# REPORT No. 343

## EFFECT OF VARIATION OF CHORD AND SPAN OF AILERONS ON ROLLING AND YAWING MOMENTS AT SEVERAL ANGLES OF PITCH

By R. H. HEALD, D. H. STROTHER, and B. H. MONISH
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### SUMMARY

*This report presents the results of an extension to higher angles of attack of the investigation described in Reference 1, of the rolling and yawing moments due to ailerons of various chords and spans on two airfoils having the Clark Y and U. S. A. 27 wing sections.*

*The measurements were made at various angles of pitch but at zero angle of roll and yaw, the wing chord being set at an angle of +4° to the fuselage axis. In the case of the Clark Y airfoil the measurements have been extended to a pitch angle of 40°, using ailerons of span equal to 67 per cent of the wing semispan and chord equal to 20 and 30 per cent of the wing chord. It is planned later to extend the investigation to hinge moments of the ailerons for the conditions covered in the rolling and yawing moment tests.*

*The work was conducted in the 10-foot wind tunnel of the Bureau of Standards on wing models of 60-inch span and 10-inch chord.*

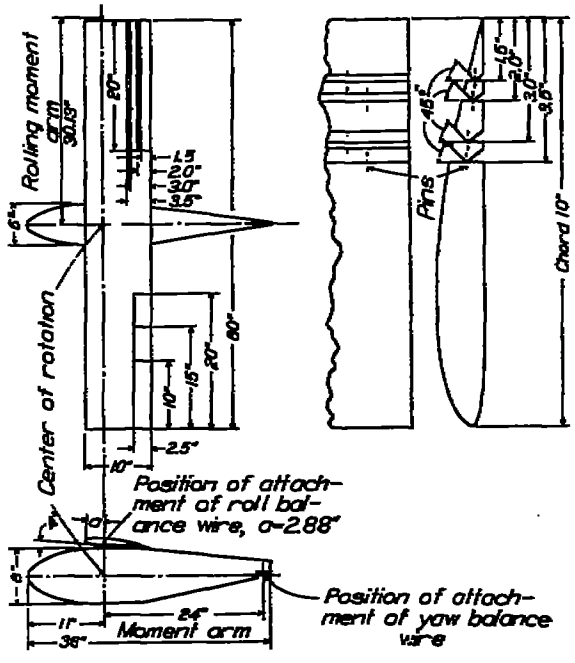
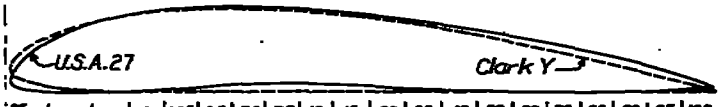




Figure 1.—Dimensioned drawing of model

### INTRODUCTION

The work was continued through the cooperation of the Aeronautics Branch of the Department of Commerce and the National Advisory Committee for Aeronautics, for the purpose of furthering the knowledge of the rolling and yawing moments due to conventional ailerons on some representative American wing sections.




| % chord | | 0 | 1.25 | 2.5 | 5.0 | 7.5 | 10 | 15 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 95 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.S.A.27 | Upper | 1.77 | 3.80 | 5.07 | 6.94 | 8.22 | 9.19 | 10.50 | 11.37 | 11.97 | 11.68 | 10.88 | 9.54 | 8.08 | 6.10 | 3.69 | 2.26 | 0.67 |
| | Lower | 1.77 | 0.50 | 0.36 | 0.19 | 0.10 | 0.02 | 0.10 | 0.36 | 0.93 | 1.14 | 0.75 | 0.26 | 0.06 | 0.01 | 0.12 | 0.33 | 0.65 |
| Clark Y | Upper | 2.62 | 5.38 | 6.43 | 7.83 | 8.79 | 9.56 | 10.63 | 11.32 | 11.68 | 11.37 | 10.45 | 9.13 | 7.34 | 5.21 | 2.79 | 1.58 | 0.12 |
| | Lower | 1.55 | 1.86 | 1.42 | 0.91 | 0.59 | 0.39 | 0.12 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Figure 2.—Profiles and coordinates of Clark Y and U. S. A. 27 wing sections

### DESCRIPTION OF APPARATUS AND MODELS

A detailed description of the apparatus and models is given in Reference 1 and a dimensioned sketch of the model is shown in Figure 1. The profiles and coordinates of the wing sections used are given in Figure 2, and a sketch of the method of mounting the model in the tunnel in Figure 3.

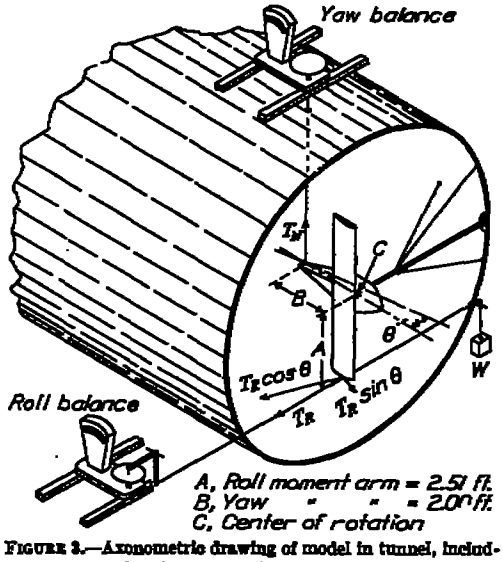



Figure 3.—Axonometric drawing of model in tunnel, including sketch of resolution of forces

### ARRANGEMENT OF BALANCES

A sketch of the balance arrangement is shown in Figure 3. The model was supported in the tunnel so that the leading edge of the wing was vertical and the

rolling and yawing forces read on balances of the pendulum type. The roll and yaw force wires were kept normal to the wind stream.

## METHOD OF OBSERVATION

As before, simultaneous measurements of the tension in the roll and yaw balance wires were made at speeds of 40, 58.7, and 80 feet per second (respectively, 27.3, 40, and 54.5 miles per hour). Observations were made at a sufficient number of aileron angles to determine the characteristics of the curves. The ailerons were set to the desired angle by the use of metal templates and were secured by thin metal strips on the top and bottom of the wing (fig. 4), as it was found that the stiffness of the pins was not sufficient to prevent a change of the aileron angle under the wind pressure.

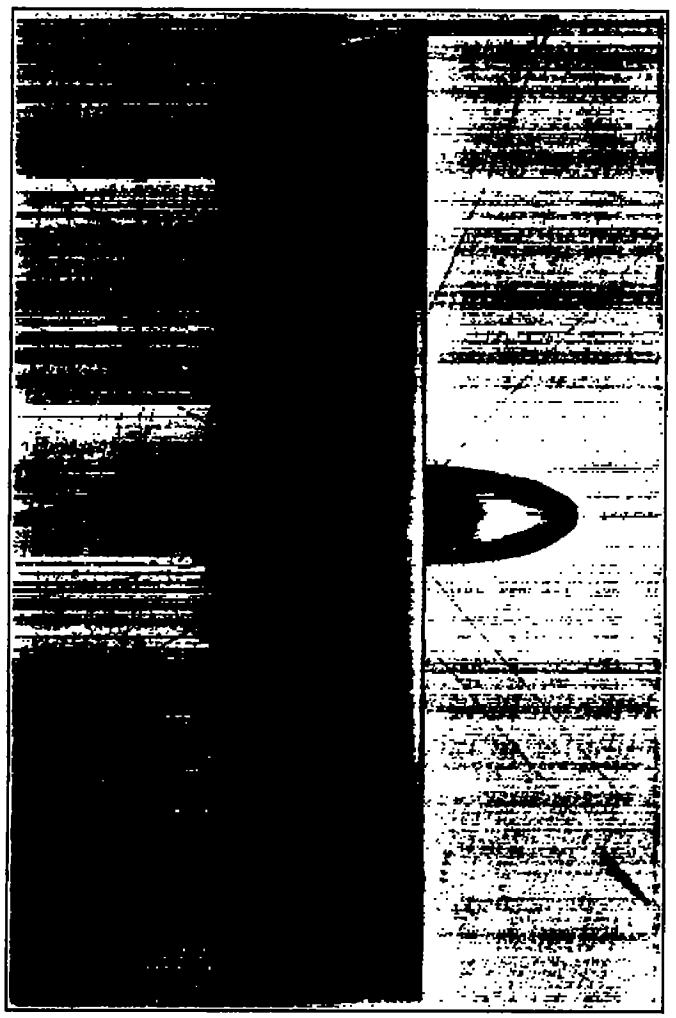


FIGURE 4.—Photograph of model set at 12° pitch in tunnel

## REDUCTION OF OBSERVATIONS

Small rolling and yawing forces, which appeared to be due to the drag of the balance wires and to a slight asymmetry of the model, were noted at zero aileron angle in all cases. Correction was made for these forces in the reduction of observations.

The results are expressed in the usual absolute coefficients, namely:[1]

$$C_L=\frac{L}{qbS} \text{ and } C_N=\frac{N}{qfS}$$

where $C_L$ and $C_N$ are the absolute rolling and yawing moment coefficients for one aileron.

$L$ and $N$ are respectively rolling and yawing moments in pounds-feet.

$q=\frac{1}{2}\rho V^2=0.001189V^2$

$b$ = wing span in feet

$f$ = distance from center of rotation of model to end of tail. (NOTE.—This distance was chosen as closely representing the distance from the center of gravity of the airplane to the leading edge of the elevator)

$S$ = wing area in square feet (chord length × span)

$V$ = wind speed in feet per second

$\rho$ = air density = 0.002378 slug per cubic foot at 15° C. and 760 mm. pressure

The results are reduced to body axes as reference axes and the directions are conventional, a moment tending to produce a clockwise rotation as viewed from the pilot's seat being considered positive. The longitudinal axis is the axis of the fuselage, the axis of yaw is perpendicular to the longitudinal axis and to the span of the wing, and the pitch axis is parallel to the wing span. The reduction to body axes is made as follows:

Referring to Figure 3, the roll force resolved parallel to the axis of yaw is $T_R \cos \theta$, where $T_R$ is the net observed tension in the roll wire and $\theta$ is the angle of pitch. The rolling moment is $AT_R \cos \theta$. Because of he inclination of the roll wire to the pitch plane, a component $T_R \sin \theta$, having an arm $A$, enters into the computation of the yawing moment. The yawing moment, therefore, is seen to be $-BT_N+AT_R \sin \theta$. Note that an increase in the yaw balance reading corresponds to a negative yawing moment according to the convention adopted; hence the minus sign.

## RESULTS

The signs and values for one aileron given in the tables and plots are for a single aileron on the right wing tip. The combined values were obtained by the direct summation of the values for corresponding aileron settings and are for the condition of right aileron up and left aileron down. The reference axes are body axes with the origin at the center of rotation of the model.

Investigation having shown the scale effects within the speed range of these tests to be small, the use of faired curves through all points representing observed values seemed justified. The values of $C_L$, $C_N$, and $N/L$ given in Tables I–XVI and Figures 5–47 were read from the faired curves.

[1] Note that the coefficients are based on wing dimensions which are held constant throughout the investigation: i. e.

$$L=C_L q \text{ times a constant}=20.83\ C_L q$$

and

$$N=C_N q \text{ times a constant}=5.06\ C_N q$$

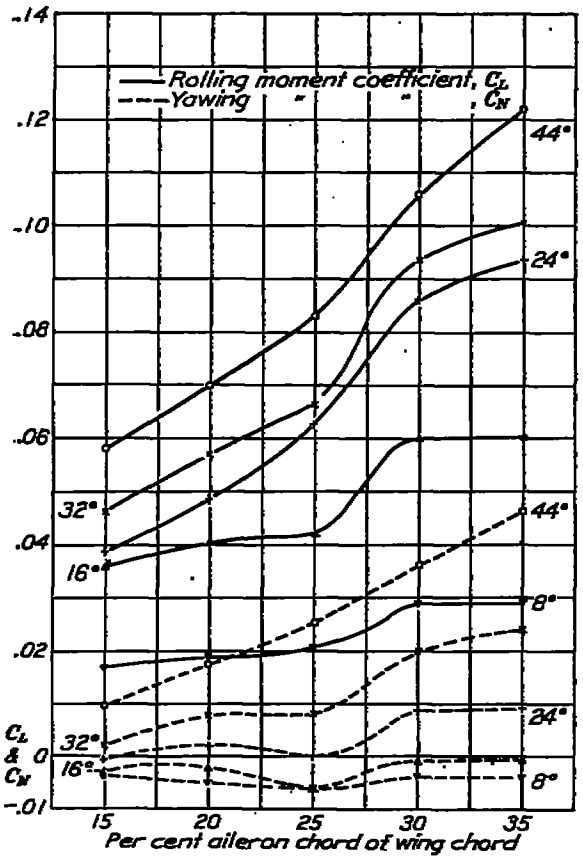



FIGURE 5.—Clark Y wing section. $C_L$ and $C_N$ for up aileron angles versus per cent aileron chord of wing chord. Pitch angle, 8°. Span, 20 inches (67 per cent of wing semispan)

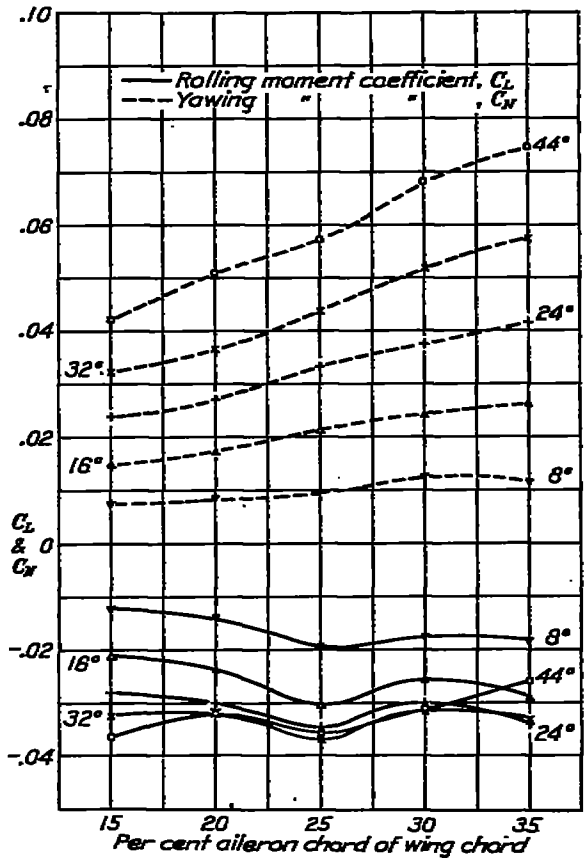



FIGURE 6.—Clark Y wing section. $C_L$ and $C_N$ for down aileron angles versus per cent aileron chord of wing chord. Pitch angle 8°. Span, 20 inches (67 per cent of wing semispan)

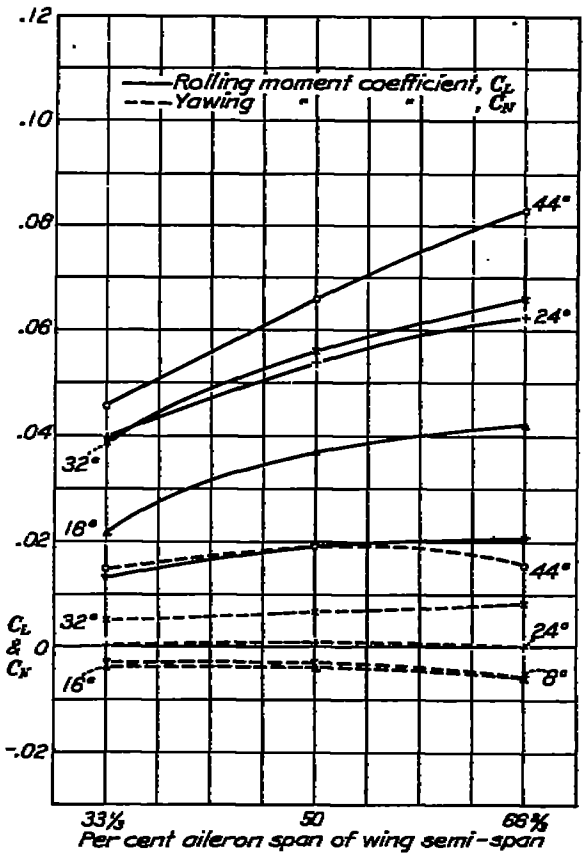



FIGURE 7.—Clark Y wing section. $C_L$ and $C_N$ for up aileron angles versus per cent aileron span of wing semispan. Pitch angle, 8°. Chord, 2.5 inches (25 per cent of wing chord)

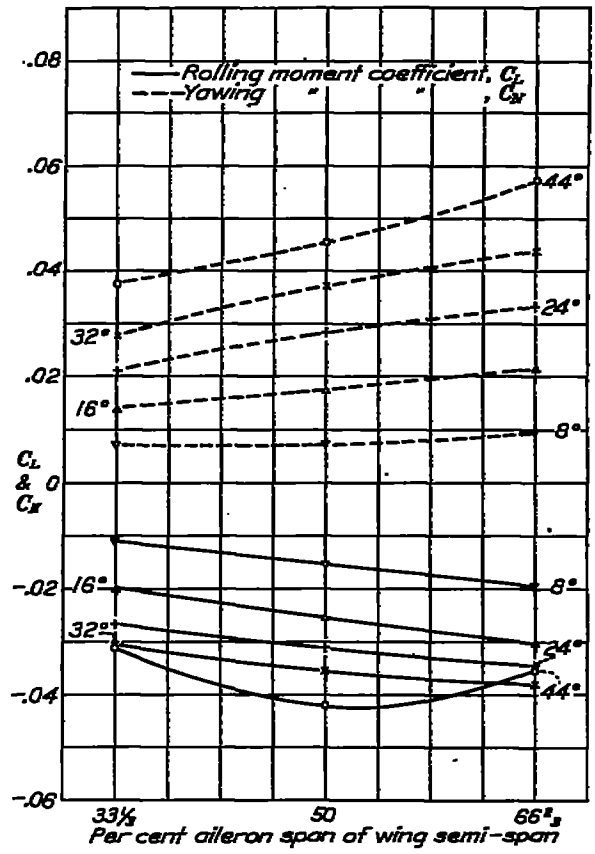



FIGURE 8.—Clark Y wing section. $C_L$ and $C_N$ for down aileron angles versus per cent aileron span of wing semispan. Pitch angle, 8°. Chord, 2.5 inches (25 per cent of wing chord)

