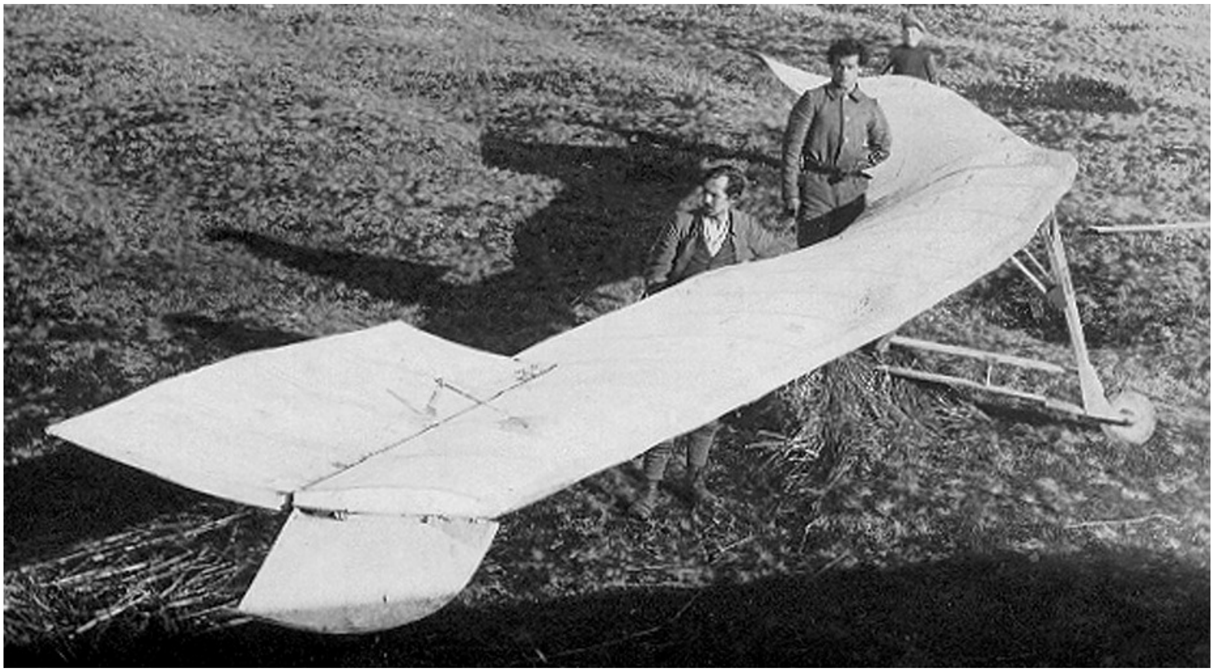
No. 387 NOVEMBER 2018

T.W.I.T.T. NEWSLETTER



Lippisch's first sweptwing tailless design was the Lippisch-Espenlaub E2 experimental glider, built in 1921.
Source: http://www.historynet.com/delta-dreamer.htm

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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PRESIDENT'S CORNER

