 30 per cent semispan			
		Standard 25° up, 25° down	Differential No. 1 35° up, 15° down	Differential No. 2 50° up, 7° down	Up only 60°	Standard 25° up, 25° down	Differential No. 1 35° up, 15° down	Differential No. 2 50° up, 7° down	Up only 60°	Standard 25° up, 25° down	Differential No. 1 35° up, 15° down	Differential No. 2 50° up, 7° down	Up only 60°
Wing area or minimum speed.	Maximum C_L ($\delta_A=0°$)	1.258	1.258	1.258	1.258	1.260	1.260	1.260	1.260	1.249	1.249	1.249	1.249
Speed range	Maximum C_L/minimum C_D ($\delta_A=0°$)	78.5	78.5	78.5	78.5	80.3	80.3	80.3	80.3	78.5	78.5	78.5	78.5
Rate of climb	L/D at $C_L=0.70$ ($\delta_A=0°$)	15.9	15.9	15.9	15.9	16.3	16.3	16.3	16.3	15.2	15.2	15.2	15.2
Lateral controllability	RC $\alpha=0°$	.226	.234	.226	.202	.229	.220	.216	.197	.199	.200	.214	.187
	RC $\alpha=10°$	.078	.084	.083	.076	.078	.082	.085	.078	.072	.077	.080	.078
	RC $\alpha=20°$	.046	.058	[g].073	[h].074	.037	.053	.064	.064	.029	.044	.054	.057
	RC $\alpha=30°$	.019	.025	.026	.022	.011	.024	.024	.028	.016	.023	.030	.032
Lateral control with sideslip.	Maximum α at which ailerons will balance C_l' due to 20° yaw.	19°	20°	22°	25°	19°	20°	21°	22°	19°	19°	20°	21°
Yawing moments due to ailerons: (+) Favorable; (−) unfavorable.	C_{n_A} $\alpha=0°$	------- −.007	.005 [b]−.002	.016 [a]−.001	.021 -------	------- −.008	.004 [b]−.003	.014 [b]−.003	.021 [a]−.001	------- −.006	.003 [b]−.003	.014 [b]−.003	.020 [a]−.001
	C_{n_A} $\alpha=10°$	------- −.007	.006 [b]−.003	.020 [a]−.002	.026 -------	------- −.006	.006 [b]−.002	.019 [b]−.002	.027 -------	------- −.006	.004 [b]−.003	.017 [a]−.003	.028 [a]−.001
	C_{n_A} $\alpha=20°$	------- −.010	.001 [b]−.008	.019 [b]−.007	.029 [a]−.003	------- [a]−.013	------- [b]−.009	.015 [b]−.008	.028 [a]−.004	------- −.014	------- [c]−.009	.010 [b]−.009	.024 [a]−.004
	C_{n_A} $\alpha=30°$	------- −.012	------- [d]−.009	.003 [a]−.005	.009 [a]−.002	------- −.013	------- [a]−.009	.002 [a]−.008	.011 [a]−.004	------- −.012	------- [a]−.008	.001 [c]−.007	.010 [a]−.002
Lateral stability ($\delta_A=0°$).	α for initial instability in rolling	18°	18°	18°	18°	-------	-------	-------	-------	-------	-------	-------	-------
	α for initial instability at $p'b/2V=0.05$: Yaw=0°.	17°	17°	17°	17°	-------	-------	-------	-------	-------	-------	-------	-------
	Ditto: Yaw=20°	12°	12°	12°	12°	-------	-------	-------	-------	-------	-------	-------	-------
	Maximum unstable C_λ at $p'b/2V=0.05$: Yaw=0°.	.022	.022	.022	.022	-------	-------	-------	-------	-------	-------	-------	-------
	Ditto: Yaw=20°	.085	.085	.085	.085	-------	-------	-------	-------	-------	-------	-------	-------

[a] to [f] Where the maximum yawing moment occurred below maximum deflection, the letters indicate the deflection of the up aileron as follows: [a]=10°, [b]=15°, [c]=20°, [d]=25°, [e]=30°, [f]=40°.

[g] RC has a minimum value of 0.066 at $\alpha=17°$ and a maximum of 0.074 at $\alpha=22°$.

[h] $RC=0.064$ at $\alpha=17°$ and 0.094 at $\alpha=22°$.