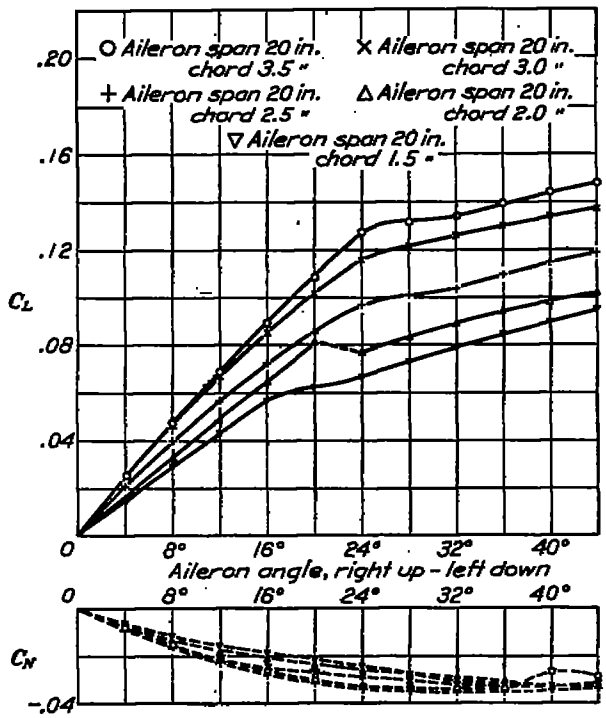



FIGURE 9.—Clark Y wing section. Combined $C_L$ and $C_N$ for varying chord ailerons versus aileron angle. Pitch angle, 8°. Note, $N/L=0.417\ C_N/C_L$

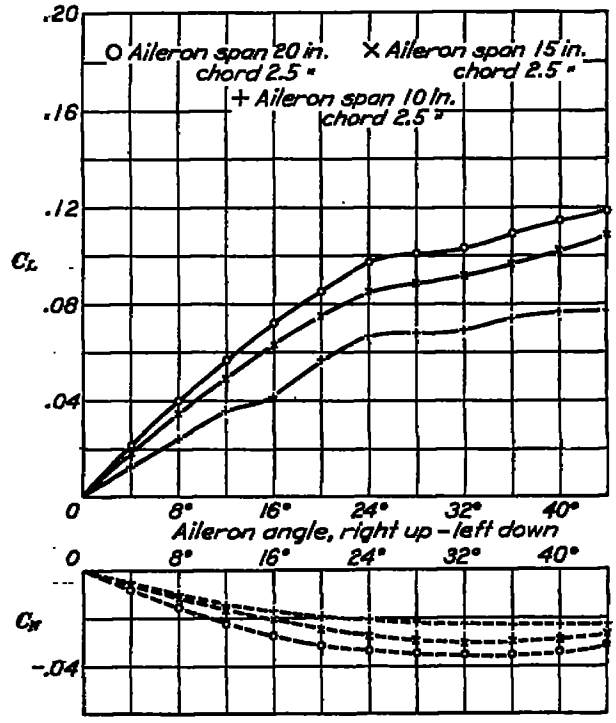



FIGURE 10.—Clark Y wing section. Combined $C_L$ and $C_N$ for varying span ailerons versus aileron angle. Pitch angle, 8°. Note, $N/L=0.417\ C_N/C_L$

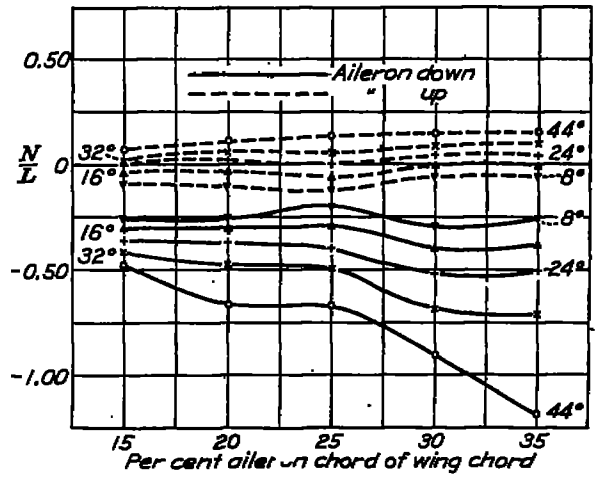



FIGURE 11.—Clark Y wing section. $N/L$ for up and down aileron angles versus per cent aileron chord of wing chord. Pitch angle, 8°. Span, 20 inches (67 per cent of wing semispan). Note, $N/L=0.417\ C_N/C_L$

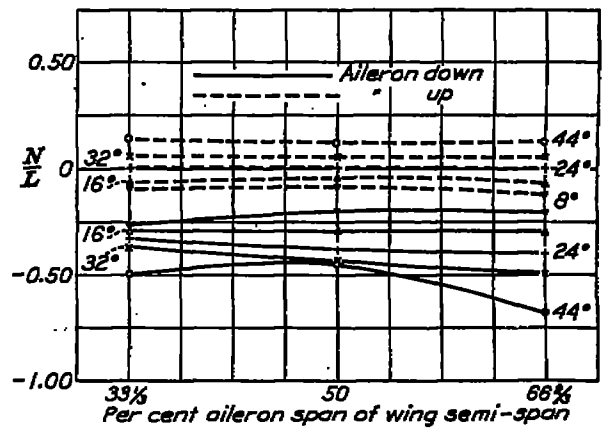



FIGURE 12.—Clark Y wing section. $N/L$ for up and down aileron angles versus per cent aileron span of wing semispan. Pitch angle, 8°. Chord, 2.5 inches (25 per cent of wing chord). Note, $N/L=0.417\ C_N/C_L$

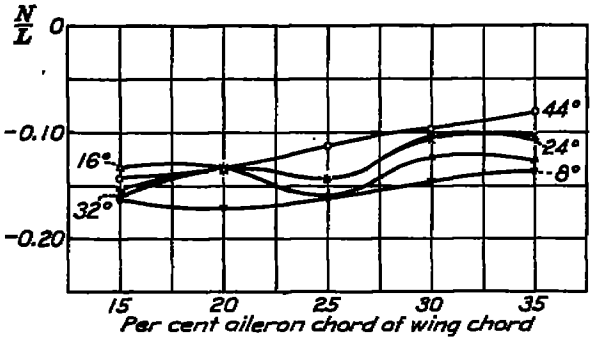



FIGURE 13.—Clark Y wing section. $N/L$ for combined ailerons (right up, left down) versus per cent aileron chord of wing chord. Pitch angle, 8°. Span, 20 inches (67 per cent of wing semispan). Note, $N/L=0.417\ C_N/C_L$

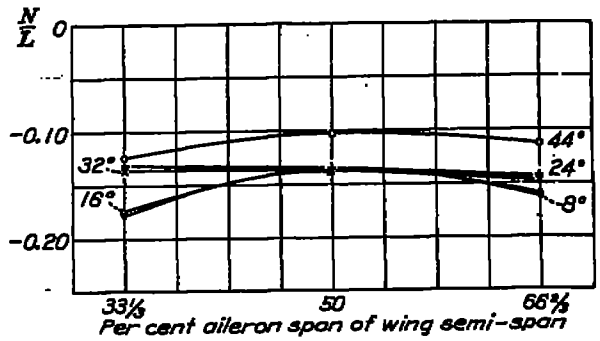



FIGURE 14.—Clark Y wing section. $N/L$ for combined ailerons (right up, left down) versus per cent aileron span of wing semispan. Pitch angle, 8°. Chord, 2.5 inches (25 per cent of wing chord). Note $N/L=0.417\ C_N/C_L$

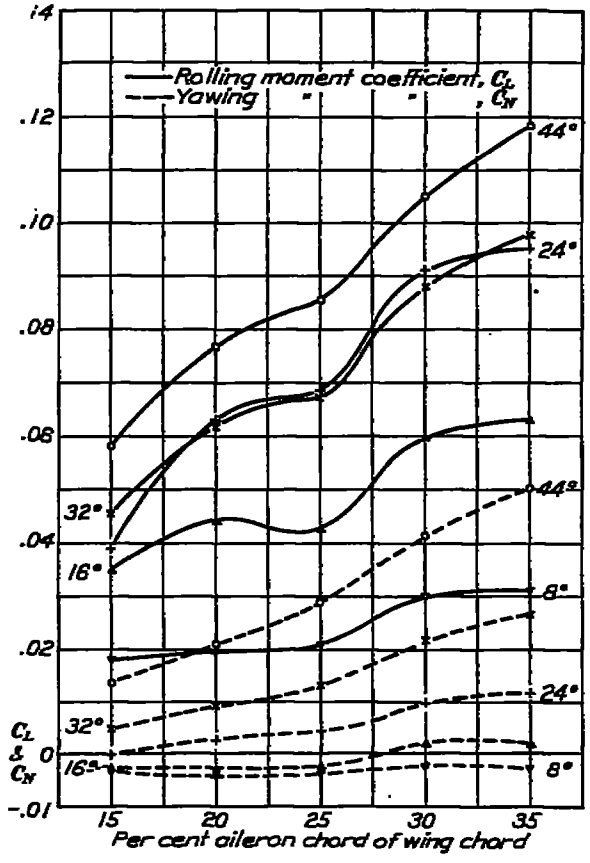



FIGURE 15.—U. S. A. 27 wing section. $C_L$ and $C_N$ for up aileron angles versus per cent aileron chord of wing chord. Pitch angle, 8°. Span, 20 inches (67 per cent of wing semispan)

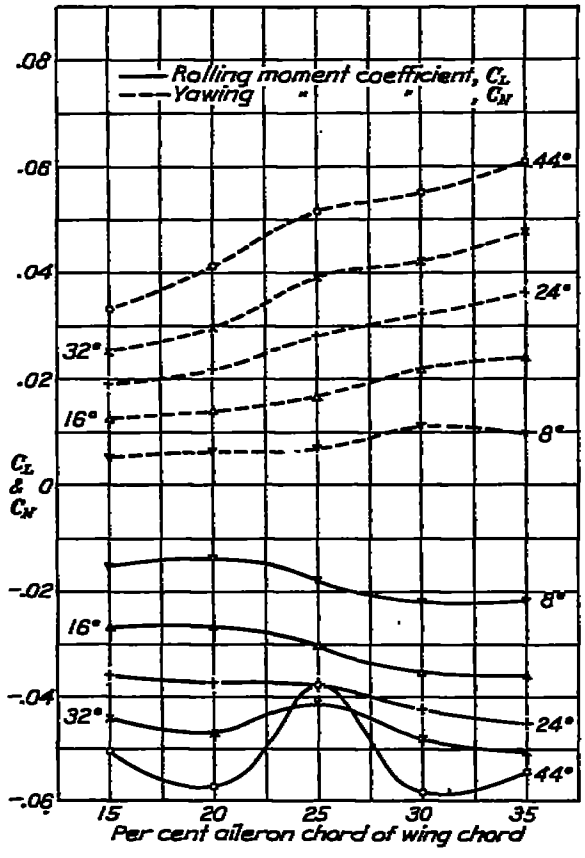



FIGURE 16.—U. S. A. 27 wing section. $C_L$ and $C_N$ for down aileron angles versus per cent aileron chord of wing chord. Pitch angle, 8°. Span, 20 inches (67 per cent of wing semispan)

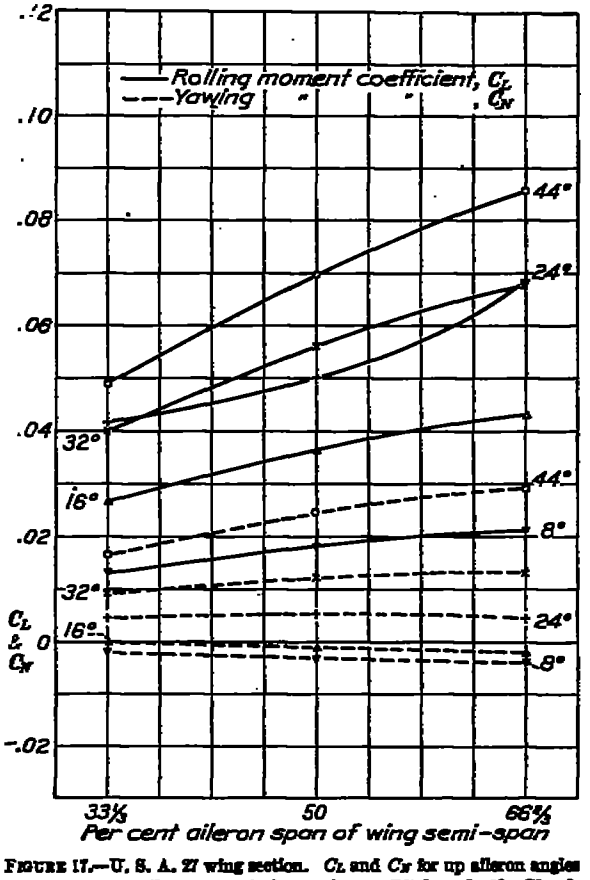



FIGURE 17.—U. S. A. 27 wing section. $C_L$ and $C_N$ for up aileron angles versus per cent aileron span of wing semispan. Pitch angle, 8°. Chord, 2.5 inches (25 per cent of wing chord)

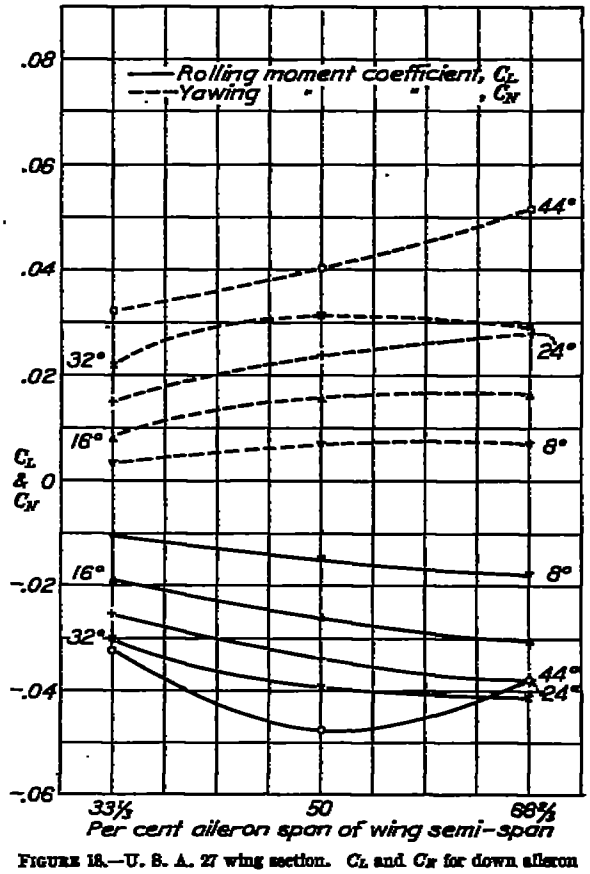



FIGURE 18.—U. S. A. 27 wing section. $C_L$ and $C_N$ for down aileron angles versus per cent aileron span of wing semispan. Pitch angle, 8°. Chord, 2.5 inches (25 per cent of wing chord)

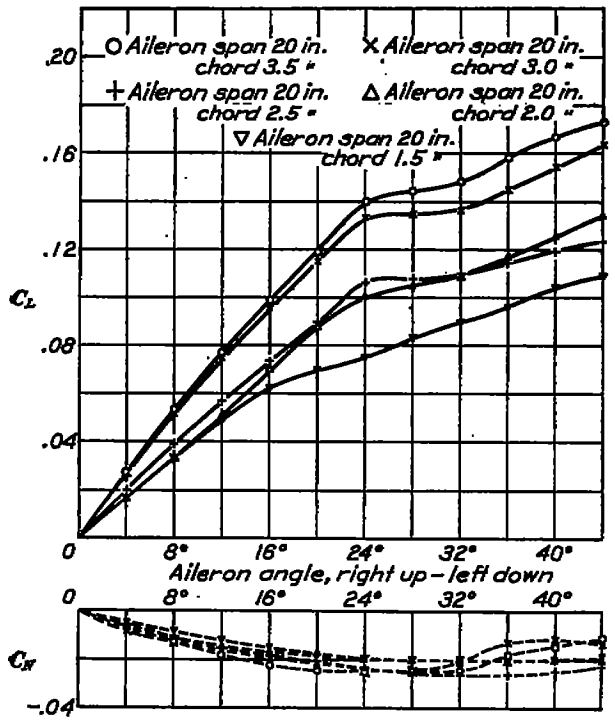



FIGURE 19.—U. S. A. 27 wing section. Combined $C_L$ and $C_N$ for varying chord ailerons versus aileron angle. Pitch angle, 8°. Note, $N/L=0.417\ C_N/C_L$

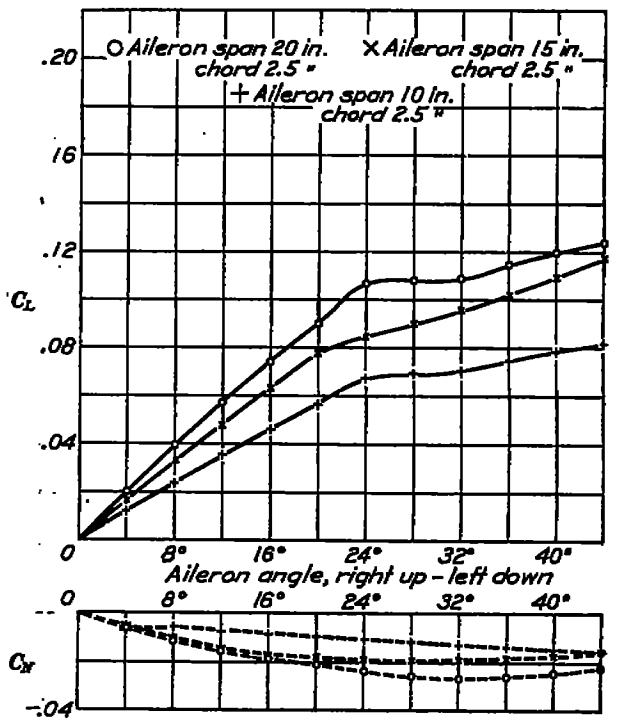



FIGURE 20.—U. S. A. 27 wing section. Combined $C_L$ and $C_N$ for varying span ailerons versus aileron angle. Pitch angle, 8°. Note, $N/L=0.417\ C_N/C_L$

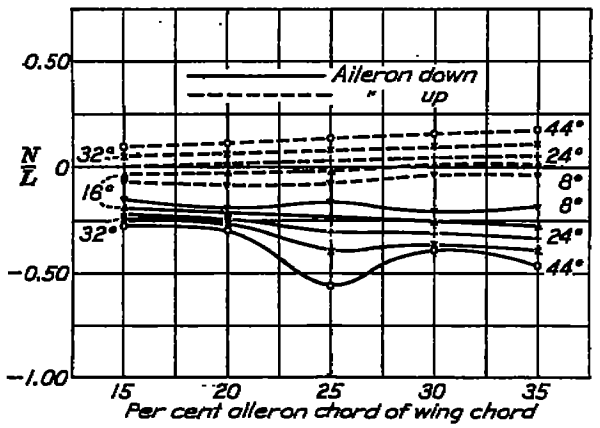



FIGURE 21.—U. S. A. 27 wing section. $N/L$ for up and down aileron angles versus per cent aileron chord of wing chord. Pitch angle, 8°. Span, 20 inches (67 per cent of wing semispan). Note, $N/L=0.417\ C_N/C_L$

