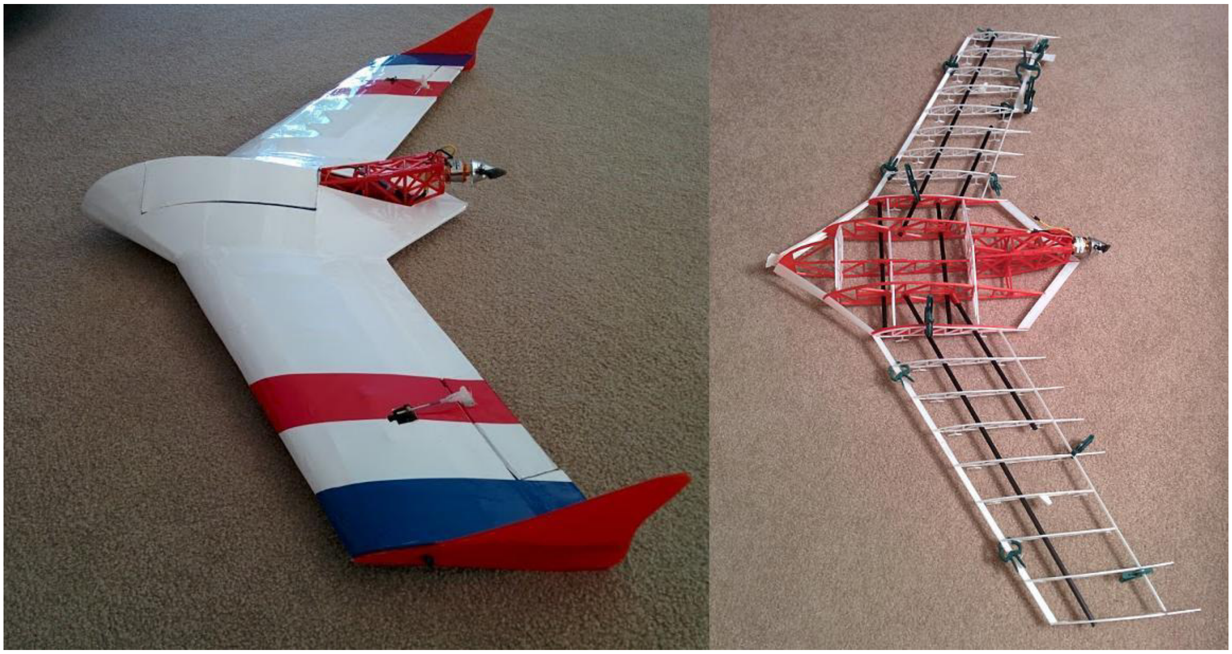
No. 386 OCTOBER 2018

T.W.I.T.T. NEWSLETTER



3D printing and RC vehicles have become quite the craze as of late within the 3D printing community. Source: https://3dprint.com/46348/openswift-flying-wing/

T.W.I.T.T.
The Wing Is The Thing
P.O. Box 20430
El Cajon, CA 92021

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THE WING IS THE THING (T.W.I.T.T.)

T.W.I.T.T. is a non-profit organization whose membership seeks to promote the research and development of flying wings and other tailless aircraft by providing a forum for the exchange of ideas and experiences on an international basis. T.W.I.T.T. is affiliated with The Hunsaker Foundation, which is dedicated to furthering education and research in a variety of disciplines.

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Gatherings are held on the third Saturday of every odd numbered month, at 1:30 PM, at Hanger A-4, Gillespie Field, El Cajon, California (first row of hangers on the south end of Joe Crosson Drive (#1720), east side of Gillespie or Skid Row for those flying in).

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PRESIDENT'S CORNER

I have been a little surprised that someone hasn't chimed in with thoughts about how some of the older material may not be applicable anymore. I am not an engineer so I wouldn't know of any new aviation developments that would override the older material. So, if you have any questions or would like to comment on a particular item, please drop me a note and I will pass it along to the others for feedback.