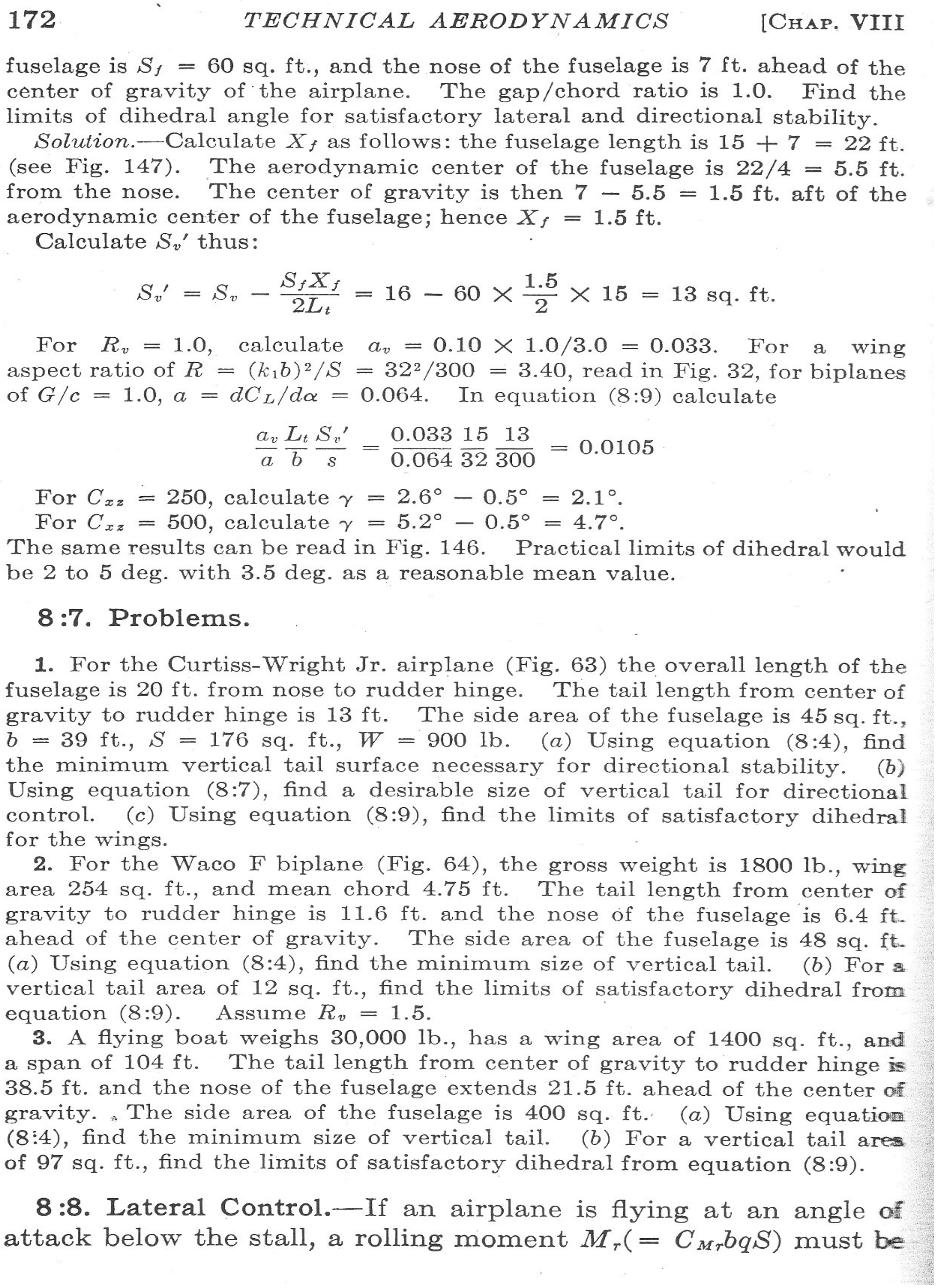
This month will include part one of the last papers sent to us by Larry Nicholson since the article is 10-pages. Then next month I will split the second part again so I can start a piece submitted by Stefanie Brochocki that is a translation of her father's presentation to the McGill University Fluid Dynamics Symposium in 1961. If you recall he is the designer and builder of the BKB-1 sailplane we have covered over the years and on our web site.

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: Wood, Karl, Technical Aerodynamics, New York & London: McGraw-Hill Book Company, 1935, pp 172-182.

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



fuselage is $S_f = 60$ sq. ft., and the nose of the fuselage is 7 ft. ahead of the center of gravity of the airplane. The gap/chord ratio is 1.0. Find the limits of dihedral angle for satisfactory lateral and directional stability.

Solution.—Calculate X_f as follows: the fuselage length is $15 + 7 = 22$ ft. (see Fig. 147). The aerodynamic center of the fuselage is $22/4 = 5.5$ ft. from the nose. The center of gravity is then $7 - 5.5 = 1.5$ ft. aft of the aerodynamic center of the fuselage; hence $X_f = 1.5$ ft.