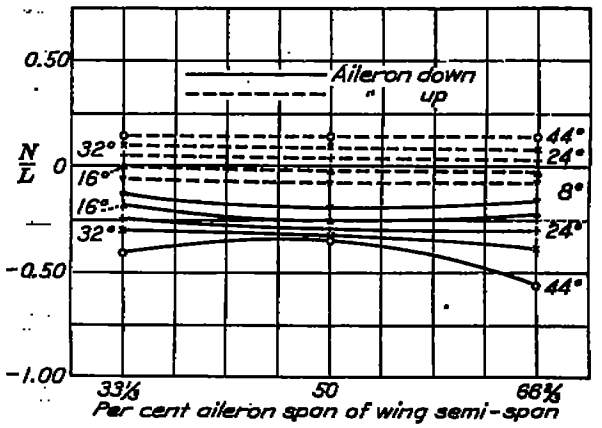



FIGURE 22.—U. S. A. 27 wing section. $N/L$ for up and down aileron angles versus per cent aileron span of wing semispan. Pitch angle, 8°. Chord, 2.5 inches (25 per cent of wing chord.) Note, $N/L=0.417\ C_N/C_L$

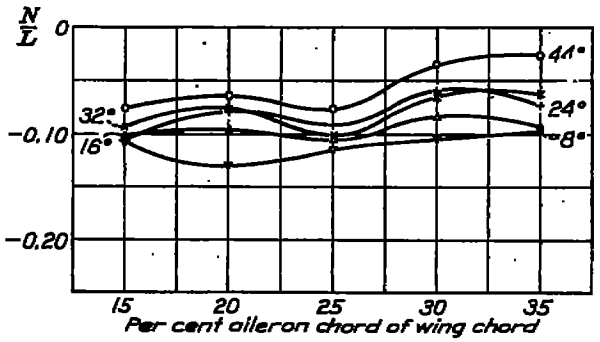



FIGURE 23.—U. S. A. 27 wing section. $N/L$ for combined ailerons (right up, left down) versus per cent aileron chord of wing chord. Pitch angle, 8°. Span, 20 inches (67 per cent of wing semispan). Note, $N/L=0.417\ C_N/C_L$

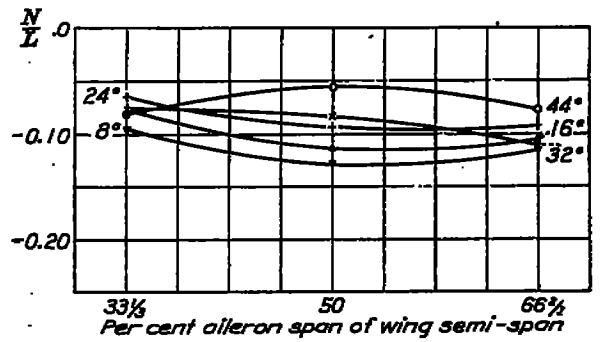



FIGURE 24.—U. S. A. 27 wing section. $N/L$ for combined ailerons (right up, left down versus per cent aileron span of wing semispan. Pitch angle, 8°. Chord, 2.5 inches (25 per cent of wing chord). Note, $N/L=0.417\ C_N/C_L$

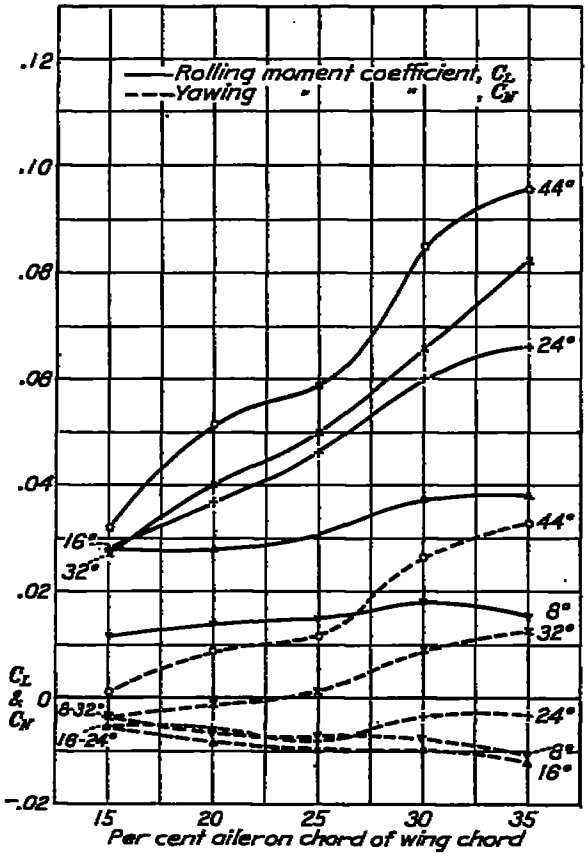



FIGURE 25.—Clark Y wing section. $C_L$ and $C_N$ for up aileron angles versus per cent aileron chord of wing chord. Pitch angle, 12°. Span, 20 inches (67 per cent of wing semispan)

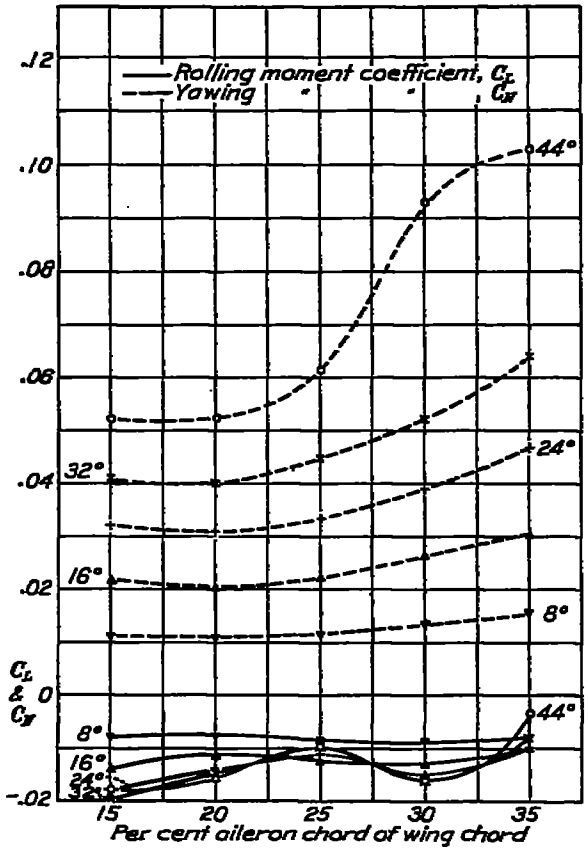



FIGURE 26.—Clark Y wing section. $C_L$ and $C_N$ for down aileron angles versus per cent aileron chord of wing chord. Pitch angle, 12°. Span, 20 inches (67 per cent of wing semispan)

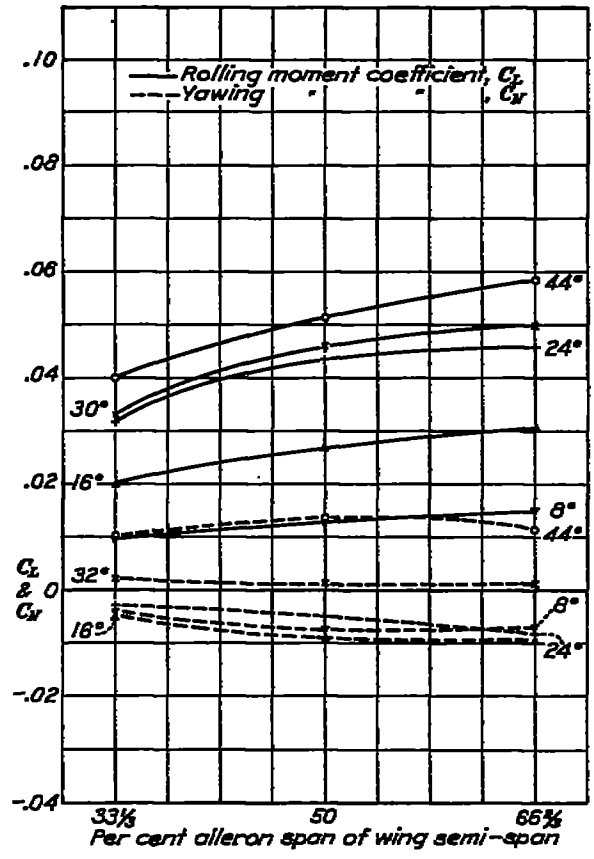



FIGURE 27.—Clark Y wing section. $C_L$ and $C_N$ for up aileron angles versus per cent aileron span of wing semispan. Pitch angle, 12°. Chord, 2.5 inches (25 per cent of wing chord)

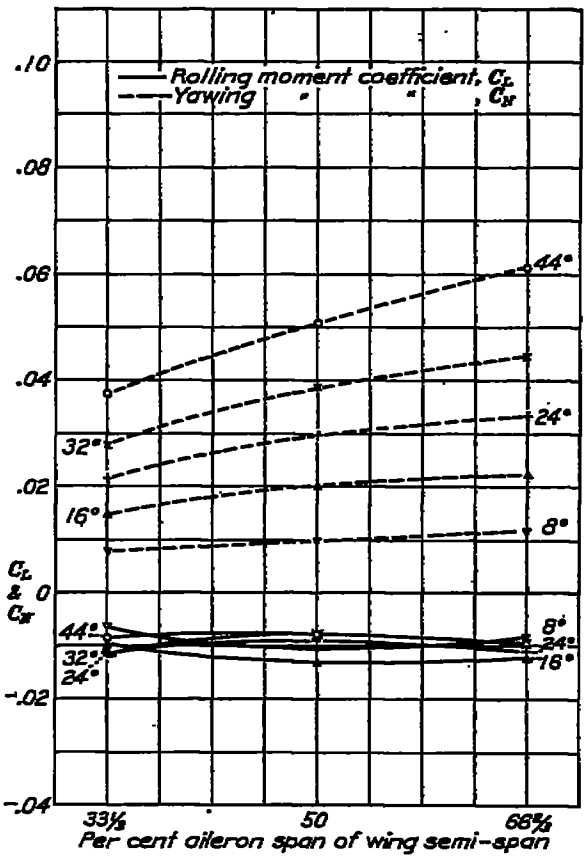



FIGURE 28.—Clark Y wing section. $C_L$ and $C_N$ for down aileron angles versus per cent aileron span of wing semispan. Pitch angle, 12°. Chord, 2.5 inches (25 per cent of wing chord)

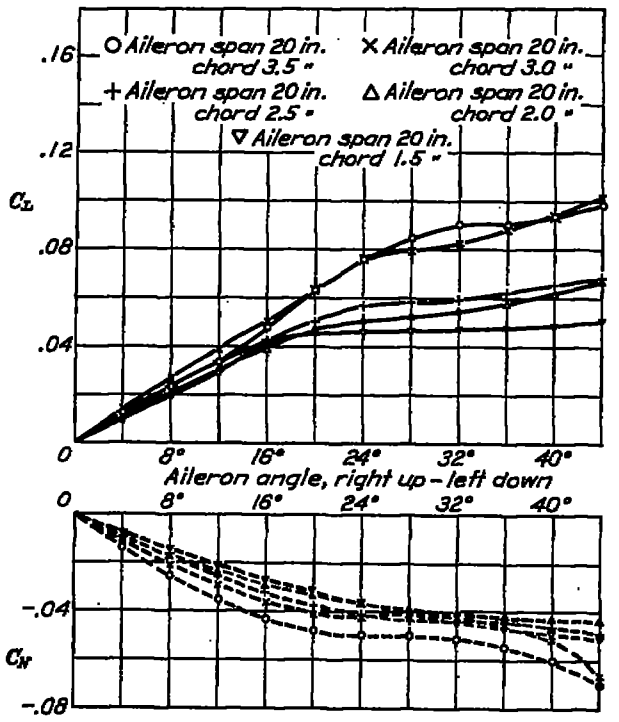



FIGURE 29.—Clark Y wing section. Combined $C_L$ and $C_N$ for varying chord ailerons versus aileron angle. Pitch angle, 12°. Note, $N/L$=0.417 $C_N/C_L$

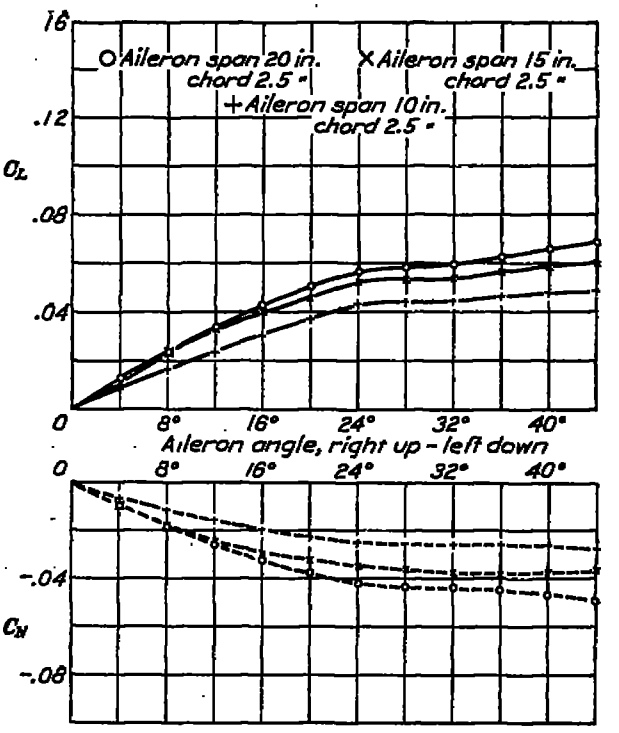



FIGURE 30.—Clark Y wing section. Combined $C_L$ and $C_N$ for varying span ailerons versus aileron angle. Pitch angle, 12°. Note, $N/L$=0.417 $C_N/C_L$

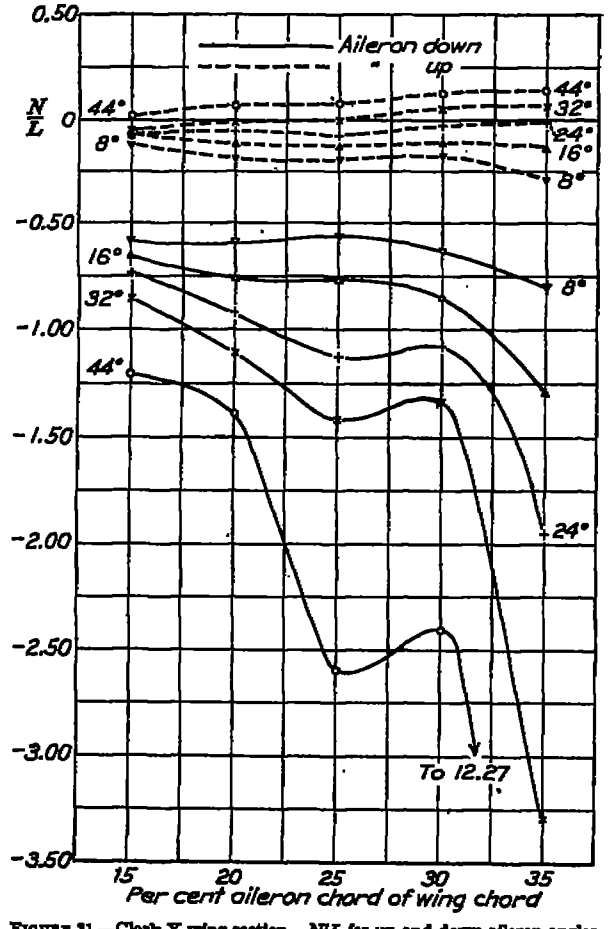



FIGURE 31.—Clark Y wing section. $N/L$ for up and down aileron angles versus per cent aileron chord of wing chord. Pitch angle, 12°. Span, 20 inches (67 per cent of wing semispan). Note, $N/L$=0.417 $C_N/C_L$

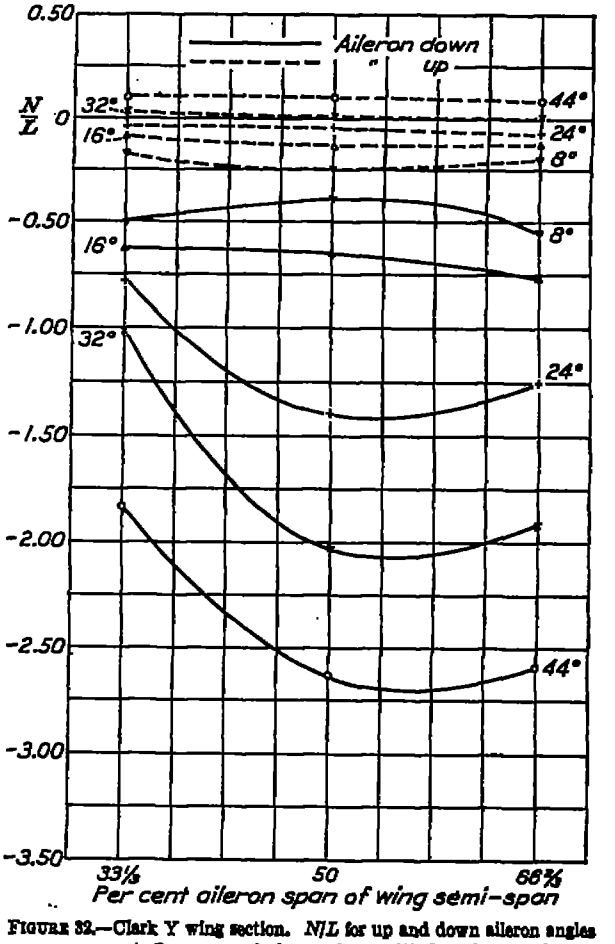



FIGURE 32.—Clark Y wing section. $N/L$ for up and down aileron angles versus per cent aileron span of wing semispan. Pitch angle, 12°. Chord, 2.5 inches (25 per cent of wing chord). Note, $N/L$=0.417 $C_N/C_L$

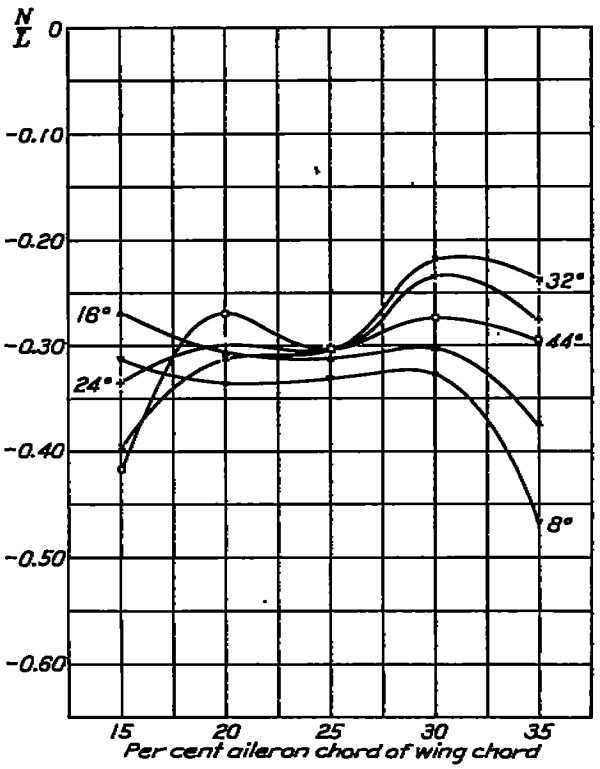



FIGURE 33.—Clark Y wing section. $N/L$ for combined ailerons (right up, left down) versus per cent aileron chord of wing chord. Pitch angle, 12°. Span, 20 inches (67 per cent of wing semispan). Note, $N/L=0.417\ C_N/C_L$