Andy

LETTERS TO THE EDITOR

The following information came to me in March from Larry Nicholson and I set it aside for a future issue then forgot I it. This is the first of several reproductions he sent along so will get done in the next few issues. The source for this month is: Perkins, Courtland and Hage, Robert, <u>Airplane Performance Stability and Control</u>. New York, London, Sydney: John Wiley & Sons, Inc. 1967. pp 367-373.

(e. - My thanks to Larry for passing this along to the membership for improving their knowledge of aircraft design.)

A chart showing the rolling performance of several fighter-type airplanes that engaged each other during World War II is shown in Figure 9–24.

9-8 Balancing the Aileron

As the emphasis during the past few years has been for higher and higher rates of roll at higher and higher speed with ever-increasing airplane sizes, the problem of designing the aileron for lightness has become so difficult that in some instances airplane designers have given up all attempts at aerodynamic balance and gone over to hydraulic boost or assist. When the designer takes this step, he takes the problem out of the hands of the aerodynamicists and places it in the hands of the hydraulic engineer. Although the general trend is towards some sort of boost for the aileron control, it is felt that the major types of lateral control and the methods used for aerodynamic balance should be presented briefly, as they are still used on the majority of present-day aircraft.

The major lateral control is, of course, the aileron, and the development of methods for balancing the aileron took up a large percentage of the aerodynamic testing facilities of this country during World War II. There are about as many methods for balancing the aileron as there are airplane designers and, therefore, any complete summary of the aileron balance picture is beyond the scope of this book. However, the major types of balance will be pointed out with a short discussion of each.

The types of aileron aerodynamic balance can be broken down into two main classes, i.e., nose balance and trailing-edge balance. Aerodynamic balance at the control surface nose consists of variations in nose shape, hinge line set-back, shrouds, gaps, and seals, while the trailing-edge types of aerodynamic balance consist of changes in airfoil contour, balancing tabs, spring tabs, and trailing-edge strips.

One of the most commonly used ailerons in the past and one that is still in use in modified forms is the frise aileron. The pure frise type aileron is characterized by an asymmetrical sharp nose located on the airfoil lower surface so that it will unport as soon as the control is deflected upwards. (See Figure 9–25.) The major purpose of this type of control is to reduce the adverse yaw of the aileron and to provide a means of balancing the aileron for small deflections. The up-going aileron is unstable, as shown in the typical frise aileron hinge moment curve of Figure 9–25, and this unstable up-going aileron helps pull down the stable down-going aileron; if rigged just right, excellent balance is obtained.

An inspection of the hinge moment curves of Figure 9–25 shows that the net balance is a function of the neutral position of the ailerons. If they are both rigged up from neutral, both controls will be overbalanced, giving unstable stick forces for small deflections. If, on the other hand, the ailerons are rigged down from neutral, both surfaces will be stable and the stick forces will become heavy. The advantages of the frise aileron are large balance for small hinge line set-back,

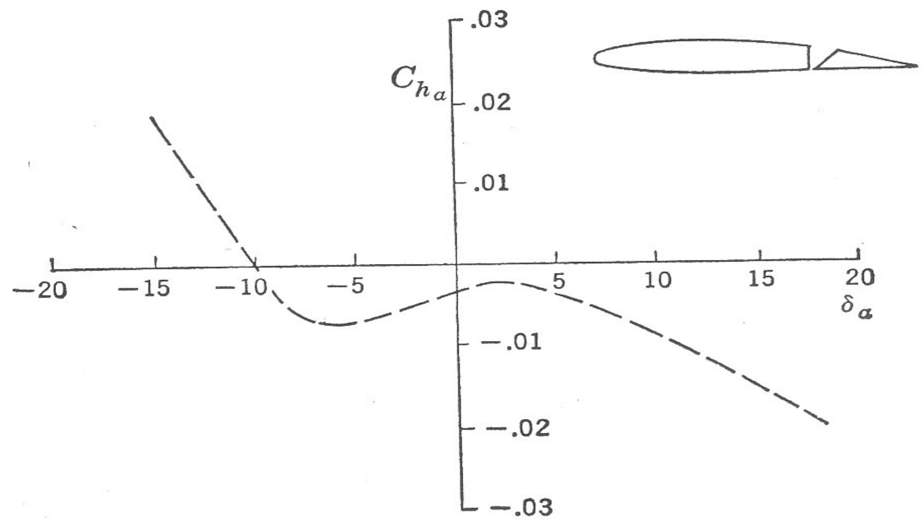


FIGURE 9–25. Typical frise aileron hinge moments.