Calculate S_v' thus:

$$S_v' = S_v - \frac{S_f X_f}{2L_t} = 16 - 60 \times \frac{1.5}{2} \times 15 = 13 \text{ sq. ft.}$$

For $R_v = 1.0$, calculate $a_v = 0.10 \times 1.0/3.0 = 0.033$. For a wing aspect ratio of $R = (k_1 b)^2/S = 32^2/300 = 3.40$, read in Fig. 32, for biplanes of $G/c = 1.0$, $a = dC_L/d\alpha = 0.064$. In equation (8:9) calculate

$$\frac{a_v}{a}\frac{L_t}{b}\frac{S_v'}{s} = \frac{0.033}{0.064}\frac{15}{32}\frac{13}{300} = 0.0105$$

For $C_{xz} = 250$, calculate $\gamma = 2.6° - 0.5° = 2.1°$.

For $C_{xz} = 500$, calculate $\gamma = 5.2° - 0.5° = 4.7°$.

The same results can be read in Fig. 146. Practical limits of dihedral would be 2 to 5 deg. with 3.5 deg. as a reasonable mean value.

8:7. Problems.

1. For the Curtiss-Wright Jr. airplane (Fig. 63) the overall length of the fuselage is 20 ft. from nose to rudder hinge. The tail length from center of gravity to rudder hinge is 13 ft. The side area of the fuselage is 45 sq. ft., $b = 39$ ft., $S = 176$ sq. ft., $W = 900$ lb. (*a*) Using equation (8:4), find the minimum vertical tail surface necessary for directional stability. (*b*) Using equation (8:7), find a desirable size of vertical tail for directional control. (*c*) Using equation (8:9), find the limits of satisfactory dihedral for the wings.

2. For the Waco F biplane (Fig. 64), the gross weight is 1800 lb., wing area 254 sq. ft., and mean chord 4.75 ft. The tail length from center of gravity to rudder hinge is 11.6 ft. and the nose of the fuselage is 6.4 ft. ahead of the center of gravity. The side area of the fuselage is 48 sq. ft. (*a*) Using equation (8:4), find the minimum size of vertical tail. (*b*) For a vertical tail area of 12 sq. ft., find the limits of satisfactory dihedral from equation (8:9). Assume $R_v = 1.5$.

3. A flying boat weighs 30,000 lb., has a wing area of 1400 sq. ft., and a span of 104 ft. The tail length from center of gravity to rudder hinge is 38.5 ft. and the nose of the fuselage extends 21.5 ft. ahead of the center of gravity. The side area of the fuselage is 400 sq. ft. (*a*) Using equation (8:4), find the minimum size of vertical tail. (*b*) For a vertical tail area of 97 sq. ft., find the limits of satisfactory dihedral from equation (8:9).

8:8. Lateral Control.—If an airplane is flying at an angle of attack below the stall, a rolling moment $M_r (= C_{M_r} bqS)$ must be applied as long as the roll is continued, because the wings resist being rolled. The wings resist being rolled, because the descending wing operates at a higher angle of attack than the ascending wing and hence gets more lift. (Beyond the stall the wings roll themselves, or *autorotate*, causing a spin, which is discussed in Art. 8:9.)

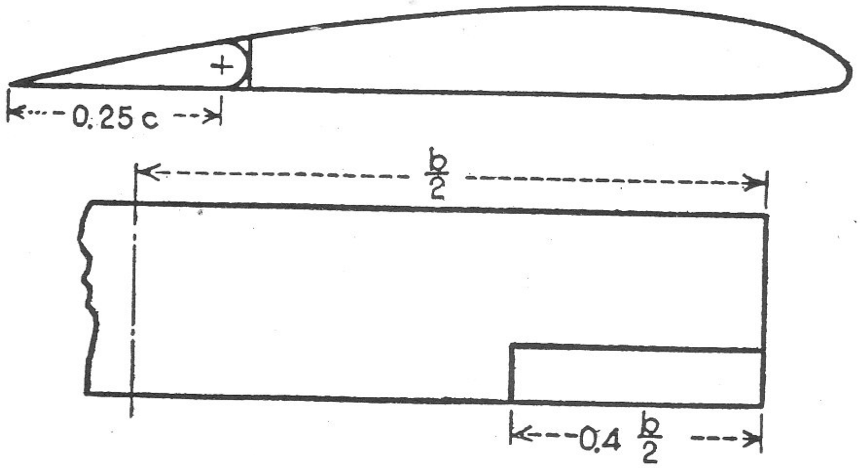


FIG. 148.—Typical aileron.