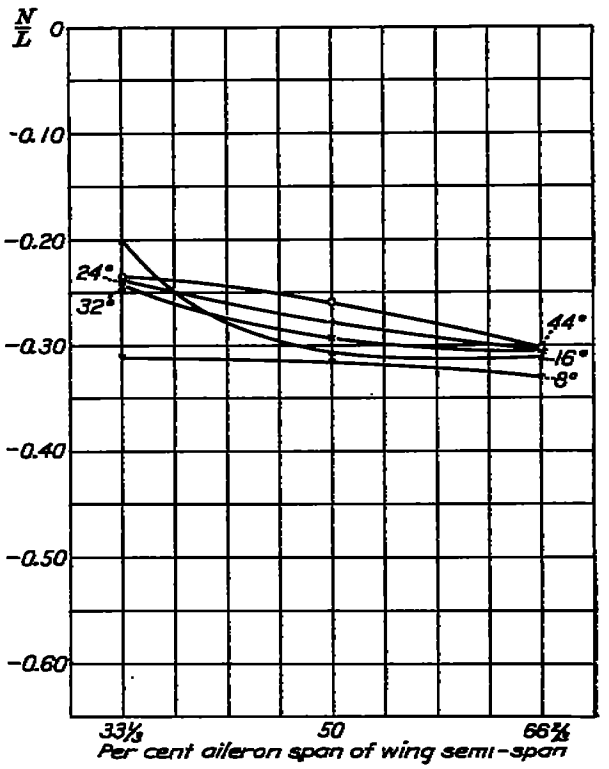



FIGURE 34.—Clark Y wing section. $N/L$ for combined ailerons (right up, left down) versus per cent aileron span of wing semispan. Pitch angle, 12°. Chord, 2.5 inches (25 per cent of wing chord). Note, $N/L=0.417\ C_N/C_L$

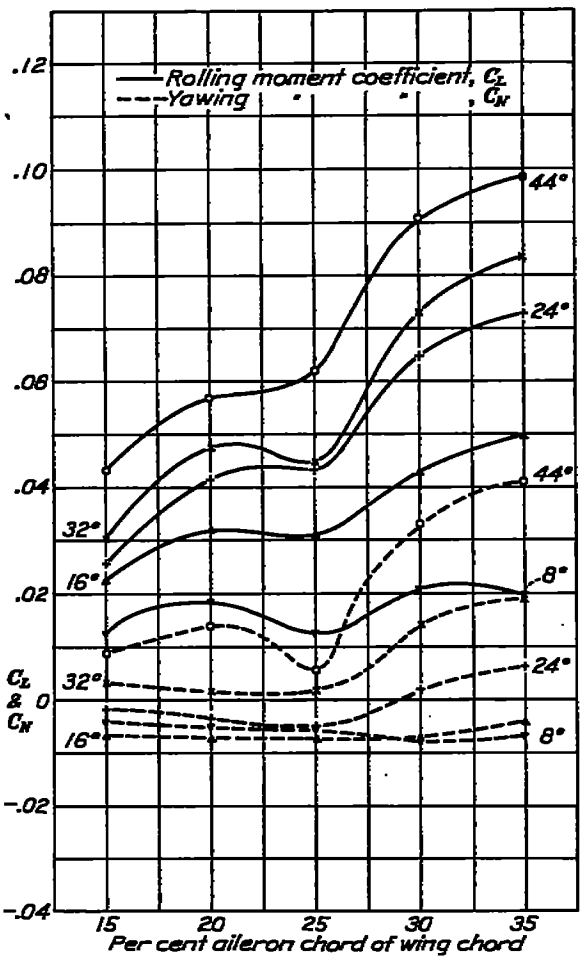



FIGURE 35.—U. S. A. 27 wing section. $C_L$ and $C_N$ for up aileron angles versus per cent aileron chord of wing chord. Pitch angle, 12°. Span, 20 inches (67 per cent of wing semispan)

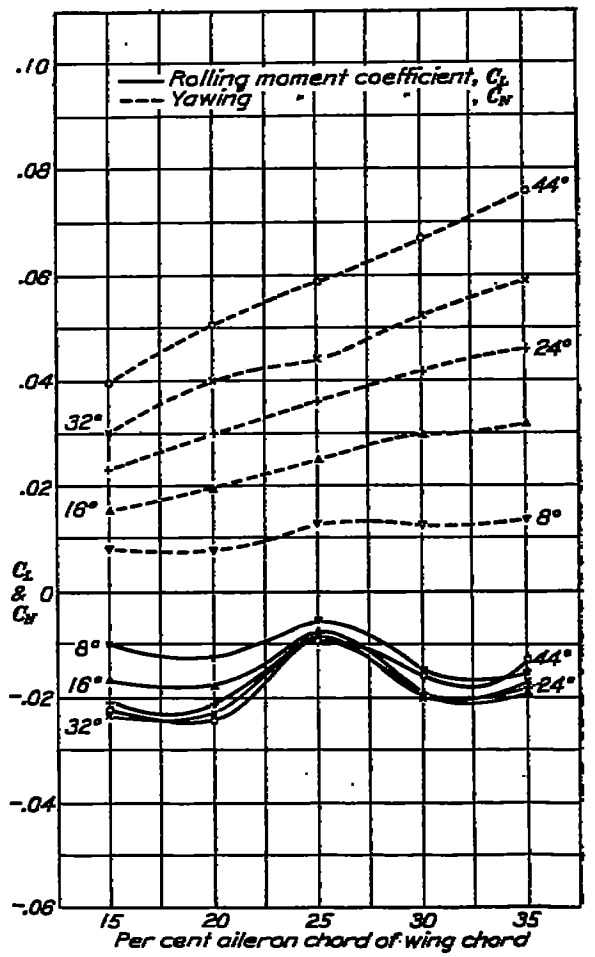



FIGURE 36.—U. S. A. 27 wing section. $C_L$ and $C_N$ for down aileron angles versus per cent aileron chord of wing chord. Pitch angle, 12°. Span, 20 inches (67 per cent of wing semispan)

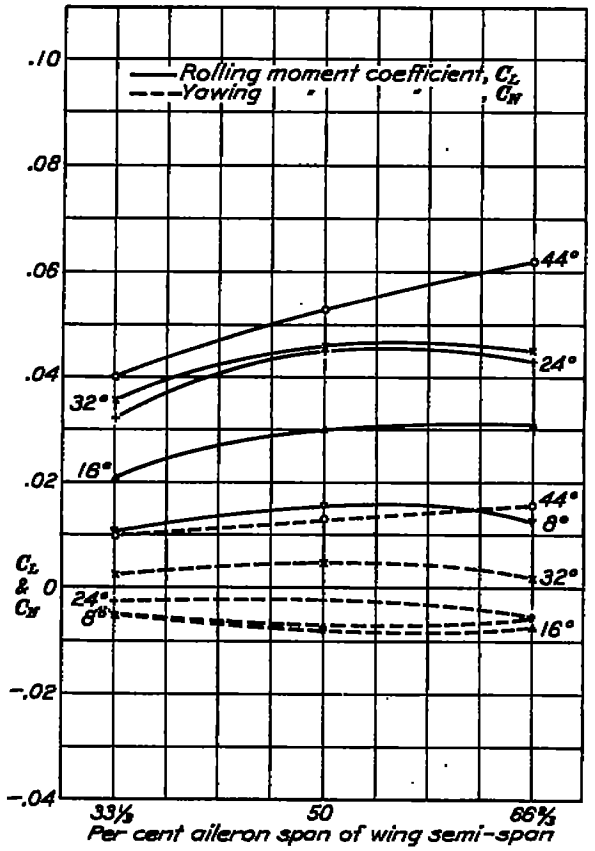



FIGURE 37.—U. S. A. 27 wing section. $C_L$ and $C_N$ for up aileron angles versus per cent aileron span of wing semispan. Pitch angle, 12°. Chord, 2.5 inches (25 per cent of wing chord)

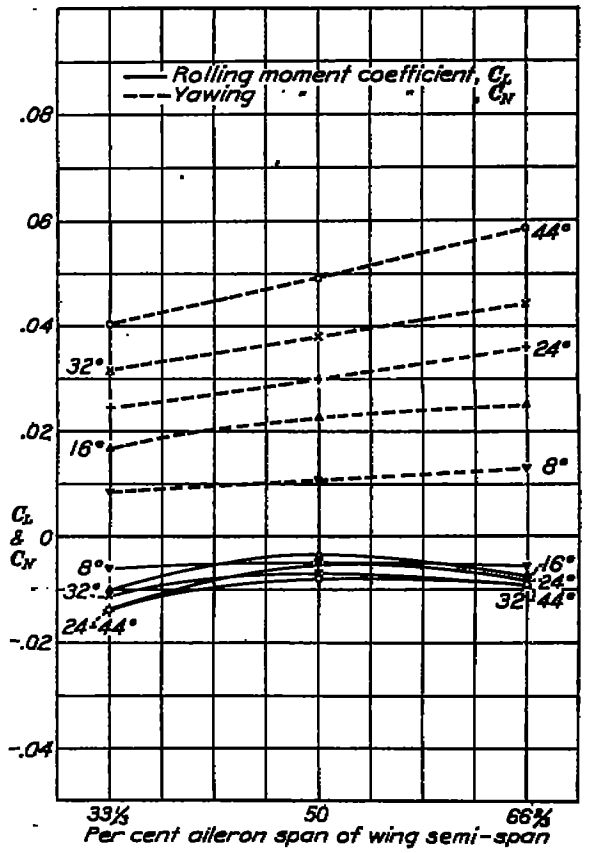



FIGURE 38.—U. S. A. 27 wing section. $C_L$ and $C_N$ for down aileron angles versus per cent aileron span of wing semispan. Pitch angle, 12°. Chord, 2.5 inches (25 per cent of wing chord)

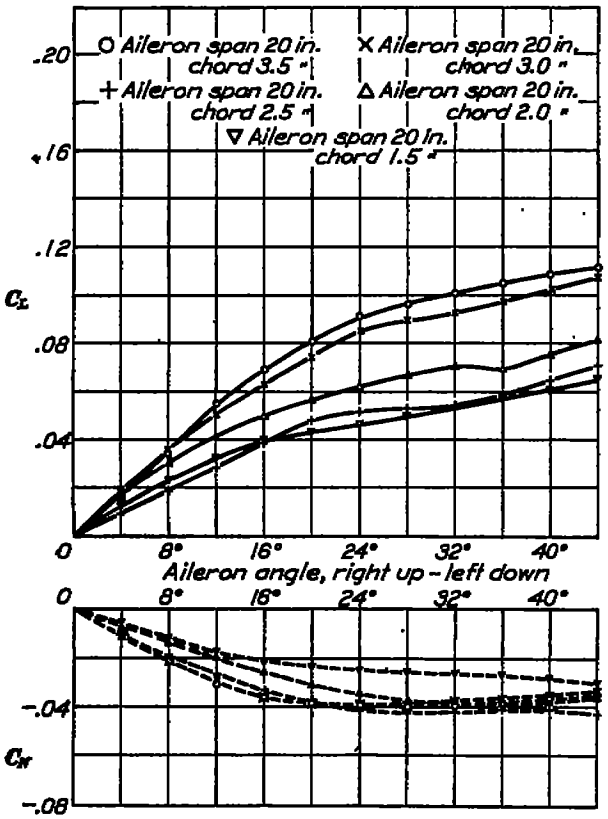



FIGURE 39.—U. S. A. 27 wing section. Combined $C_L$ and $C_N$ for varying chord ailerons versus aileron angle. Pitch angle, 12°. Note, $N/L=0.417\ C_N/C_L$

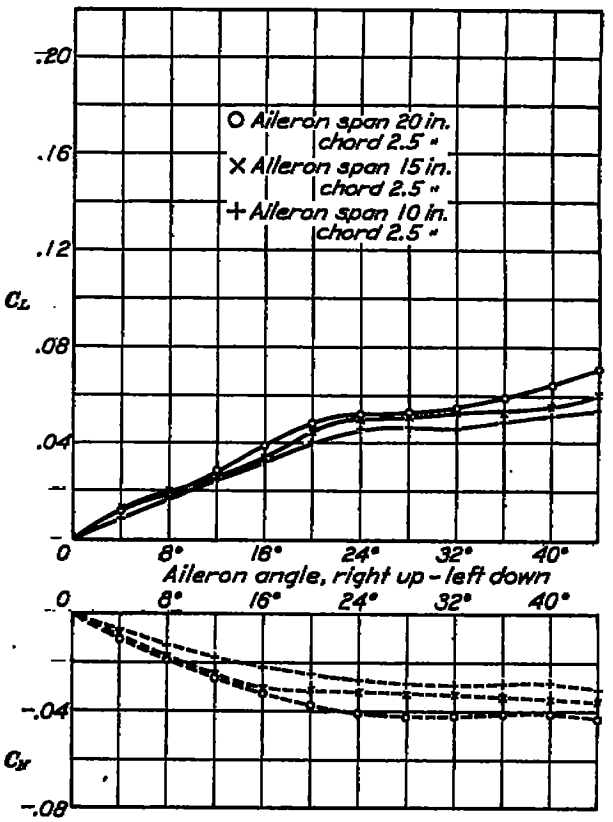



FIGURE 40.—U. S. A. 27 wing section. Combined $C_L$ and $C_N$ for varying span ailerons versus aileron angle. Pitch angle, 12°. Note, $N/L=0.417\ C_N/C_L$

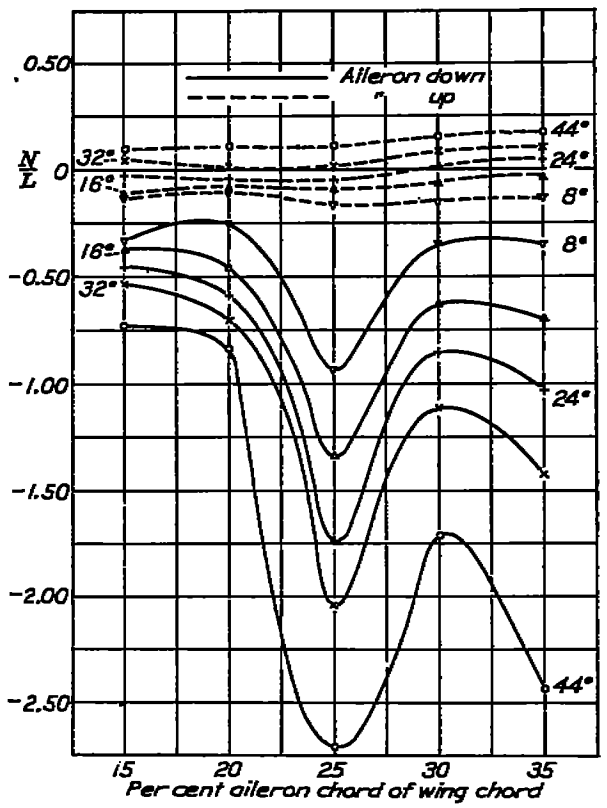



FIGURE 41.—U. S. A. 27 wing section. $N/L$ for up and down aileron angles versus per cent aileron chord of wing chord. Pitch angle, 12°. Span, 20 inches (67 per cent of wing semispan). Note, $N/L=0.417\ C_N/C_L$

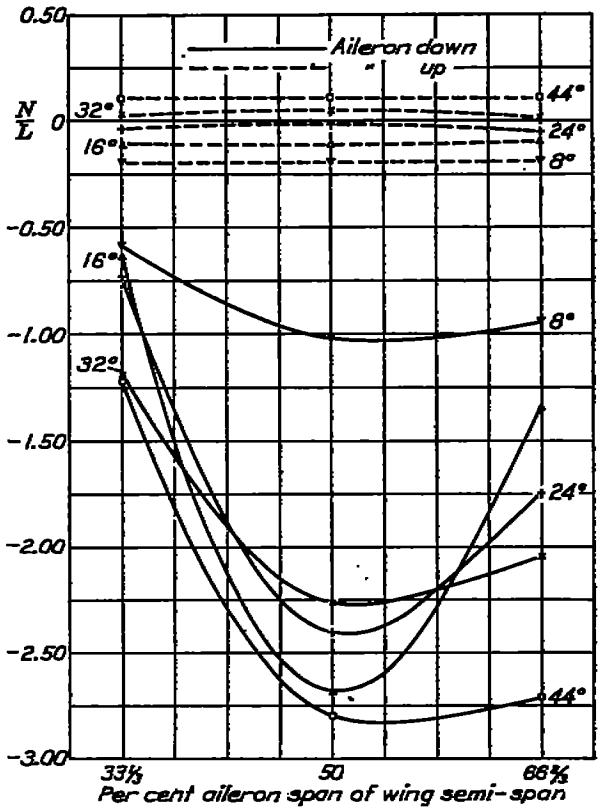



FIGURE 42.—U. S. A. 27 wing section. $N/L$ for up and down aileron angles versus per cent aileron span of wing semispan. Pitch angle, 12°. Chord, 2.5 inches (25 per cent of wing chord). Note, $N/L=0.417\ C_N/C_L$

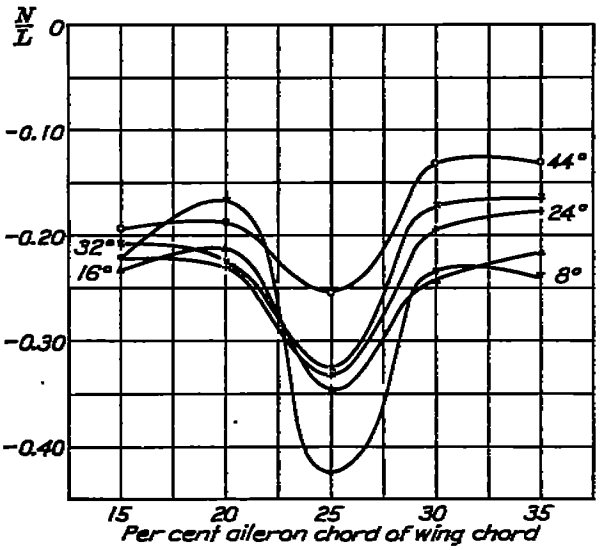



FIGURE 43.—U. S. A. 27 wing section. $N/L$ for combined ailerons (right up, left down) versus per cent aileron chord of wing chord. Pitch angle, 12°. Span, 20 inches (67 per cent of wing semispan). Note, $N/L=0.417\ C_N/C_L$