simplicity of construction, and reduction of aileron adverse yaw. The disadvantages of the frise aileron are its sensitivity to rigging, the tendency of the air to separate off the lower surface of the up-going aileron, causing aileron buffet and loss of effectiveness, and the tendency of the aileron to overbalance at high speed because of the aileron floating up as a result of control cable stretch.

The disadvantages of the frise ailerons mentioned above are well recognized, and most modern airplanes having ailerons of this type use modified frise ailerons with raised nose shapes which smooth out the hinge moment curves and avoid the high-speed difficulties mentioned above. Unfortunately at the same time some of the advantages of the pure frise aileron are also eliminated. In general, however, the characteristics of the pure frise at high speeds and at high deflection are so objectionable that the modified raised nose control is almost mandatory. There are an infinite number of variations of the frise, and on the whole they have proved to be a very effective and useful control.

The internal seal type of balance is another nose balance that has had widespread use in the past few years (Figure 9–26). This type of balance has essentially a very sharp nose with a heavily set-back hinge, with curtains covering the balance area, vented close to the hinge line. Typical hinge moment curves for this type of aileron are shown in Figure 9–26 and can be seen to be quite linear. This type of balance is quite popular because of the fact that its hinge moments can be maintained in production, it is not very sensitive to rigging, and it behaves quite well at high speed. Its disadvantage lies in its complicated construction and maintenance problems.

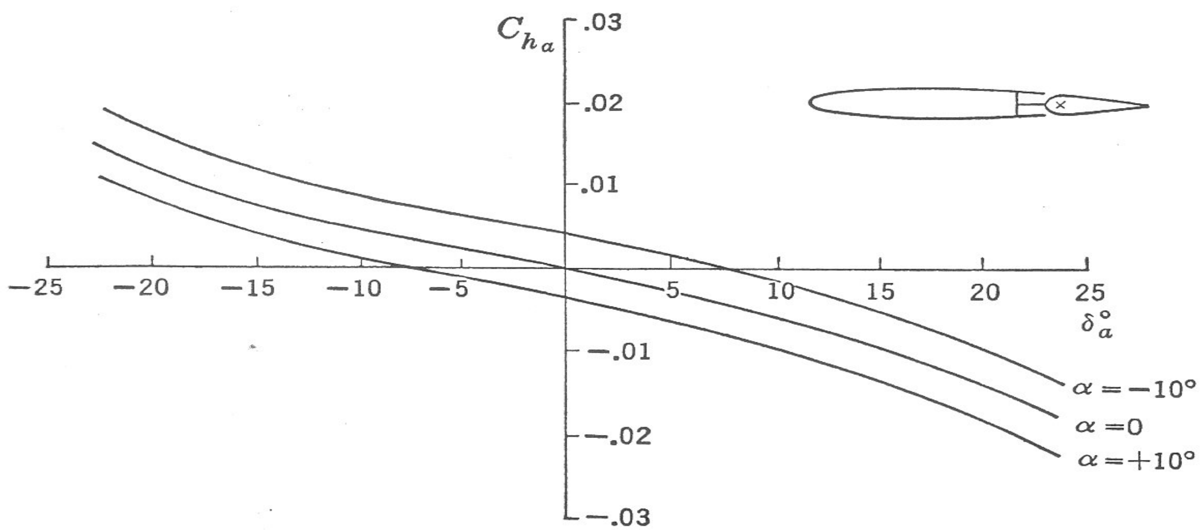


FIGURE 9–26. Typical internal seal aileron hinge moments.