Wings are commonly rolled at the will of the pilot by means of *ailerons* (see Fig. 148) connected by wires or rods to the control stick (or wheel), but *spoilers* (see Fig. 149) have also been used for this purpose. The aileron operates by changing the effective camber of the outer portion of the wing. The spoiler operates by causing a burbling flow over one wing tip so as to reduce its lift. A combination of ailerons and spoilers is more effective than either alone.

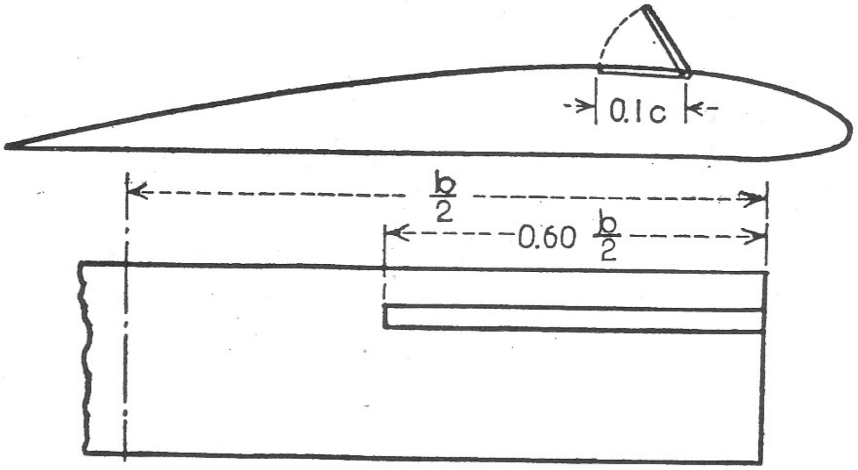


FIG. 149.—Spoiler for lateral control.

Ordinary ailerons (Fig. 148) will exert little or no rolling moment when the wings are stalled, making a stalled airplane dangerously uncontrollable. The air flow around the wing with aileron down is little different from the flow around the wing with aileron up, as shown in Fig. 150.

To get both slow landing speed and adequate lateral control has been the object of numerous unusual types of slot- and flap-equipped wings. Slow landing requires the highest possible $C_{L\max}$; if both wings are operating at their highest possible $C_{L\max}$, lateral control is then possible only by reducing the $C_{L\max}$ of one of the wings. The simple flap (Fig. 150) has been found relatively ineffective. Slotted flaps, as in Fig. 154(*a*), are more effective but at a sacrifice in $C_{L\max}$. Auxiliary trailing-edge airfoils, as in Fig. 151*b*(*A*), are still more effective but add expense and drag; auxiliary leading-edge airfoils, as in Fig. 151*b*(*B*), are also effective when rigged to operate up-only, but in flight, like spoilers, they have a peculiar initial response to control-stick movement which is opposite from the desired rolling movement. A combination of the two, as in Fig. 151, is probably more effective than any device hitherto tested and would probably avoid the adverse initial response of the leading-edge airfoil alone, but the added safety is of course obtainable at a sacrifice in cost and drag.

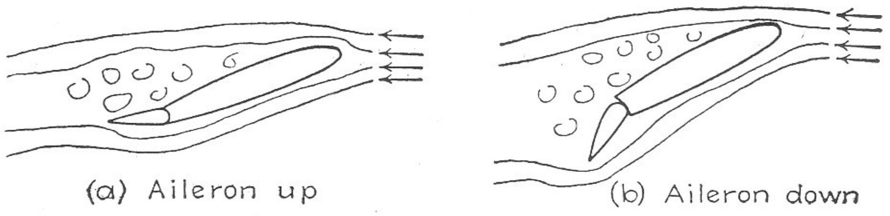

(a) Aileron up (b) Aileron down

FIG. 150.—Air flow around a stalled wing.