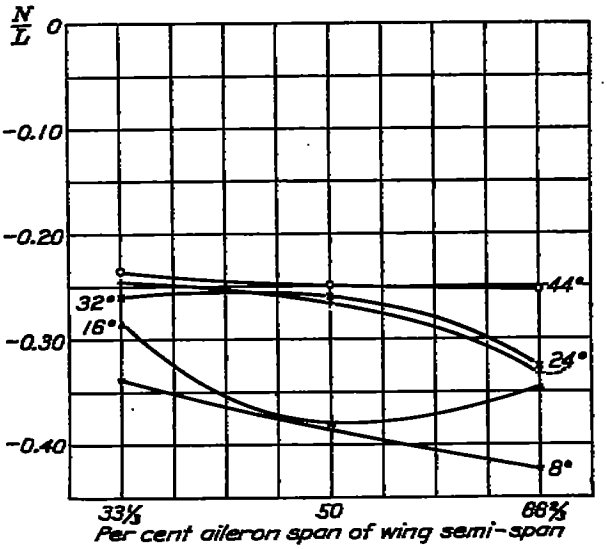



FIGURE 44.—U. S. A. 27 wing section. $N/L$ for combined ailerons (right up, left down) versus per cent aileron span of wing semispan. Pitch angle, 12°. Chord, 2.5 inches (25 per cent of wing chord). Note, $N/L=0.417\ C_N/C_L$

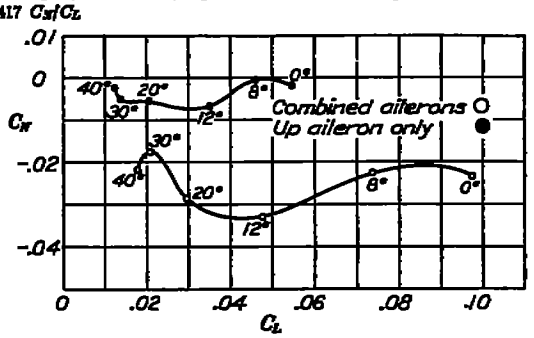



FIGURE 45.—Clark Y wing section. $C_L$ versus $C_N$ for varying pitch angle of 20-inch span by 2-inch chord aileron set at 20° for up only and for combined up and down positions

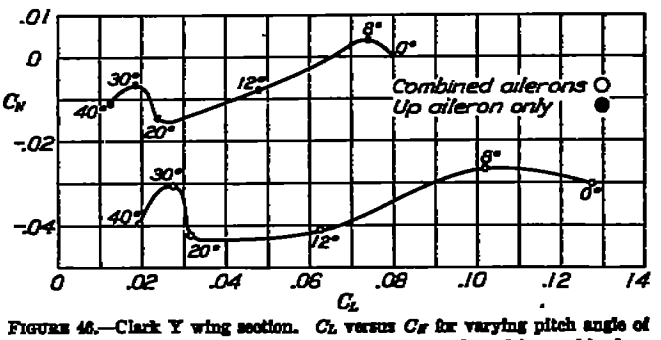



FIGURE 46.—Clark Y wing section. $C_L$ versus $C_N$ for varying pitch angle of 20-inch span by 3-inch chord aileron set at 20° for up only and for combined up and down positions

## ROLLING MOMENT COEFFICIENTS FOR A SINGLE AILERON

In Reference 1 attention has been called to the fact that when the fuselage axis is horizontal (angle of attack of wing +4°), the rolling moment produced by a given angular displacement of the aileron upward is greater than that produced by the same downward displacement. British tests (Reference 2), in which a biplane cell was used, show the same tendency but to a lesser degree. Figure 47 shows that the loss in rolling moment of the down aileron is considerably greater than that of the up aileron as the angle of pitch is increased.

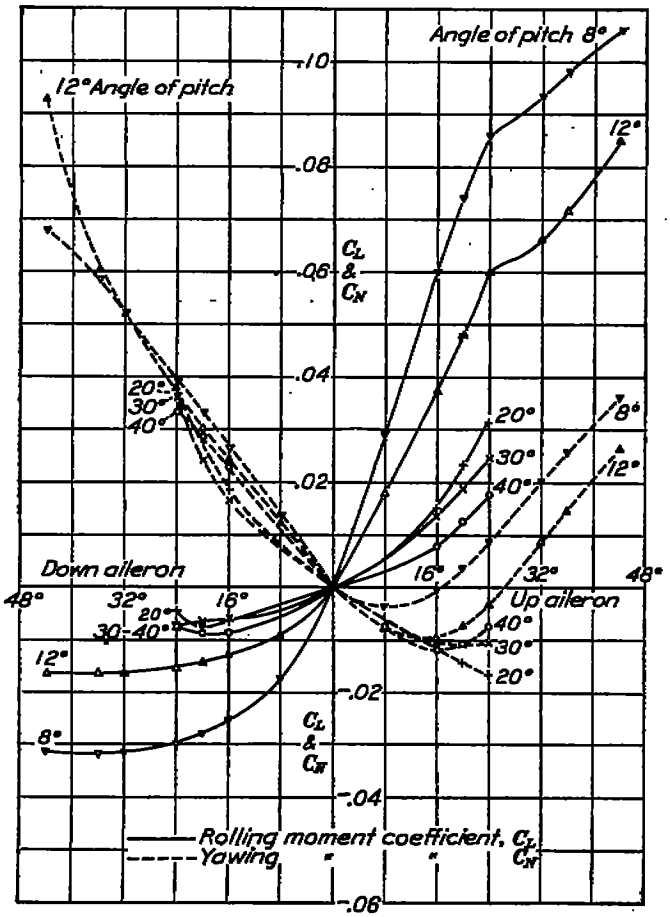



FIGURE 47.—Clark Y wing section. $C_L$ and $C_N$ versus aileron angle for various pitch angles of 20-inch span by 3-inch chord aileron

Figures 5, 15, 25, and 35 show that the rolling moment due to an upward displacement of the aileron increases as the chord of the aileron is increased. The effect of the wing section is not great at an angle of pitch of 8°, but at 12° the same aileron displacement gives a much greater rolling moment on the U. S. A. 27 wing section, presumably because the Clark Y wing section burbles at a somewhat lower angle of attack than the U. S. A. 27 section. The rolling moment caused by a given upward displacement decreases greatly as the angle of pitch increases. (Compare fig. 47.) Figures 7, 17, 27, and 37 show the effect of increasing the span of the aileron. The effects are of the same nature as for increasing chord, except that for the smaller span the difference between the curves for the two wing sections does not appear.

Figures 6, 16, 26, and 36 show the effect of the chord of the aileron on the rolling moment when the displacement is down instead of up. The same aileron gives a greater rolling moment on the U. S. A. 27 section. Figure 6 shows that an increase of aileron angle beyond 24° has little effect on the rolling moment at an angle of pitch of 8° for the Clark Y section. Figure 26 shows that the limit is as low as 8° when the angle of pitch is increased to 12°. The limitations are not as great for the U. S. A. 27 section, again presumably because of the difference in the burbling angles of the two sections. Figures 8, 18, 28, and 38 show the effect of span. The general impression of the whole family of curves is that the downward motion is much less effective than the upward motion in the production of rolling moment.

The points for the aileron of 20-inch span and 2.5-inch chord show a tendency to lie below the curve indicated by the remaining ailerons in Figures 5, 6, 15, 16, 25, 26, 35, and 36. It is believed that this irregularity in the results is to be attributed to the combined effect of asymmetry in the model and asymmetry in the tunnel airflow. It will be recalled from Figure 1 that this aileron (a member of the variable span group) is on the opposite wing tip from the variable chord group. The rolling moment produced by a given angle of the aileron varies rapidly with the angle of pitch, as shown by Figure 47, and a difference in angle of attack of the wing tips of approximately 1° would account for the observed results. It is known that there is a small rotation of the air stream in the tunnel in the proper direction to account for the observed irregularity.

## YAWING MOMENT COEFFICIENTS FOR A SINGLE AILERON

The yawing moment coefficients are shown in the same figures as the rolling moment coefficients. Thus Figures 5, 15, 25, and 35 show the yawing moments produced by upward displacements, Figures 6, 16, 26, and 36 by downward displacements for the variable chord group, Figures 7, 17, 27, and 37 show the yawing moments produced by upward displacements, and Figures 8, 18, 28, and 38 by downward displacements for the variable span group. The curves show an approximately linear increase in yawing moment coefficient with increasing chord or span. In all cases the yawing moment coefficients for upward displacements are considerably less than for corresponding downward displacements. For a large range of aileron angles the upward displacement produces a negative yawing moment, corresponding to a decreased drag on the wing tip, after which the yawing moment becomes positive. The maximum negative yawing moment coefficient observed is of the order of 0.010. (Fig. 25.)

The angle of the aileron at which the yawing moment coefficient produced by the upward displacement is again zero decreases with increasing aileron chord for a given angle of attack of the wing and increases with angle of attack for a given aileron. (Tables I, II, III, IV, IX, X, XI, and XII.)

The general impression derived from the yawing moment curves is that the upward displacements produce much smaller yawing moments than the downward displacements.

### RATIO OF YAWING MOMENT TO ROLLING MOMENT FOR A SINGLE AILERON

The ratio of rolling moment to yawing moment produced by the ailerons is often called the efficiency of the ailerons. In order to avoid infinite values, we prefer to invert the ratio and use the ratio of yawing moment to rolling moment. The most effective ailerons in the sense of producing the least yawing moment for a given rolling moment are the ones having the smallest value of this ratio.

Figures 11, 12, 21, 22, 31, 32, 41, and 42 show values of this ratio for the single ailerons. It is seen that the ratio is greatest for the downward displacements and that the values increase in general with increasing chord and span of the aileron, with increasing angle of the aileron, and with increasing angle of attack of the wing. For upward displacements the values change sign and are in general small. Thus the upward displacement gives greater effectiveness.

For angles of attack below the angle of maximum lift the decrease of effectiveness (increase of the ratio) for downward displacements is greater for increasing chord than for increasing span. At large angles of attack the differences are less marked than at low angles.

The effectiveness decreases more rapidly with increasing aileron angle at the higher angles of attack.

### COMBINED COEFFICIENTS

From the tables and curves the coefficients for any combination of displacements of ailerons on the two wing tips may be computed. The values for equal displacements, with right aileron up and left aileron down, are given in Tables V, VI, VII, VIII, XIII, XIV, XV, and XVI, and in Figures 9, 10, 19, 20, 29, 30, 39, and 40.

The increase of the chord of the ailerons for the purpose of increasing the rolling moment has less and less advantage as the angle of attack is increased. In the neighborhood of the angle of maximum lift the effect of increasing the aileron chord 2.33 times at 20° aileron angle is to increase the rolling moment only 40 per cent in the case of the Clark Y airfoil and 88 per cent in the case of the U. S. A. 27 airfoil. The maximum yawing moment coefficient observed is of the order of 0.050.

Tables V, VI, VII, VIII, XIII, XIV, XV, and XVI also contain values of the ratio of yawing moment to rolling moment for the ailerons combined and Figures 13, 14, 23, 24, 33, 34, 43, and 44 show these values. The values are somewhat irregular, but the effectiveness of the same aileron is clearly greater on the U. S. A. 27 section. For both wing sections the effectiveness in general increases with increasing chord of the aileron at an angle of pitch of 8°, while at an angle of pitch of 12° the effectiveness reaches a maximum for the aileron of 3-inch chord. In the variable span group the effectiveness tends to decrease with an increase of span.

### MEASUREMENTS AT ANGLES BEYOND THE ANGLE OF MAXIMUM LIFT

The observations have been carried to angles of pitch up to 40° in the case of the Clark Y airfoil, using ailerons of 20-inch span by 2-inch and 3-inch chord. Figures 45 and 46 show a part of these results, namely, the rolling and yawing moments produced by an aileron displacement of 20° for an upward displacement of one aileron only and for equal upward and downward displacements of both ailerons. It will be seen that the value of the rolling moment coefficients reaches values between 0.010 and 0.020 at an angle of pitch of 40° (angle of attack of wing, 44°). Figure 47 shows the results for the 20-inch span by 3-inch chord aileron. Table XVII gives the values plotted in Figures 45 and 46.

### SUGGESTED USE OF UPWARD DISPLACEMENTS ALONE

The results of the investigation indicate very definite aerodynamic advantages in the use of upward displacements alone—i. e., the use of a cam or other mechanical device which would retain the normal down moving aileron in the neutral position while displacing the other aileron upward. While not to be compared to the use of the slot-and-aileron lateral control in effectiveness, the mechanical complications are not as great.

Figures 45 and 46 illustrate the very great reduction of the undesirable yawing moment. Quoting from Reference 3: "The yawing moment is of importance not only because it must be balanced by the use of the rudder if a straight course is to be maintained, but also because the yawing action of the aileron has an indirect effect directly opposed to that of the rolling moment from the same source. If, for example, the right wing of an airplane is low, the normal maneuver in raising it and restoring the wings to the horizontal is to pull down the right aileron and pull up the one on the left, giving a negative rolling moment. In general, however, this movement of the ailerons produces a positive yawing moment, tending to cause the machine to turn to the right; and if unopposed the resulting turn to the right will create a positive rolling moment

proportional to the positive value of $L_r$, the rolling moment due to yaw. $L_r$ has a positive value, it will be remembered, because of the difference of lift between the two wing tips moving at different speeds when the machine is turning.[1] This yawing action becomes especially important at high angles of attack." When upward travel only is employed, the yawing moment is greatly reduced, and with a sufficiently large aileron travel (20° to 30° at stall, 30° to 35° beyond stall) can be reversed in direction so as to assist the turn.

As against this very great advantage there are, of course, certain disadvantages. The rolling moments due to upward travel alone are less than those due to two ailerons combined, and it is necessary to use larger ailerons or greater aileron travel, or possibly both. For purpose of illustration, let us suppose that the aileron of 10-inch span by 2.5-inch chord on the Clark Y wing section is regarded as satisfactory when used combined in the conventional manner with a travel of ±32°. Table VI shows that the rolling moment coefficient at maximum travel at an angle of pitch of 8° is 0.0690, the yawing moment coefficient −0.0225. The rolling moment coefficient at 12° pitch (Table XIV) is 0.0445, the yawing moment coefficient −0.0260. Table X shows that a rolling moment coefficient at 12° pitch of 0.0500 could be obtained with the upward travel of one aileron of the same chord and moving through the same angle, but of 20-inch span, with a yawing moment coefficient of +0.0010, i. e., reversed in sign. The yawing moment coefficient does not exceed −0.0095 in the range of travel of the aileron. At 8° pitch under the same conditions the rolling moment coefficient is 0.0662, the yawing moment coefficient +0.0082. (Table II.)

From the same tables it can be seen that an aileron of 15-inch span by 2.5-inch chord at the same upward displacement will give at 12° pitch a rolling moment coefficient of 0.0460 with a yawing moment coefficient of +0.0010 and at 8° pitch a rolling moment coefficient of 0.0560 with a yawing moment coefficient of +0.0068. This aileron would give satisfactory roll at 12° pitch and 80 per cent of the desired rolling moment at 8° pitch, both with a yawing force which will tend to help the rolling force.

Other possibilities suggest themselves from the tables. It is necessary to study the hinge moments, and measurements of hinge moments are now in progress. The use of the upward motion alone is not suggested as a remedy for all the disadvantageous features of the usual control, but as a step in the direction of better control at low speeds which is worthy of study on full-scale airplanes.

[1] It has been pointed out that this moment is due not only to the difference in speed between the two wing tips resulting from the yawing motion, but also, and in larger measure, to the change in loading along the span which occurs at large angles of attack when the wing is displaced in yaw.

## CONCLUSION

It is not possible to trace general relations which are applicable to both wing sections at all angles of attack. For this reason no detailed statements of the effect of varying chord and span, of angle of attack, of wing section, etc., is attempted. We do wish to mention that while one aileron of a given chord and span at a given angular displacement gives almost the same rolling and yawing moment on the Clark Y and U. S. A. 27 wing sections, the differences are sufficiently great and add up in such a manner that the ratio of rolling moment to yawing moment produced by the usual combination of two ailerons is from one and one-half to two times as great on the U. S. A. 27 section as on the Clark Y section. Finally, the use of ailerons which move only upward presents advantages which make this type of control worthy of further study. The design of a mechanism which will give motion of the proper aileron upward with absolutely no motion of the opposite aileron is a difficult matter and in practice it would be easier to combine a large upward movement of one aileron with a small downward movement of the other. The result is an extension of the well-known differential aileron to as large ratios of up travel to down travel as may prove feasible mechanically. While this type of control is not quite as advantageous as one in which there is no downward movement, it still has advantages over the conventional control.

## ACKNOWLEDGMENT

We wish to acknowledge the assistance of Mr. W. Hunter Boyd in making the measurements and of Dr. H. L. Dryden in the preparation of the manuscript.

Bureau of Standards,
Washington, D. C., *October 7, 1929.*

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2. Irving, H. B., Ower, E., and Hankins, G. A.: An Investigation of the Aerodynamic Properties of Wing Ailerons. Part I: The Effect of Variation of Plan Form of Wing Tip, and Span of Aileron. Aeronautical Research Committee (Great Britain), R. & M. 550, 1918.
3. Warner, E. P.: Airplane Design—Aerodynamics. (McGraw-Hill, 1927.)

## TABLE I.—CLARK Y WING SECTION—$C_L$, $C_N$, AND $N/L$ FOR ONE AILERON

Varying chord of aileron. Angle of pitch of airplane, +8°; angle of attack of wing, +12°; angle of yaw, 0°; angle of roll, 0°

[NOTE.—The values apply to either right or left aileron; the signs refer to the right aileron. $N/L=0.417\ C_N/C_L$.]

### AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

#### AILERON CHORD, 1.5 INCHES (15 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0080 | −.0026 | −0.130 | 4° | −.0068 | +.0033 | −0.203 |
| 8° | .0170 | −.0039 | −.096 | 8° | −.0122 | .0076 | −.260 |
| 12° | .0260 | −.0039 | −.063 | 12° | −.0170 | .0114 | −.279 |
| 16° | .0360 | −.0030 | −.035 | 16° | −.0210 | .0152 | −.302 |
| 20° | .0372 | −.0020 | −.022 | 20° | −.0249 | .0195 | −.327 |
| 24° | .0383 | −.0006 | −.006 | 24° | −.0280 | .0240 | −.358 |
| 28° | .0422 | +.0005 | +.005 | 28° | −.0308 | .0283 | −.387 |
| 32° | .0462 | .0022 | .020 | 32° | −.0326 | .0334 | −.414 |
| 36° | .0500 | .0044 | .037 | 36° | −.0342 | .0380 | −.439 |
| 40° | .0540 | .0066 | .051 | 40° | −.0356 | .0393 | −.462 |
| 44° | .0582 | .0095 | .068 | 44° | −.0365 | .0420 | −.490 |

#### AILERON CHORD, 2 INCHES (20 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0095 | −.0031 | −0.136 | 4° | −.0072 | +.0042 | −0.243 |
| 8° | .0190 | −.0050 | −.110 | 8° | −.0140 | .0086 | −.256 |
| 12° | .0295 | −.0050 | −.071 | 12° | −.0193 | .0130 | −.281 |
| 16° | .0405 | −.0030 | −.031 | 16° | −.0238 | .0176 | −.308 |
| 20° | .0460 | −.0005 | −.004 | 20° | −.0275 | .0222 | −.337 |
| 24° | .0475 | +.0020 | +.018 | 24° | −.0300 | .0270 | −.375 |
| 28° | .0525 | .0049 | .039 | 28° | −.0312 | .0320 | −.426 |
| 32° | .0570 | .0078 | .057 | 32° | −.0320 | .0365 | −.476 |
| 36° | .0620 | .0105 | .071 | 36° | −.0322 | .0411 | −.532 |
| 40° | .0660 | .0140 | .089 | 40° | −.0322 | .0462 | −.598 |
| 44° | .0700 | .0175 | .104 | 44° | −.0320 | .0510 | −.664 |

#### AILERON CHORD, 3 INCHES (30 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0145 | −.0028 | −0.080 | 4° | −.0100 | +.0080 | −0.260 |
| 8° | .0290 | −.0038 | −.055 | 8° | −.0175 | .0126 | −.298 |
| 12° | .0445 | −.0030 | −.028 | 12° | −.0221 | .0183 | −.345 |
| 16° | .0600 | −.0008 | −.006 | 16° | −.0255 | .0244 | −.399 |
| 20° | .0740 | +.0036 | +.020 | 20° | −.0280 | .0306 | −.454 |
| 24° | .0850 | .0058 | .043 | 24° | −.0300 | .0375 | −.522 |
| 28° | .0900 | .0140 | .066 | 28° | −.0310 | .0446 | −.600 |
| 32° | .0935 | .0200 | .080 | 32° | −.0319 | .0520 | −.680 |
| 36° | .0980 | .0268 | .110 | 36° | −.0320 | .0588 | −.760 |
| 40° | .1020 | .0310 | .127 | 40° | −.0320 | .0635 | −.827 |
| 44° | .1060 | .0360 | .141 | 44° | −.0312 | .0680 | −.900 |

#### AILERON CHORD, 3.5 INCHES (35 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0145 | −.0031 | −0.089 | 4° | −.0108 | +.0051 | −0.197 |
| 8° | .0290 | −.0040 | −.058 | 8° | −.0185 | .0118 | −.299 |
| 12° | .0440 | −.0030 | −.028 | 12° | −.0245 | .0185 | −.314 |
| 16° | .0600 | −.0005 | −.004 | 16° | −.0290 | .0263 | −.378 |
| 20° | .0760 | +.0035 | +.019 | 20° | −.0321 | .0340 | −.441 |
| 24° | .0935 | .0091 | .041 | 24° | −.0340 | .0415 | −.509 |
| 28° | .0970 | .0160 | .069 | 28° | −.0345 | .0495 | −.598 |
| 32° | .1005 | .0240 | .100 | 32° | −.0334 | .0575 | −.718 |
| 36° | .1075 | .0315 | .122 | 36° | −.0319 | .0658 | −.857 |
| 40° | .1145 | .0441 | .161 | 40° | −.0295 | .0710 | −1.004 |
| 44° | .1220 | .0460 | .157 | 44° | −.0260 | .0745 | −1.195 |

## TABLE II.—CLARK Y WING SECTION—$C_L$, $C_N$, AND $N/L$ FOR ONE AILERON

[Varying span of aileron. Angle of pitch of airplane, +8°; angle of attack of wing, +12°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—The values apply to either right or left aileron; the signs refer to the right aileron. $N/L=0.417\ C_N/C_L$]

### AILERON CHORD, 2.5 INCHES (25 PER CENT OF WING CHORD)

AILERON SPAN, 10 INCHES (33 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0066 | −.0018 | −0.114 | 4° | −.0058 | +.0035 | −0.252 |
| 8° | .0131 | −.0031 | −.099 | 8° | −.0110 | .0071 | −.269 |
| 12° | .0198 | −.0040 | −.084 | 12° | −.0160 | .0105 | −.274 |
| 16° | .0265 | −.0034 | −.066 | 16° | −.0200 | .0140 | −.292 |
| 20° | .0330 | −.0018 | −.023 | 20° | −.0238 | .0177 | −.310 |
| 24° | .0395 | +.0002 | +.002 | 24° | −.0266 | .0210 | −.329 |
| 28° | .0460 | .0025 | .027 | 28° | −.0290 | .0245 | −.352 |
| 32° | .0525 | .0051 | .055 | 32° | −.0305 | .0276 | −.377 |
| 36° | .0590 | .0080 | .079 | 36° | −.0316 | .0308 | −.406 |
| 40° | .0445 | .0112 | .105 | 40° | −.0319 | .0342 | −.447 |
| 44° | .0456 | .0147 | .135 | 44° | −.0311 | .0375 | −.503 |

AILERON SPAN, 15 INCHES (50 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0095 | −.0028 | −0.122 | 4° | −.0085 | +.0031 | −0.152 |
| 8° | .0190 | −.0040 | −.088 | 8° | −.0155 | .0072 | −.194 |
| 12° | .0290 | −.0040 | −.060 | 12° | −.0212 | .0120 | −.236 |
| 16° | .0370 | −.0030 | −.034 | 16° | −.0255 | .0175 | −.286 |
| 20° | .0460 | −.0015 | −.014 | 20° | −.0290 | .0232 | −.334 |
| 24° | .0540 | +.0008 | +.006 | 24° | −.0310 | .0282 | −.379 |
| 28° | .0530 | .0035 | .027 | 28° | −.0331 | .0330 | −.416 |
| 32° | .0560 | .0068 | .051 | 32° | −.0355 | .0370 | −.435 |
| 36° | .0585 | .0105 | .075 | 36° | −.0380 | .0402 | −.441 |
| 40° | .0620 | .0142 | .095 | 40° | −.0400 | .0431 | −.450 |
| 44° | .0660 | .0190 | .120 | 44° | −.0420 | .0453 | −.450 |

AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0102 | −.0035 | −0.143 | 4° | −.0110 | +.0042 | −0.159 |
| 8° | .0205 | −.0060 | −.122 | 8° | −.0195 | .0095 | −.203 |
| 12° | .0310 | −.0070 | −.094 | 12° | −.0258 | .0155 | −.251 |
| 16° | .0420 | −.0060 | −.060 | 16° | −.0308 | .0215 | −.296 |
| 20° | .0522 | −.0033 | −.026 | 20° | −.0330 | .0278 | −.351 |
| 24° | .0635 | 0 | 0 | 24° | −.0348 | .0333 | −.399 |
| 28° | .0646 | +.0033 | +.025 | 28° | −.0361 | .0387 | −.447 |
| 32° | .0662 | .0062 | .052 | 32° | −.0370 | .0438 | −.494 |
| 36° | .0720 | .0135 | .075 | 36° | −.0375 | .0486 | −.541 |
| 40° | .0775 | .0191 | .103 | 40° | −.0370 | .0531 | −.598 |
| 44° | .0830 | .0255 | .128 | 44° | −.0356 | .0573 | −.671 |

## TABLE III.—U. S. A. 27 WING SECTION—$C_L$, $C_N$, AND $N/L$ FOR ONE AILERON

[Varying chord of aileron. Angle of pitch of airplane, +8°; angle of attack of wing, +12°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—The values apply to either right or left aileron; the signs refer to the right aileron. $N/L=0.417\ C_N/C_L$]

### AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

#### AILERON CHORD, 1.5 INCHES (15 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0088 | −.0020 | −0.095 | 4° | −.0080 | +.0026 | −0.130 |
| 8° | .0180 | −.0030 | −.069 | 8° | −.0152 | .0056 | −.151 |
| 12° | .0275 | −.0030 | −.045 | 12° | −.0215 | .0090 | −.175 |
| 16° | .0380 | −.0025 | −.030 | 16° | −.0270 | .0126 | −.193 |
| 20° | .0350 | −.0018 | −.020 | 20° | −.0315 | .0168 | −.209 |
| 24° | .0390 | 0 | 0 | 24° | −.0360 | .0190 | −.220 |
| 28° | .0428 | +.0021 | +.020 | 28° | −.0406 | .0220 | −.227 |
| 32° | .0455 | .0030 | .046 | 32° | −.0440 | .0250 | −.237 |
| 36° | .0500 | .0077 | .064 | 36° | −.0474 | .0280 | −.247 |
| 40° | .0540 | .0106 | .081 | 40° | −.0500 | .0305 | −.254 |
| 44° | .0580 | .0135 | .097 | 44° | −.0508 | .0330 | −.273 |

#### AILERON CHORD, 2 INCHES (20 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0095 | −.0028 | −0.114 | 4° | −.0067 | +.0030 | −0.187 |
| 8° | .0195 | −.0040 | −.086 | 8° | −.0140 | .0065 | −.194 |
| 12° | .0305 | −.0040 | −.055 | 12° | −.0205 | .0103 | −.210 |
| 16° | .0445 | −.0025 | −.023 | 16° | −.0265 | .0140 | −.220 |
| 20° | .0560 | 0 | 0 | 20° | −.0320 | .0180 | −.234 |
| 24° | .0630 | +.0023 | +.019 | 24° | −.0375 | .0218 | −.242 |
| 28° | .0625 | .0060 | .040 | 28° | −.0425 | .0255 | −.250 |
| 32° | .0620 | .0094 | .053 | 32° | −.0470 | .0293 | −.260 |
| 36° | .0656 | .0130 | .081 | 36° | −.0510 | .0332 | −.272 |
| 40° | .0712 | .0170 | .100 | 40° | −.0546 | .0372 | −.284 |
| 44° | .0770 | .0210 | .114 | 44° | −.0575 | .0412 | −.299 |

#### AILERON CHORD, 3 INCHES (30 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0150 | −.0030 | −0.083 | 4° | −.0120 | +.0062 | −0.181 |
| 8° | .0300 | −.0022 | −.031 | 8° | −.0220 | .0108 | −.205 |
| 12° | .0450 | 0 | 0 | 12° | −.0295 | .0162 | −.229 |
| 16° | .0600 | +.0022 | +.015 | 16° | −.0355 | .0215 | −.253 |
| 20° | .0750 | .0038 | .031 | 20° | −.0391 | .0270 | −.288 |
| 24° | .0910 | .0098 | .045 | 24° | −.0425 | .0320 | −.314 |
| 28° | .0895 | .0145 | .069 | 28° | −.0453 | .0370 | −.341 |
| 32° | .0830 | .0215 | .102 | 32° | −.0453 | .0420 | −.363 |
| 36° | .0935 | .0335 | .149 | 36° | −.0615 | .0465 | −.376 |
| 40° | .0990 | .0390 | .164 | 40° | −.0550 | .0515 | −.387 |
| 44° | .1050 | .0412 | .164 | 44° | −.0586 | .0550 | −.391 |

#### AILERON CHORD, 3.5 INCHES (35 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0155 | −.0022 | −0.059 | 4° | −.0115 | +.0040 | −0.145 |
| 8° | .0310 | −.0028 | −.038 | 8° | −.0215 | .0095 | −.184 |
| 12° | .0470 | −.0010 | −.009 | 12° | −.0295 | .0170 | −.240 |
| 16° | .0630 | +.0020 | +.013 | 16° | −.0360 | .0240 | −.278 |
| 20° | .0780 | .0060 | .032 | 20° | −.0410 | .0300 | −.306 |
| 24° | .0950 | .0118 | .050 | 24° | −.0450 | .0360 | −.334 |
| 28° | .0965 | .0177 | .076 | 28° | −.0480 | .0420 | −.365 |
| 32° | .0975 | .0255 | .109 | 32° | −.0505 | .0476 | −.394 |
| 36° | .1060 | .0345 | .136 | 36° | −.0525 | .0525 | −.417 |
| 40° | .1125 | .0425 | .157 | 40° | −.0540 | .0570 | −.440 |
| 44° | .1182 | .0500 | .176 | 44° | −.0545 | .0610 | −.457 |

## TABLE IV.—U. S. A. 27-WING SECTION—$C_L$, $C_N$, AND $N/L$ FOR ONE AILERON

[Varying span of aileron. Angle of pitch of airplane, +8°; angle of attack of wing, +12°; angle of yaw, 0°, angle of roll, 0°]

[NOTE.—The values refer to either right or left aileron; the signs refer to the right aileron. $N/L=0.417\ C_N/C_L$]

### AILERON CHORD 2.5 INCHES (25 PER CENT OF WING CHORD)

AILERON SPAN, 10 INCHES (33 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0068 | −.0015 | −0.092 | 4° | −.0062 | +.0012 | −0.006 |
| 8° | .0130 | −.0020 | −.064 | 8° | −.0105 | .0034 | −.135 |
| 12° | .0198 | −.0018 | −.038 | 12° | −.0150 | .0056 | −.155 |
| 16° | .0266 | 0 | 0 | 16° | −.0190 | .0085 | −.185 |
| 20° | .0336 | +.0022 | +.027 | 20° | −.0226 | .0115 | −.212 |
| 24° | .0415 | .0045 | .045 | 24° | −.0255 | .0150 | −.245 |
| 28° | .0408 | .0070 | .072 | 28° | −.0280 | .0184 | −.274 |
| 32° | .0400 | .0092 | .096 | 32° | −.0300 | .0219 | −.304 |
| 36° | .0430 | .0118 | .115 | 36° | −.0312 | .0252 | −.337 |
| 40° | .0460 | .0141 | .128 | 40° | −.0322 | .0289 | −.374 |
| 44° | .0490 | .0166 | .141 | 44° | −.0325 | .0322 | −.413 |

AILERON SPAN, 15 INCHES (50 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0090 | −.0020 | −0.093 | 4° | −.0075 | +.0082 | −0.178 |
| 8° | .0180 | −.0032 | −.074 | 8° | −.0150 | .0070 | −.195 |
| 12° | .0270 | −.0030 | −.046 | 12° | −.0206 | .0118 | −.237 |
| 16° | .0365 | −.0010 | −.011 | 16° | −.0260 | .0160 | −.257 |
| 20° | .0470 | +.0020 | +.018 | 20° | −.0306 | .0200 | −.271 |
| 24° | .0500 | .0052 | .043 | 24° | −.0340 | .0240 | −.294 |
| 28° | .0530 | .0088 | .069 | 28° | −.0368 | .0280 | −.317 |
| 32° | .0562 | .0122 | .091 | 32° | −.0395 | .0318 | −.330 |
| 36° | .0600 | .0160 | .111 | 36° | −.0418 | .0346 | −.345 |
| 40° | .0648 | .0200 | .129 | 40° | −.0445 | .0378 | −.354 |
| 44° | .0695 | .0245 | .147 | 44° | −.0475 | .0402 | −.358 |

AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0105 | −.0022 | −0.087 | 4° | −.0095 | +.0032 | −0.140 |
| 8° | .0210 | −.0038 | −.075 | 8° | −.0180 | .0070 | −.162 |
| 12° | .0320 | −.0038 | −.050 | 12° | −.0248 | .0115 | −.193 |
| 16° | .0430 | −.0020 | −.019 | 16° | −.0308 | .0165 | −.227 |
| 20° | .0550 | +.0011 | +.008 | 20° | −.0348 | .0215 | −.258 |
| 24° | .0685 | .0045 | .027 | 24° | −.0380 | .0260 | −.307 |
| 28° | .0680 | .0082 | .053 | 28° | −.0400 | .0340 | −.355 |
| 32° | .0675 | .0130 | .080 | 32° | −.0412 | .0392 | −.397 |
| 36° | .0735 | .0180 | .102 | 36° | −.0412 | .0440 | −.447 |
| 40° | .0795 | .0235 | .123 | 40° | −.0402 | .0480 | −.499 |
| 44° | .0855 | .0290 | .142 | 44° | −.0380 | .0515 | −.566 |

## TABLE V.—CLARK Y WING SECTION—COMBINED VALUES OF $C_L$, $C_N$, AND $N/L$ (RIGHT AILERON UP, LEFT AILERON DOWN)

[Varying chord of aileron. Angle of pitch of airplane, +8°; angle of attack of wing, +12°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—$N/L=0.417\ C_N/C_L$]

### AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

| AILERON CHORD, 1.5 INCHES (15 PER CENT OF WING CHORD) | | | | AILERON CHORD, 2 INCHES (20 PER CENT OF WING CHORD) | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0148 | −.0063 | −0.177 | 4° | +.0167 | −.0073 | −0.182 |
| 8° | .0292 | −.0115 | −.164 | 8° | .0330 | −.0136 | −.172 |
| 12° | .0430 | −.0153 | −.149 | 12° | .0488 | −.0180 | −.154 |
| 16° | .0570 | −.0182 | −.133 | 16° | .0643 | −.0206 | −.134 |
| 20° | .0621 | −.0215 | −.144 | 20° | .0738 | −.0227 | −.116 |
| 24° | .0668 | −.0245 | −.153 | 24° | .0775 | −.0250 | −.135 |
| 28° | .0728 | −.0278 | −.159 | 28° | .0837 | −.0271 | −.135 |
| 32° | .0788 | −.0302 | −.160 | 32° | .0890 | −.0287 | −.135 |
| 36° | .0842 | −.0316 | −.157 | 36° | .0942 | −.0306 | −.136 |
| 40° | .0895 | −.0327 | −.152 | 40° | .0982 | −.0323 | −.137 |
| 44° | .0947 | −.0325 | −.143 | 44° | .1030 | −.0335 | −.137 |

| AILERON CHORD, 2.5 INCHES (25 PER CENT OF WING CHORD) | | | | AILERON CHORD, 3.5 INCHES (35 PER CENT OF WING CHORD) | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0245 | −.0088 | −0.150 | 4° | +.0253 | −.0082 | −0.135 |
| 8° | .0465 | −.0163 | −.146 | 8° | .0475 | −.0155 | −.136 |
| 12° | .0666 | −.0212 | −.147 | 12° | .0696 | −.0215 | −.131 |
| 16° | .0856 | −.0253 | −.123 | 16° | .0890 | −.0268 | −.126 |
| 20° | .1020 | −.0269 | −.110 | 20° | .1061 | −.0305 | −.118 |
| 24° | .1160 | −.0287 | −.103 | 24° | .1275 | −.0324 | −.106 |
| 28° | .1210 | −.0306 | −.104 | 28° | .1315 | −.0335 | −.106 |
| 32° | .1254 | −.0320 | −.106 | 32° | .1339 | −.0335 | −.104 |
| 36° | .1300 | −.0326 | −.104 | 36° | .1394 | −.0341 | −.102 |
| 40° | .1340 | −.0325 | −.101 | 40° | .1440 | −.0269 | −.078 |
| 44° | .1372 | −.0320 | −.097 | 44° | .1480 | −.0235 | −.080 |