The types of trailing edge balance include such devices as the beveled trailing edge, the balancing tab, the spring tab, and strips. The beveled trailing-edge balance was developed by the NACA and has been proved to be an effective means of balance, although it had practically no tactical use during World War II. The balancing tab can be used with discretion, but it cuts down the aileron effectiveness and tends to make the airplane laterally unstable stick-free. The English have done a lot of work with trailing-edge chords or strips. These devices are shown to increase both C_{h_α} and C_{h_δ} and are recommended for use with a balancing tab that will lower C_{h_δ} but will leave C_{h_α} high and negative. The English recommend this combination for its very favorable response factor, but it has not been used in this country as yet because of the danger of lateral instability with the stick free with this type of aileron.

The spring tab for ailerons is receiving a lot of attention at the present time. This device is a tab that deflects as a function of the pilot's force only. It has proved to be a very successful device and will be seen more often in the future. Finally, aileron differential coupled with a heavy upfloating tendency due to fixed bent tabs on the aileron trailing edge has been recommended, but as yet has had no actual use in the field. This type of balance makes use of a higher gearing on the up-going aileron than on the down-going aileron. Therefore the increased mechanical advantage of the up-going aileron will help balance out the down-going aileron.

Before leaving the subject of the lateral control, mention must be made of the spoiler-type aileron. This type of lateral control was first investigated by the NACA and used for the first time on a production airplane on the Northrop P-61 night fighter. This type of control creates a rolling moment by spoiling the lift on one wing panel. (See Figure 9–27.) The effectiveness of the spoiler increases as its location on the wing chord moves forward. However, at the same time the lag in the action of the aileron becomes objectionably large, and the location at the present time is limited to a position about 70 per cent of the local wing chord. Spoiler ailerons are useful as they permit more extensive use of flaps and have very low aerodynamic hinge moments.

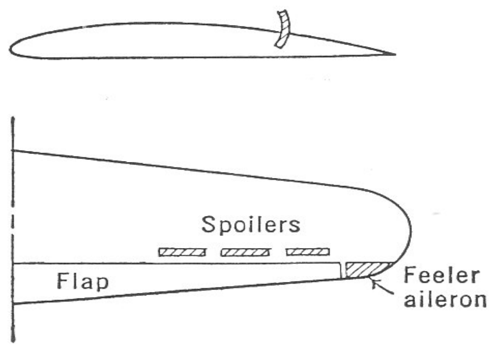


FIGURE 9–27. A spoiler-type aileron installation.

It would take many volumes to do justice to all the types of lateral control and their relative advantages and disadvantages. This short summary is only meant to present the reader with the major design trends of the present time and to refer him to the extensive literature on this subject for further study.

SUGGESTED READING

1. NACA TR 715, "Lateral Control Required for Satisfactory Flying Qualities Based on Flight Tests of Numerous Airplanes," by Gilruth and Turner, 1941.
2. NACA TR 799, "Charts for the Determination of Wing Torsional Stiffness Required for Specified Rolling Characteristics or Aileron Reversal Speed," Pearson and Aiken, 1944.
3. USAF TR 5180, "Prediction of Aileron Effectiveness," by J. D. Bitner, 1945.
4. NACA TR 635, "Theoretical Stability and Control Characteristics of Wings with Various Amounts of Taper and Twist," by Pearson and Jones, 1938.
5. NACA TN 825, "Wind-tunnel Investigation of Effect of Yaw on Lateral Stability Characteristics. III. Symmetrically Tapered Wing at Various Positions on Circular Fuselage with and without Vertical Tail," by Recant and Wallace, 1941. (Also others in this series.)
6. NACA WR L-419, "Collection of Balanced Aileron Data," by F. M. Rogallo, 1944.