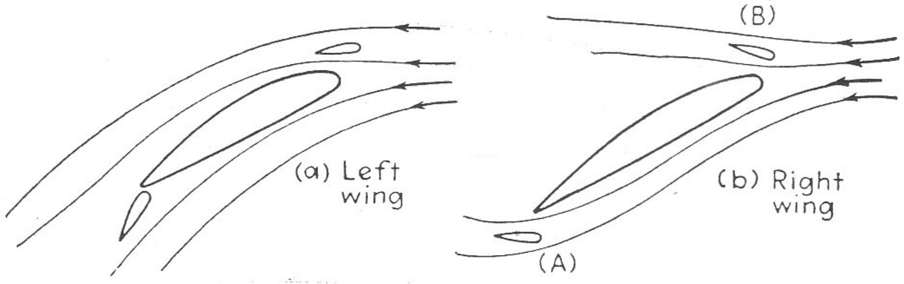


FIG. 151.—An effective but expensive and high-drag type of lateral control.

Ailerons are usually connected to the control stick so that in their neutral position (control stick vertical) they form, with the portion of the wing in front of them, a normal wing section and move 25 deg. up or down from this position. They are somewhat more effective, however, if rigged 10 deg. up when neutral but at a sacrifice in $C_{L\max}$, and still more effective if permitted to find their own neutral position by *floating* in the wind stream by a mechanism similar to that shown in Fig. 152. Floating ailerons, however, give little or no lift and are probably not economically justifiable. Ailerons may also be rigged *differentially*, so that the up-motion is considerably greater than the down-motion as in Fig. 153, or so that they operate *upward only*.

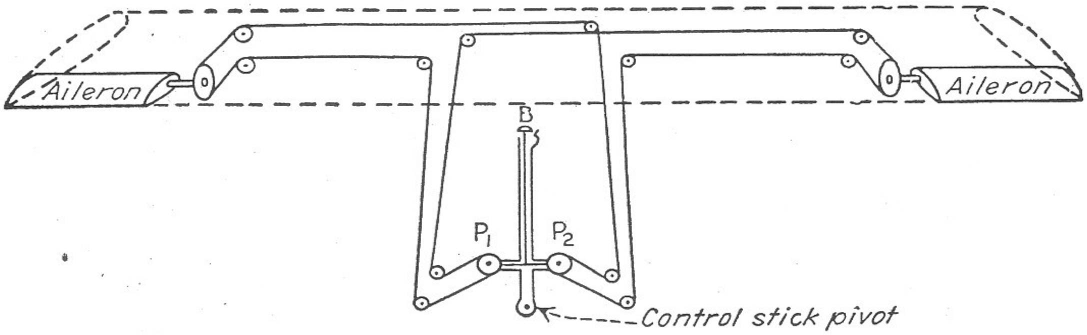


FIG. 152.—Rigging permitting ailerons to act either floating or fixed, according to the will of the pilot. If pulleys P_1 and P_2 are free, ailerons float; if locked by button B, ailerons are fixed relative to wing.

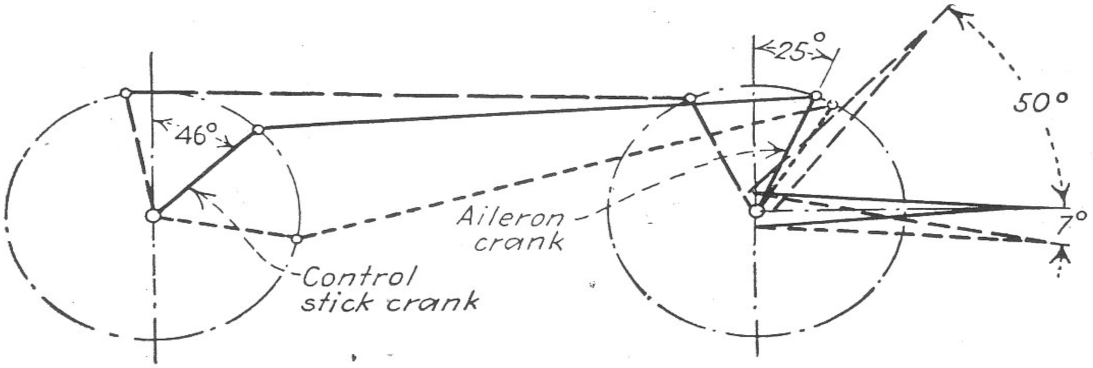
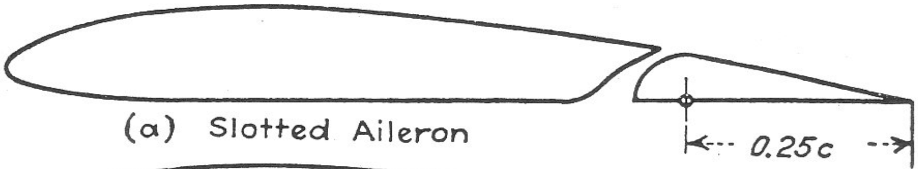