## TABLE VI.—CLARK Y WING SECTION—COMBINED VALUES OF $C_L$, $C_N$, AND $N/L$ (RIGHT AILERON UP LEFT AILERON DOWN)

[Varying span of aileron. Angle of pitch of airplane, +8°; angle of attack of wing, +12°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—$N/L=0.417\ C_N/C_L$]

### AILERON CHORD, 2.5 INCHES (25 PER CENT OF WING CHORD)

| AILERON SPAN, 10 INCHES (33 PER CENT OF WING SEMISPAN) | | | | AILERON SPAN, 15 INCHES (50 PER CENT OF WING SEMISPAN) | | | | AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0124 | −.0068 | −0.173 | 4° | +.0180 | −.0059 | −0.137 | 4° | +.0212 | −.0077 | −0.151 |
| 8° | .0241 | −.0102 | −.177 | 8° | .0345 | −.0112 | −.135 | 8° | .0400 | −.0155 | −.162 |
| 12° | .0358 | −.0145 | −.168 | 12° | .0492 | −.0160 | −.136 | 12° | .0568 | −.0235 | −.165 |
| 16° | .0455 | −.0174 | −.175 | 16° | .0625 | −.0205 | −.137 | 16° | .0723 | −.0275 | −.159 |
| 20° | .0568 | −.0195 | −.143 | 20° | .0780 | −.0247 | −.137 | 20° | .0882 | −.0311 | −.152 |
| 24° | .0681 | −.0208 | −.131 | 24° | .0890 | −.0274 | −.135 | 24° | .0973 | −.0323 | −.143 |
| 28° | .0680 | −.0220 | −.135 | 28° | .0881 | −.0295 | −.141 | 28° | .1007 | −.0349 | −.145 |
| 32° | .0690 | −.0226 | −.136 | 32° | .0915 | −.0302 | −.134 | 32° | .1062 | −.0356 | −.144 |
| 36° | .0726 | −.0228 | −.129 | 36° | .0965 | −.0297 | −.128 | 36° | .1096 | −.0351 | −.134 |
| 40° | .0764 | −.0230 | −.126 | 40° | .1020 | −.0289 | −.118 | 40° | .1145 | −.0340 | −.124 |
| 44° | .0766 | −.0228 | −.124 | 44° | .1080 | −.0263 | −.102 | 44° | .1186 | −.0318 | −.112 |

## TABLE VII.—U. S. A. 27 WING SECTION—COMBINED VALUES OF $C_L$, $C_N$, AND $N/L$ (RIGHT AILERON UP, LEFT AILERON DOWN)

[Varying chord of aileron. Angle of pitch of airplane, +8°; angle of attack of wing, +12°; angle of yaw, 0°; angle of roll, 0°

[NOTE.—$N/L=0.417\ C_N/C_L$]

### AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

| AILERON CHORD, 1.5 INCHES (15 PER CENT OF WING CHORD) | | | | AILERON CHORD, 2 INCHES (20 PER CENT OF WING CHORD) | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0168 | −.0045 | −0.112 | 4° | +.0162 | −.0056 | −0.144 |
| 8° | .0332 | −.0085 | −.107 | 8° | .0635 | −.0105 | −.131 |
| 12° | .0490 | −.0120 | −.102 | 12° | .0510 | −.0143 | −.117 |
| 16° | .0630 | −.0150 | −.101 | 16° | .0710 | −.0165 | −.097 |
| 20° | .0695 | −.0176 | −.106 | 20° | .0880 | −.0180 | −.085 |
| 24° | .0750 | −.0190 | −.106 | 24° | .1005 | −.0190 | −.079 |
| 28° | .0833 | −.0199 | −.100 | 28° | .1050 | −.0195 | −.077 |
| 32° | .0895 | −.0200 | −.093 | 32° | .1090 | −.0199 | −.076 |
| 36° | .0974 | −.0203 | −.087 | 36° | .1176 | −.0202 | −.072 |
| 40° | .1040 | −.0200 | −.080 | 40° | .1258 | −.0202 | −.067 |
| 44° | .1083 | −.0195 | −.075 | 44° | .1345 | −.0202 | −.063 |

| AILERON CHORD, 3 INCHES (30 PER CENT OF WING CHORD) | | | | AILERON CHORD, 3.5 INCHES (35 PER CENT OF WING CHORD) | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0270 | −.0082 | −0.127 | 4° | +.0270 | −.0062 | −0.096 |
| 8° | .0520 | −.0130 | −.104 | 8° | .0535 | −.0123 | −.096 |
| 12° | .0745 | −.0162 | −.091 | 12° | .0785 | −.0180 | −.096 |
| 16° | .0955 | −.0193 | −.083 | 16° | .0990 | −.0220 | −.093 |
| 20° | .1141 | −.0214 | −.078 | 20° | .1190 | −.0240 | −.084 |
| 24° | .1335 | −.0222 | −.069 | 24° | .1400 | −.0245 | −.073 |
| 28° | .1348 | −.0222 | −.069 | 28° | .1445 | −.0243 | −.071 |
| 32° | .1363 | −.0205 | −.063 | 32° | .1480 | −.0231 | −.062 |
| 36° | .1450 | −.0130 | −.037 | 36° | .1585 | −.0180 | −.047 |
| 40° | .1540 | −.0120 | −.032 | 40° | .1665 | −.0145 | −.036 |
| 44° | .1636 | −.0138 | −.035 | 44° | .1727 | −.0110 | −.027 |

## TABLE VIII.—U. S. A. 27 WING SECTION—COMBINED VALUES OF $C_L$, $C_N$, AND $N/L$ (RIGHT AILERON UP LEFT AILERON DOWN)

[Varying span of aileron. Angle of pitch of airplane, +8°; angle of attack of wing, +12°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—$N/L=0.417\ C_N/C_L$]

### AILERON CHORD, 2.5 INCHES (25 PER CENT OF WING CHORD)

| AILERON SPAN, 10 INCHES (33 PER CENT OF WING SEMISPAN) | | | | AILERON SPAN, 15 INCHES (50 PER CENT OF WING SEMISPAN) | | | | AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0120 | −.0027 | −0.094 | 4° | +.0165 | −.0052 | −0.131 | 4° | +.0200 | −.0054 | −0.113 |
| 8° | .0235 | −.0054 | −.096 | 8° | .0330 | −.0102 | −.129 | 8° | .0390 | −.0108 | −.115 |
| 12° | .0348 | −.0074 | −.089 | 12° | .0478 | −.0148 | −.129 | 12° | .0568 | −.0153 | −.112 |
| 16° | .0456 | −.0085 | −.078 | 16° | .0625 | −.0170 | −.113 | 16° | .0738 | −.0185 | −.105 |
| 20° | .0562 | −.0093 | −.069 | 20° | .0778 | −.0180 | −.096 | 20° | .0898 | −.0204 | −.095 |
| 24° | .0670 | −.0105 | −.065 | 24° | .0840 | −.0188 | −.093 | 24° | .1055 | −.0235 | −.092 |
| 28° | .0688 | −.0114 | −.069 | 28° | .0898 | −.0192 | −.089 | 28° | .1080 | −.0254 | −.098 |
| 32° | .0700 | −.0127 | −.076 | 32° | .0967 | −.0191 | −.083 | 32° | .1087 | −.0262 | −.101 |
| 36° | .0742 | −.0134 | −.075 | 36° | .1018 | −.0186 | −.076 | 36° | .1147 | −.0260 | −.095 |
| 40° | .0782 | −.0148 | −.079 | 40° | .1092 | −.0178 | −.068 | 40° | .1197 | −.0245 | −.085 |
| 44° | .0815 | −.0156 | −.080 | 44° | .1170 | −.0157 | −.056 | 44° | .1235 | −.0225 | −.076 |

## TABLE IX.—CLARK Y WING SECTION—$C_L$, $C_N$, AND $N/L$ FOR ONE AILERON

[Varying chord of aileron. Angle of pitch of airplane, +12°; angle of attack of wing, +16°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—The values refer to either right or left aileron; the signs refer to the right aileron. $N/L=0.417\ C_N/C_L$]

### AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

AILERON CHORD, 1.5 INCHES (15 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0055 | −.0026 | −0.190 | 4° | −.0040 | +.0056 | −0.584 |
| 8° | .0115 | −.0035 | −.127 | 8° | −.0080 | .0112 | −.582 |
| 12° | .0185 | −.0045 | −.101 | 12° | −.0110 | .0168 | −.637 |
| 16° | .0260 | −.0060 | −.074 | 16° | −.0140 | .0220 | −.655 |
| 20° | .0290 | −.0060 | −.072 | 20° | −.0165 | .0270 | −.652 |
| 24° | .0280 | −.0050 | −.074 | 24° | −.0180 | .0320 | −.742 |
| 28° | .0272 | −.0045 | −.069 | 28° | −.0191 | .0365 | −.797 |
| 32° | .0270 | −.0035 | −.054 | 32° | −.0198 | .0410 | −.864 |
| 36° | .0278 | −.0018 | −.027 | 36° | −.0198 | .0450 | −.943 |
| 40° | .0296 | −.0002 | −.003 | 40° | −.0189 | .0488 | −1.078 |
| 44° | .0330 | +.0010 | +.013 | 44° | −.0179 | .0530 | −1.212 |

AILERON CHORD, 2 INCHES (20 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0070 | −.0035 | −0.208 | 4° | −.0040 | +.0065 | −0.509 |
| 8° | +.0140 | −.0065 | −.194 | 8° | −.0077 | .0110 | −.596 |
| 12° | .0210 | −.0080 | −.159 | 12° | −.0093 | .0160 | −.682 |
| 16° | .0250 | −.0080 | −.119 | 16° | −.0114 | .0210 | −.768 |
| 20° | .0350 | −.0070 | −.083 | 20° | −.0128 | .0260 | −.848 |
| 24° | .0368 | −.0055 | −.062 | 24° | −.0140 | .0310 | −.923 |
| 28° | .0382 | −.0035 | −.038 | 28° | −.0145 | .0355 | −1.020 |
| 32° | .0400 | −.0010 | −.010 | 32° | −.0150 | .0400 | −1.111 |
| 36° | .0428 | +.0020 | +.019 | 36° | −.0152 | .0445 | −1.220 |
| 40° | .0460 | .0052 | .047 | 40° | −.0156 | .0485 | −1.296 |
| 44° | .0515 | .0090 | .073 | 44° | −.0158 | .0525 | −1.384 |

AILERON CHORD, 3 INCHES (30 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0092 | −.0047 | −0.213 | 4° | −.0065 | +.0070 | −0.530 |
| 8° | .0180 | −.0076 | −.176 | 8° | −.0090 | .0136 | −.630 |
| 12° | .0275 | −.0092 | −.140 | 12° | −.0113 | .0202 | −.745 |
| 16° | .0372 | −.0095 | −.107 | 16° | −.0130 | .0267 | −.857 |
| 20° | .0480 | −.0080 | −.069 | 20° | −.0145 | .0330 | −.949 |
| 24° | .0600 | −.0032 | −.022 | 24° | −.0152 | .0390 | −1.070 |
| 28° | .0630 | +.0030 | +.020 | 28° | −.0160 | .0450 | −1.172 |
| 32° | .0660 | .0090 | .057 | 32° | −.0162 | .0520 | −1.337 |
| 36° | .0720 | .0148 | .088 | 36° | −.0163 | .0605 | −1.546 |
| 40° | .0780 | .0205 | .110 | 40° | −.0162 | .0720 | −1.822 |
| 44° | .0850 | .0265 | .130 | 44° | −.0161 | .0930 | −2.410 |

AILERON CHORD, 3.5 INCHES (35 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0076 | −.0068 | −0.373 | 4° | −.0060 | +.0077 | −0.642 |
| 8° | .0152 | −.0105 | −.288 | 8° | −.0080 | .0155 | −.809 |
| 12° | .0245 | −.0120 | −.204 | 12° | −.0090 | .0230 | −1.068 |
| 16° | .0380 | −.0120 | −.132 | 16° | −.0100 | .0310 | −1.293 |
| 20° | .0535 | −.0095 | −.074 | 20° | −.0101 | .0390 | −1.610 |
| 24° | .0660 | −.0030 | −.019 | 24° | −.0100 | .0470 | −1.960 |
| 28° | .0752 | +.0050 | +.028 | 28° | −.0091 | .0550 | −2.520 |
| 32° | .0828 | .0125 | .068 | 32° | −.0081 | .0640 | −3.295 |
| 36° | .0828 | .0195 | .099 | 36° | −.0070 | .0740 | −4.410 |
| 40° | .0890 | .0265 | .124 | 40° | −.0062 | .0865 | −6.940 |
| 44° | .0955 | .0330 | .144 | 44° | −.0035 | .1030 | −12.27 |

## TABLE X.—CLARK Y WING SECTION—$C_L$, $C_N$, AND $N/L$ FOR ONE AILERON

[Varying span of aileron. Angle of pitch of airplane, +12°; angle of attack of wing, +16°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—The values apply to either right or left aileron, the signs refer to the right aileron. $N/L=0.417\ C_N/C_L$]

### AILERON CHORD, 2.5 INCHES (25 PER CENT OF WING CHORD)

AILERON SPAN, 10 INCHES (33 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0045 | −.0025 | −0.232 | 4° | −.0038 | +.0040 | −0.439 |
| 8° | .0095 | −.0040 | −.175 | 8° | −.0066 | .0080 | −.506 |
| 12° | .0145 | −.0045 | −.129 | 12° | −.0089 | .0110 | −.535 |
| 16° | .0200 | −.0045 | −.094 | 16° | −.0100 | .0150 | −.626 |
| 20° | .0260 | −.0040 | −.064 | 20° | −.0110 | .0182 | −.690 |
| 24° | .0315 | −.0030 | −.040 | 24° | −.0115 | .0215 | −.780 |
| 28° | .0323 | −.0010 | −.013 | 28° | −.0117 | .0248 | −.884 |
| 32° | .0330 | +.0020 | +.025 | 32° | −.0115 | .0280 | −1.015 |
| 36° | .0350 | .0050 | .060 | 36° | −.0110 | .0310 | −1.175 |
| 40° | .0372 | .0075 | .084 | 40° | −.0102 | .0340 | −1.390 |
| 44° | .0400 | .0100 | .104 | 44° | −.0085 | .0373 | −1.830 |

AILERON SPAN, 15 INCHES (50 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0062 | −.0045 | −0.303 | 4° | −.0055 | +.0050 | −0.379 |
| 8° | .0130 | −.0078 | −.250 | 8° | −.0105 | .0100 | −.397 |
| 12° | .0195 | −.0092 | −.197 | 12° | −.0131 | .0155 | −.494 |
| 16° | .0270 | −.0090 | −.139 | 16° | −.0131 | .0205 | −.652 |
| 20° | .0350 | −.0070 | −.083 | 20° | −.0108 | .0255 | −.988 |
| 24° | .0435 | −.0050 | −.048 | 24° | −.0090 | .0300 | −1.390 |
| 28° | .0445 | −.0021 | −.020 | 28° | −.0090 | .0345 | −1.800 |
| 32° | .0460 | +.0010 | +.009 | 32° | −.0090 | .0389 | −2.028 |
| 36° | .0480 | .0045 | .039 | 36° | −.0085 | .0429 | −2.105 |
| 40° | .0498 | .0080 | .075 | 40° | −.0085 | .0465 | −2.281 |
| 44° | .0515 | .0135 | .109 | 44° | −.0080 | .0505 | −2.630 |

AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0075 | −.0040 | −0.222 | 4° | −.0050 | +.0060 | −0.500 |
| 8° | .0150 | −.0072 | −.200 | 8° | −.0086 | .0115 | −.558 |
| 12° | .0230 | −.0090 | −.163 | 12° | −.0110 | .0170 | −.645 |
| 16° | .0305 | −.0095 | −.130 | 16° | −.0122 | .0225 | −.770 |
| 20° | .0382 | −.0095 | −.104 | 20° | −.0122 | .0280 | −.958 |
| 24° | .0460 | −.0083 | −.075 | 24° | −.0111 | .0335 | −1.259 |
| 28° | .0480 | −.0046 | −.040 | 28° | −.0102 | .0391 | −1.500 |
| 32° | .0500 | +.0010 | +.008 | 32° | −.0097 | .0447 | −1.921 |
| 36° | .0530 | .0055 | .043 | 36° | −.0091 | .0502 | −2.300 |
| 40° | .0556 | .0090 | .067 | 40° | −.0092 | .0558 | −2.530 |
| 44° | .0585 | .0115 | .082 | 44° | −.0098 | .0612 | −2.600 |

## TABLE XI.—U. S. A. 27 WING SECTION—$C_L$, $C_N$, AND $N/L$ FOR ONE AILERON

[Varying chord of aileron. Angle of pitch of airplane, +12°; angle of attack of wing, +16°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—The values refer to either right or left aileron; the signs refer to the right aileron. $N/L=0.417\ C_N/C_L$]

### AILERON SPAN 20 INCHES (67 PER CENT OF WING SEMISPAN)

#### AILERON CHORD, 1.5 INCHES (15 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0063 | −.0030 | −0.123 | 4° | −.0065 | −.0035 | +0.258 |
| 8° | .0125 | −.0040 | −.133 | 8° | −.0100 | .0080 | −.334 |
| 12° | .0175 | −.0068 | −.136 | 12° | −.0140 | .0120 | −.357 |
| 16° | .0225 | −.0055 | −.120 | 16° | −.0168 | .0155 | −.385 |
| 20° | .0240 | −.0040 | −.070 | 20° | −.0190 | .0195 | −.426 |
| 24° | .0255 | −.0018 | −.029 | 24° | −.0208 | .0230 | −.461 |
| 28° | .0277 | +.0008 | +.012 | 28° | −.0225 | .0265 | −.491 |
| 32° | .0301 | .0032 | .044 | 32° | −.0232 | .0300 | −.537 |
| 36° | .0333 | .0060 | .075 | 36° | −.0240 | .0331 | −.575 |
| 40° | .0375 | .0080 | .089 | 40° | −.0238 | .0362 | −.634 |
| 44° | .0430 | .0090 | .087 | 44° | −.0225 | .0396 | −.732 |

#### AILERON CHORD, 2 INCHES (20 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0100 | −.0030 | −0.125 | 4° | −.0070 | +.0030 | −0.179 |
| 8° | .0185 | −.0049 | −.110 | 8° | −.0125 | .0075 | −.250 |
| 12° | .0258 | −.0060 | −.097 | 12° | −.0168 | .0135 | −.334 |
| 16° | .0320 | −.0062 | −.081 | 16° | −.0180 | .0195 | −.452 |
| 20° | .0370 | −.0060 | −.068 | 20° | −.0200 | .0250 | −.521 |
| 24° | .0415 | −.0045 | −.045 | 24° | −.0213 | .0300 | −.588 |
| 28° | .0450 | −.0022 | −.020 | 28° | −.0225 | .0352 | −.652 |
| 32° | .0475 | +.0016 | +.014 | 32° | −.0235 | .0400 | −.710 |
| 36° | .0460 | .0060 | .054 | 36° | −.0240 | .0440 | −.764 |
| 40° | .0515 | .0098 | .079 | 40° | −.0245 | .0475 | −.810 |
| 44° | .0570 | .0140 | .102 | 44° | −.0245 | .0505 | −.861 |