7. NACA RB, "Résumé of Data for Internally Balanced Ailerons," by Rogallo and Lowry, 1943.
8. NACA WR L-169, "Résumé of Hinge Moment Data for Unshielded Horn-Balance Control Surfaces," by J. G. Lowry, 1943.
9. NACA TR 548, "Effect of Tip Shape and Dihedral on Lateral Stability Characteristics," by J. A. Shortal.
10. USAF MR ENG-M-51/VF 18 Add 1, "The Computation of the Critical Speeds of Aileron Reversal, Wing Torsional Divergence, and Wing Aileron Divergence," by L. N. Shornick, 1942.
11. NACA TN 1245, "Summary of Lateral Control Research," by Langley Research Department, compiled by T. A. Toll, March 1947.

PROBLEMS

9–1. A fighter airplane with a 40-ft wing span and ailerons extending from .90 to .50 semispan gives a $pb/2V$ for full aileron deflection of .09. What would be the estimated rate of roll in degrees per second for a geometrically similar airplane at 200 mph indicated speed at 10,000 ft for full aileron deflection?

9–2. An airplane having a straight tapered wing ($TR = 2$ and $A = 10$) has $.20c$ internal seal ailerons extending from .90 semispan to .55 semispan. If the ailerons deflect up 20° and down 10° at full deflection, estimate the airplane's $pb/2V$. If the wing span of this airplane is 50 ft, plot the rate of roll in degrees per second versus indicated airspeed in miles per hour for an altitude of 10,000 ft.

9–3. Compare the value of $pb/2V$ obtained by the spanwise loading method for the example given in Problem 9–2 with the $pb/2V$ obtained from the strip integration method discussed in this chapter.

9–4. The ailerons of the airplane given in Problem 9–2 have hinge moment characteristics such that 30 lb stick force will just give full aileron deflection at 200 mph indicated speed at 10,000 ft.

a. Plot the variation of $pb/2V$ per degree aileron throw for a speed range of 0–500 mph V_i.

b. Plot the variation of total aileron deflection throughout the same speed range.

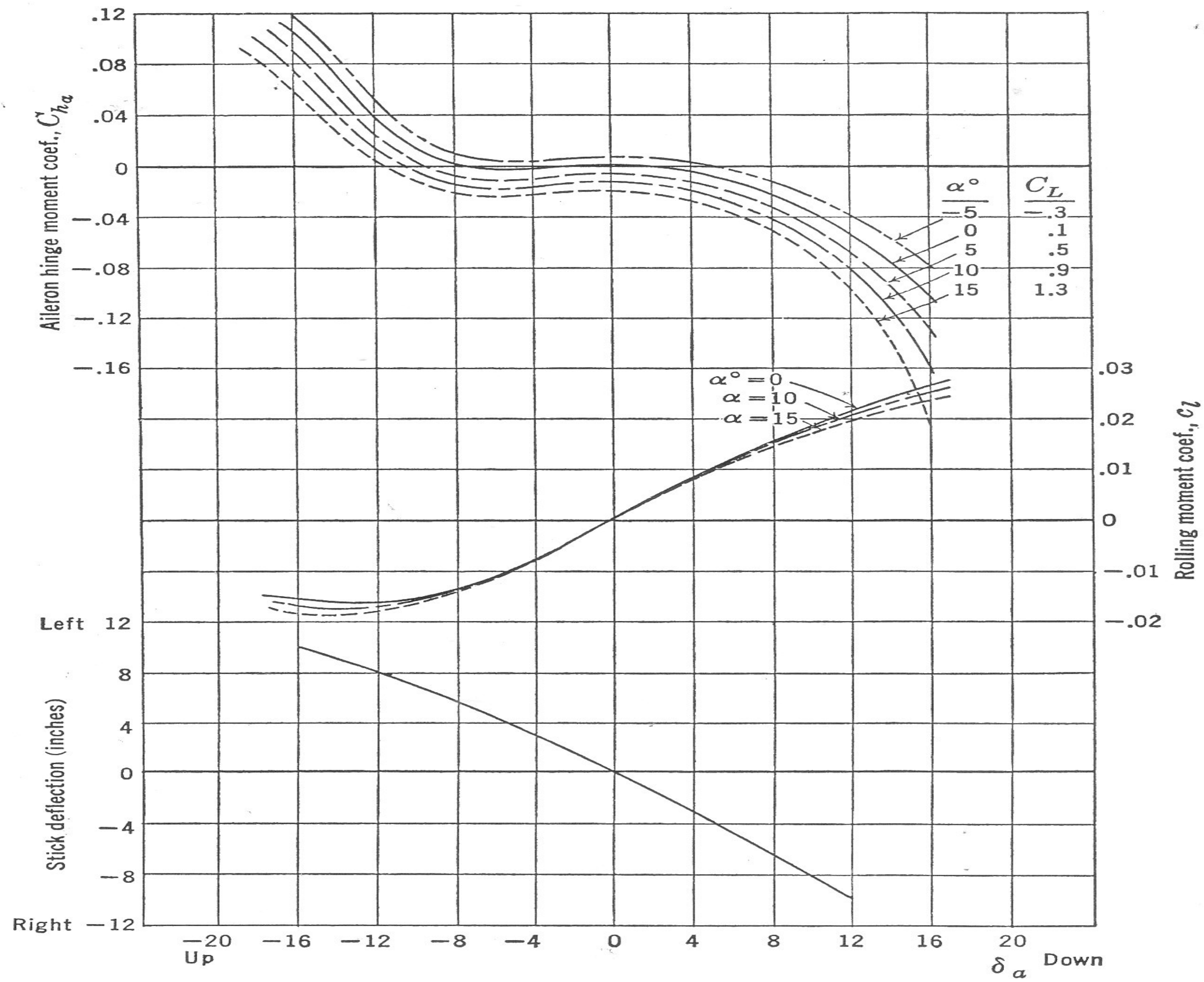
c. Plot the variation of rate of roll in degrees per second throughout this speed range.