FIG. 153.—Differential aileron linkage.

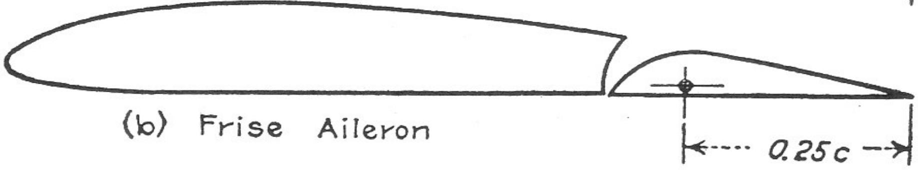
Ailerons are sometimes *balanced* (to reduce the forces necessary to operate them) with favorable results, as in Fig. 154; but other types of balance, as in Fig. 155, have been found unsatisfactory. Types *A* and *B*, Fig. 155, have a tendency to flutter.

A quantitative comparison of the effectiveness of ailerons should consider the following criteria:

1. The limiting angular velocity of roll (ω) resulting from maximum aileron deflection. For a given airplane flying at a given speed, the rolling moment coefficient C_{Mr} is a measure of this limiting angular velocity and is one measure of the maneuverability of the airplane. Control below the stall has been considered satisfactory if $C_{Mr} \geq 0.07$.



(a) Slotted Aileron



(b) Frise Aileron

FIG. 154.—Desirable types of aileron balance.

2. The angular acceleration of roll resulting from maximum aileron deflection. For level flight, this is measured by the ratio C_{Mr}/C_L (see NACA *Rept.* 419) which determines the lateral position of the center of pressure in terms of the span. It is considered that $C_{Mr}/C_L \geq 0.07$ would be desirable.

3. Yawed flight (as in a side slip) produces a rolling moment which the ailerons should be able to balance; but for a given angle of yaw, there is always a limiting angle of attack beyond which the ailerons will not balance the rolling moment due to yaw. This limiting angle α with 20-deg. yaw has been taken as a measure of lateral control in side slip. It is approximately a measure of the limit of effectiveness of the ailerons in preventing a spin.

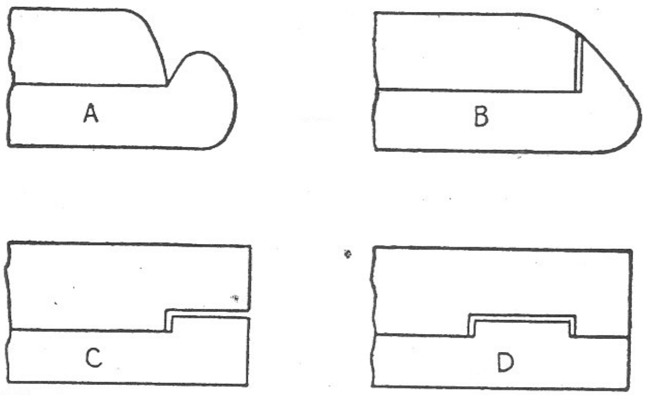


FIG. 155.—Undesirable types of aileron balance. (*From Diehl.*)

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VHS tape of July 15, 2000 presentation by Stefanie Brochocki on the design history of the BKB-1 (Brochocki,Kasper,Bodek) as related by her father Stefan. The second part of this program was conducted by Henry Jex on the design and flights of the radio controlled Quetzalcoatlus northropi (pterodactyl) used in the Smithsonian IMAX film. This was an Aerovironment project led by Dr. Paul MacCready.

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