#### AILERON CHORD, 3 INCHES (30 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0105 | −.0062 | −0.207 | 4° | −.0085 | +.0055 | −0.270 |
| 8° | .0210 | −.0078 | −.155 | 8° | −.0150 | .0125 | −.342 |
| 12° | .0320 | −.0065 | −.111 | 12° | −.0181 | .0214 | −.493 |
| 16° | .0430 | −.0070 | −.068 | 16° | −.0197 | .0295 | −.625 |
| 20° | .0540 | −.0032 | −.025 | 20° | −.0201 | .0360 | −.746 |
| 24° | .0650 | +.0022 | +.014 | 24° | −.0203 | .0420 | −.863 |
| 28° | .0695 | .0082 | .049 | 28° | −.0201 | .0475 | −.985 |
| 32° | .0730 | .0145 | .083 | 32° | −.0196 | .0525 | −1.115 |
| 36° | .0790 | .0205 | .110 | 36° | −.0188 | .0575 | −1.275 |
| 40° | .0850 | .0267 | .131 | 40° | −.0177 | .0625 | −1.475 |
| 44° | .0910 | .0330 | .151 | 44° | −.0163 | .0670 | −1.710 |

#### AILERON CHORD, 3.5 INCHES (35 PER CENT OF WING CHORD)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0085 | −.0042 | −0.206 | 4° | −.0063 | +.0060 | −0.284 |
| 8° | .0200 | −.0068 | −.142 | 8° | −.0155 | .0135 | −.363 |
| 12° | .0365 | −.0070 | −.080 | 12° | −.0187 | .0235 | −.524 |
| 16° | .0500 | −.0040 | −.033 | 16° | −.0192 | .0320 | −.694 |
| 20° | .0620 | +.0010 | +.007 | 20° | −.0190 | .0395 | −.867 |
| 24° | .0730 | .0068 | .039 | 24° | −.0186 | .0460 | −1.030 |
| 28° | .0782 | .0130 | .069 | 28° | −.0180 | .0530 | −1.227 |
| 32° | .0835 | .0195 | .097 | 32° | −.0172 | .0590 | −1.430 |
| 36° | .0885 | .0260 | .122 | 36° | −.0160 | .0650 | −1.694 |
| 40° | .0935 | .0325 | .149 | 40° | −.0148 | .0705 | −1.966 |
| 44° | .0985 | .0410 | .174 | 44° | −.0130 | .0760 | −2.433 |

## TABLE XII.—U. S. A. 27 WING SECTION—$C_L$, $C_N$, AND $N/L$ FOR ONE AILERON

[Varying span of aileron. Angle of pitch of airplane, +12°; angle of attack of wing, +16°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—The values apply to either right or left aileron; the signs refer to the right aileron. $N/L=0.417\ C_N/C_L$]

### AILERON CHORD, 2.5 INCHES (25 PER CENT OF WING CHORD)

AILERON SPAN, 10 INCHES (33 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0052 | −.0030 | −0.241 | 4° | −.0035 | +.0040 | −0.476 |
| 8° | .0105 | −.0060 | −.199 | 8° | −.0061 | .0085 | −.581 |
| 12° | .0160 | −.0062 | −.136 | 12° | −.0087 | .0130 | −.622 |
| 16° | .0210 | −.0062 | −.103 | 16° | −.0111 | .0168 | −.631 |
| 20° | .0264 | −.0043 | −.068 | 20° | −.0138 | .0205 | −.619 |
| 24° | .0320 | −.0025 | −.033 | 24° | −.0140 | .0245 | −.730 |
| 28° | .0338 | 0 | 0 | 28° | −.0130 | .0282 | −.904 |
| 32° | .0355 | +.0025 | +.029 | 32° | −.0110 | .0315 | −1.195 |
| 36° | .0380 | .0060 | .066 | 36° | −.0110 | .0347 | −1.315 |
| 40° | .0395 | .0090 | .095 | 40° | −.0120 | .0376 | −1.307 |
| 44° | .0400 | .0100 | .104 | 44° | −.0138 | .0404 | −1.221 |

AILERON SPAN, 15 INCHES (50 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0078 | −.0040 | −0.214 | 4° | −.0045 | +.0050 | −0.463 |
| 8° | .0153 | −.0072 | −.193 | 8° | −.0045 | .0110 | −1.020 |
| 12° | .0226 | −.0082 | −.151 | 12° | −.0039 | .0175 | −1.870 |
| 16° | .0300 | −.0080 | −.111 | 16° | −.0035 | .0225 | −2.680 |
| 20° | .0375 | −.0050 | −.056 | 20° | −.0042 | .0260 | −2.582 |
| 24° | .0450 | −.0020 | −.019 | 24° | −.0062 | .0300 | −2.405 |
| 28° | .0455 | +.0015 | +.014 | 28° | −.0062 | .0340 | −2.283 |
| 32° | .0460 | .0050 | .045 | 32° | −.0070 | .0380 | −2.263 |
| 36° | .0458 | .0078 | .071 | 36° | −.0072 | .0418 | −2.420 |
| 40° | .0472 | .0105 | .093 | 40° | −.0076 | .0455 | −2.496 |
| 44° | .0530 | .0120 | .102 | 44° | −.0073 | .0490 | −2.800 |

AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

| Aileron up | | | | Aileron down | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0065 | −.0035 | −0.268 | 4° | −.0038 | +.0068 | −0.746 |
| 8° | .0125 | −.0056 | −.187 | 8° | −.0058 | .0130 | −.934 |
| 12° | .0215 | −.0070 | −.136 | 12° | −.0070 | .0192 | −1.144 |
| 16° | .0310 | −.0072 | −.097 | 16° | −.0078 | .0250 | −1.340 |
| 20° | .0400 | −.0070 | −.078 | 20° | −.0082 | .0305 | −1.552 |
| 24° | .0430 | −.0052 | −.050 | 24° | −.0086 | .0360 | −1.745 |
| 28° | .0440 | −.0020 | −.019 | 28° | −.0090 | .0405 | −1.875 |
| 32° | .0450 | +.0018 | +.017 | 32° | −.0090 | .0440 | −2.040 |
| 36° | .0500 | .0065 | .054 | 36° | −.0090 | .0475 | −2.200 |
| 40° | .0555 | .0112 | .084 | 40° | −.0090 | .0522 | −2.418 |
| 44° | .0620 | .0155 | .104 | 44° | −.0090 | .0585 | −2.710 |

## TABLE XIII.—CLARK Y WING SECTION—COMBINED VALUES OF $C_L$, $C_N$, AND $N/L$ (RIGHT AILERON UP, LEFT AILERON DOWN)

[Varying chord of aileron. Angle of pitch of airplane, +12°; angle of attack of wing, +16°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—$N/L$=0.417 $C_N/C_L$]

### AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

| AILERON CHORD, 1.5 INCHES (15 PER CENT OF WING CHORD) | | | | AILERON CHORD, 2 INCHES (20 PER CENT OF WING CHORD) | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0095 | −.0081 | −0.356 | 4° | +.0115 | −.0090 | −0.326 |
| 8° | .0195 | −.0147 | −.314 | 8° | .0217 | −.0175 | −.336 |
| 12° | .0295 | −.0213 | −.301 | 12° | .0308 | −.0240 | −.325 |
| 16° | .0420 | −.0270 | −.268 | 16° | .0394 | −.0290 | −.307 |
| 20° | .0455 | −.0320 | −.293 | 20° | .0478 | −.0330 | −.288 |
| 24° | .0460 | −.0370 | −.335 | 24° | .0508 | −.0365 | −.300 |
| 28° | .0463 | −.0410 | −.369 | 28° | .0527 | −.0390 | −.309 |
| 32° | .0468 | −.0445 | −.397 | 32° | .0550 | −.0410 | −.311 |
| 36° | .0476 | −.0468 | −.410 | 36° | .0580 | −.0425 | −.306 |
| 40° | .0485 | −.0490 | −.421 | 40° | .0616 | −.0433 | −.293 |
| 44° | .0509 | −.0510 | −.418 | 44° | .0673 | −.0435 | −.270 |

| AILERON CHORD, 3 INCHES (30 PER CENT OF WING CHORD) | | | | AILERON CHORD, 3.5 INCHES (35 PER CENT OF WING CHORD) | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0147 | −.0117 | −0.332 | 4° | +.0126 | −.0145 | −0.480 |
| 8° | .0270 | −.0212 | −.327 | 8° | .0252 | −.0260 | −.467 |
| 12° | .0388 | −.0294 | −.316 | 12° | .0385 | −.0350 | −.436 |
| 16° | .0502 | −.0362 | −.301 | 16° | .0480 | −.0430 | −.374 |
| 20° | .0625 | −.0410 | −.274 | 20° | .0636 | −.0485 | −.318 |
| 24° | .0732 | −.0422 | −.224 | 24° | .0760 | −.0500 | −.274 |
| 28° | .0790 | −.0420 | −.222 | 28° | .0843 | −.0500 | −.247 |
| 32° | .0822 | −.0430 | −.218 | 32° | .0904 | −.0510 | −.238 |
| 36° | .0863 | −.0457 | −.216 | 36° | .0993 | −.0545 | −.253 |
| 40° | .0942 | −.0515 | −.228 | 40° | .0942 | −.0600 | −.266 |
| 44° | .1011 | −.0565 | −.274 | 44° | .0990 | −.0700 | −.295 |

## TABLE XIV.—CLARK Y WING SECTION—COMBINED VALUES OF $C_L$, $C_N$, AND $N/L$ (RIGHT AILERON UP, LEFT AILERON DOWN)

[Varying span of aileron. Angle of pitch of airplane, +12°; angle of attack of wing, +16°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—$N/L$=0.417 $C_N/C_L$]

### AILERON CHORD, 2.5 INCHES (25 PER CENT OF WING CHORD)

| AILERON SPAN, 10 INCHES (33 PER CENT OF WING SEMI-SPAN) | | | | AILERON SPAN, 15 INCHES (50 PER CENT OF WING SEMI-SPAN) | | | | AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMI-SPAN) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | | 0° | 0 | 0 | | 0° | 0 | 0 | |
| 4° | +.0063 | −.0065 | −0.327 | 4° | +.0117 | −.0095 | −0.338 | 4° | +.0125 | −.0100 | −0.334 |
| 8° | .0161 | −.0120 | −.311 | 8° | .0235 | −.0178 | −.316 | 8° | .0236 | −.0187 | −.331 |
| 12° | .0234 | −.0155 | −.276 | 12° | .0336 | −.0247 | −.316 | 12° | .0340 | −.0260 | −.319 |
| 16° | .0300 | −.0195 | −.301 | 16° | .0401 | −.0295 | −.307 | 16° | .0427 | −.0320 | −.312 |
| 20° | .0370 | −.0222 | −.255 | 20° | .0458 | −.0325 | −.296 | 20° | .0504 | −.0375 | −.310 |
| 24° | .0430 | −.0245 | −.238 | 24° | .0535 | −.0350 | −.278 | 24° | .0571 | −.0418 | −.305 |
| 28° | .0440 | −.0258 | −.245 | 28° | .0528 | −.0366 | −.289 | 28° | .0582 | −.0437 | −.313 |
| 32° | .0445 | −.0260 | −.244 | 32° | .0540 | −.0370 | −.293 | 32° | .0597 | −.0457 | −.306 |
| 36° | .0460 | −.0260 | −.236 | 36° | .0565 | −.0384 | −.284 | 36° | .0621 | −.0447 | −.300 |
| 40° | .0474 | −.0265 | −.233 | 40° | .0583 | −.0375 | −.268 | 40° | .0645 | −.0468 | −.301 |
| 44° | .0485 | −.0273 | −.235 | 44° | .0596 | −.0370 | −.259 | 44° | .0653 | −.0497 | −.303 |

## TABLE XV.—U. S. A. 27 WING SECTION—COMBINED VALUES OF $C_L$, $C_N$, AND $N/L$ (RIGHT AILERON UP, LEFT AILERON DOWN)

[Varying chord of aileron. Angle of pitch of airplane, +12°; angle of attack of wing, +16°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—$N/L=0.417\ C_N/C_L$]

### AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

| AILERON CHORD, 1.5 INCHES (15 PER CENT OF WING CHORD) | | | | AILERON CHORD, 2 INCHES (20 PER CENT OF WING CHORD) | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0122 | −.0055 | −0.186 | 4° | +.0170 | −.0060 | −0.147 |
| 8° | .0225 | −.0120 | −.222 | 8° | .0310 | −.0124 | −.167 |
| 12° | .0318 | −.0178 | −.233 | 12° | .0416 | −.0198 | −.198 |
| 16° | .0393 | −.0220 | −.233 | 16° | .0500 | −.0257 | −.214 |
| 20° | .0430 | −.0235 | −.228 | 20° | .0570 | −.0310 | −.227 |
| 24° | .0463 | −.0248 | −.223 | 24° | .0628 | −.0345 | −.229 |
| 28° | .0502 | −.0267 | −.213 | 28° | .0675 | −.0374 | −.231 |
| 32° | .0534 | −.0268 | −.209 | 32° | .0710 | −.0384 | −.226 |
| 36° | .0573 | −.0271 | −.197 | 36° | .0700 | −.0380 | −.226 |
| 40° | .0613 | −.0282 | −.192 | 40° | .0760 | −.0378 | −.207 |
| 44° | .0655 | −.0305 | −.194 | 44° | .0815 | −.0366 | −.187 |

| AILERON CHORD, 3 INCHES (30 PER CENT OF WING CHORD) | | | | AILERON CHORD, 3.5 INCHES (35 PER CENT OF WING CHORD) | | | |
|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0190 | −.0107 | −0.235 | 4° | +.0178 | −.0102 | −0.244 |
| 8° | .0360 | −.0203 | −.235 | 8° | .0355 | −.0203 | −.239 |
| 12° | .0501 | −.0299 | −.246 | 12° | .0562 | −.0305 | −.230 |
| 16° | .0627 | −.0365 | −.243 | 16° | .0692 | −.0360 | −.217 |
| 20° | .0741 | −.0392 | −.221 | 20° | .0810 | −.0385 | −.198 |
| 24° | .0853 | −.0398 | −.195 | 24° | .0918 | −.0392 | −.178 |
| 28° | .0906 | −.0393 | −.183 | 28° | .0962 | −.0400 | −.174 |
| 32° | .0926 | −.0380 | −.171 | 32° | .1007 | −.0395 | −.164 |
| 36° | .0978 | −.0370 | −.158 | 36° | .1045 | −.0390 | −.155 |
| 40° | .1027 | −.0358 | −.145 | 40° | .1083 | −.0370 | −.142 |
| 44° | .1073 | −.0340 | −.132 | 44° | .1115 | −.0350 | −.131 |

## TABLE XVI.—U. S. A. 27 WING SECTION—COMBINED VALUES OF $C_L$, $C_N$, AND $N/L$ (RIGHT AILERON UP, LEFT AILERON DOWN)

[Varying span of aileron. Angle of pitch of airplane, +12°; angle of attack of wing, +16°; angle of yaw, 0°; angle of roll, 0°]

[NOTE.—$N/L=0.417\ C_N/C_L$]

### AILERON CHORD, 2.5 INCHES (25 PER CENT OF WING CHORD)

| AILERON SPAN, 10 INCHES (33 PER CENT OF WING SEMISPAN) | | | | AILERON SPAN, 15 INCHES (50 PER CENT OF WING SEMISPAN) | | | | AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ | $\delta_a$ | $C_L$ | $C_N$ | $N/L$ |
| 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- | 0° | 0 | 0 | ---------- |
| 4° | +.0087 | −.0070 | −0.335 | 4° | +.0122 | −.0090 | −0.305 | 4° | +.0098 | −.0106 | −0.475 |
| 8° | .0166 | −.0135 | −.339 | 8° | .0197 | −.0152 | −.388 | 8° | .0183 | −.0186 | −.424 |
| 12° | .0247 | −.0182 | −.307 | 12° | .0265 | −.0257 | −.404 | 12° | .0285 | −.0262 | −.383 |
| 16° | .0321 | −.0220 | −.286 | 16° | .0335 | −.0305 | −.380 | 16° | .0388 | −.0322 | −.346 |
| 20° | .0402 | −.0248 | −.254 | 20° | .0417 | −.0310 | −.310 | 20° | .0482 | −.0375 | −.324 |
| 24° | .0460 | −.0270 | −.245 | 24° | .0502 | −.0320 | −.266 | 24° | .0516 | −.0412 | −.333 |
| 28° | .0468 | −.0282 | −.251 | 28° | .0517 | −.0325 | −.262 | 28° | .0530 | −.0425 | −.334 |
| 32° | .0455 | −.0290 | −.260 | 32° | .0530 | −.0330 | −.260 | 32° | .0540 | −.0422 | −.326 |
| 36° | .0490 | −.0287 | −.244 | 36° | .0530 | −.0340 | −.268 | 36° | .0590 | −.0410 | −.296 |
| 40° | .0515 | −.0286 | −.233 | 40° | .0548 | −.0350 | −.266 | 40° | .0645 | −.0410 | −.265 |
| 44° | .0538 | −.0304 | −.236 | 44° | .0608 | −.0350 | −.249 | 44° | .0710 | −.0430 | −.253 |

## TABLE XVII.—CLARK Y WING SECTION—$C_L$ AND $C_N$ FOR ONE AILERON

[Aileron set at 20°. Angle of yaw, 0°; angle of roll, 0°]

[NOTE.—The values refer to either right or left aileron, the signs refer to the right aileron]

### AILERON SPAN, 20 INCHES (67 PER CENT OF WING SEMISPAN)

| Aileron chord, 2 inches (20 per cent of wing chord) | | | | | |
|---|---|---|---|---|---|
| Aileron up | | | Aileron down | | |
| $\delta_a$ | $C_L$ | $C_N$ | $\delta_a$ | $C_L$ | $C_N$ |
| 8° | +0.0480 | −0.0005 | 8° | −0.0275 | −0.0222 |
| 12° | .0350 | −.0070 | 12° | −.0128 | .0260 |
| 20° | .0208 | −.0055 | 20° | −.0090 | .0234 |
| 30° | .0133 | −.0052 | 30° | −.0071 | .0125 |
| 40° | .0125 | −.0022 | 40° | −.0054 | .0197 |

| Aileron chord, 3 inches (30 per cent of wing chord) | | | | | |
|---|---|---|---|---|---|
| Aileron up | | | Aileron down | | |
| $\delta_a$ | $C_L$ | $C_N$ | $\delta_a$ | $C_L$ | $C_N$ |
| 8° | +0.0740 | +0.0036 | 8° | −0.0260 | +0.0305 |
| 12° | .0480 | −.0080 | 12° | −.0145 | .0330 |
| 20° | .0239 | −.0145 | 20° | −.0077 | .0227 |
| 30° | .0187 | −.0066 | 30° | −.0087 | .0240 |
| 40° | .0124 | −.0110 | 40° | −.0069 | .0282 |