9–5. The internal seal type of ailerons on a typical fighter-type aircraft extend from the tip to .60 semispan. The aileron chord is a constant 20 per cent of the wing chord. If the wing of this airplane has an aspect ratio $A = 6$ and a 2 : 1 taper ratio, what will be the $pb/2V$ per degree aileron throw? The area of each aileron is 8 sq ft, the root-mean-square chord $c_a = .8$ ft, and the centroid of the aileron area is at .75 $b/2$. If these ailerons have no differential and go up and down 15 degrees maximum with a gearing $d\delta_a/ds = .35$ radian per foot, what will be the indicated air speed beyond which full deflection cannot be obtained with a 30-lb force applied at the top of the stick? The balance characteristics of these ailerons are as follows:

$$C_{h\alpha} = -.005$$
$$C_{h\delta} = -.010$$

9–6. If the floating tendency ($C_{h\alpha}$) in Problem 9–5 is reduced to zero and $C_{h\delta}$ is left unchanged, what would the limiting speed become?

9–7. With the floating tendency, $C_{h\alpha}$, of the airplane in Problem 9–5 held equal to zero, what would be the value of $C_{h\delta}$ required to permit full deflection of the ailerons up to 300 mph V_i?



PROBLEM 9–8. Aerodynamic moments due to left aileron deflection.

9–8. A fighter-type aircraft is equipped with frise ailerons, whose aerodynamic characteristics are given in the accompanying figure. This airplane weighs 10,000 lb and has a wing span of 40 ft and a wing area of 250 sq ft. Its taper ratio is 2 : 1. If the aileron centroid is at .75 $b/2$ and the stick aileron kinematics are as given in the figure, calculate and plot the maximum rate of roll available for a 30-lb maximum stick force in degrees per second versus true airspeed in miles per

hour for a speed range from the stall $C_{L_{max}} = 1.3$. to 500 mph. Estimate for an altitude of 10,000 ft. The area of each aileron is 10 sq ft, and the root-mean-square chord is .70 ft.

9–9. For the airplane given in Problem 9–8, plot the variation of stick force versus aileron deflection for an indicated airspeed of 200 mph.

9–10. If the ailerons of the airplane in Problem 9–8 are rigged up 3°, plot the variation of stick force versus aileron deflection for an indicated air speed of 200 mph. Repeat with the ailerons rigged down 3°.