FULL-SPAN FLAPS

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A. H. Cronkhite, a member of the Technical Committee of the SSA, presents in this paper an important step toward the improvement of soaring efficiency. Performance in spiraling flight is treated as a criterion for gaining altitude. By this consideration, thermal soaring flight conditions are reduced to spiralling in a thermal at minimum turning radius and cross-country glide at best cruising speed. Whether the first is absolutely valid depends on the size of the thermals and the distribution of lift through the thermal.

The reader may be interested to consider another point of view in H. W. Sibert's paper in the Journal of Aeronautical Sciences Jan. 1941. A general solution for minimum sinking speed in spiralling flight must consider the possibility of thermals large enough not to need the minimum turning radius.—Tech. Ed.

THE ability of a sailplane to make tight spiral glide turns efficiently can mean the difference between a successful return to the cloud base and the termination of a soaring flight.

So important is this feature that minimum turning radius and sinking speed in the spiral glide should be included in the presentation of all sailplane performance.

Conventional practice is to present polars for lift-drag and sinking speed vs. gliding speed, as a measure of overall sailplane performance. Such plots do furnish the glide performance characteristics but do not register a complete picture of its soaring ability.

Soaring is achieved largely by maintaining a spiral glide path within the boundaries of a thermal. The maximum rate of climb will be realized only when the strongest lift area of the thermal can be worked at a minimum rate descent. For a sailplane to conform to this requirement efficiently, positive minimum turning radius executed at minimum sinking speed is essential. Thus, it seems logical that this important phase of performance should be given as much consideration as linear glide factors, or perhaps even more.

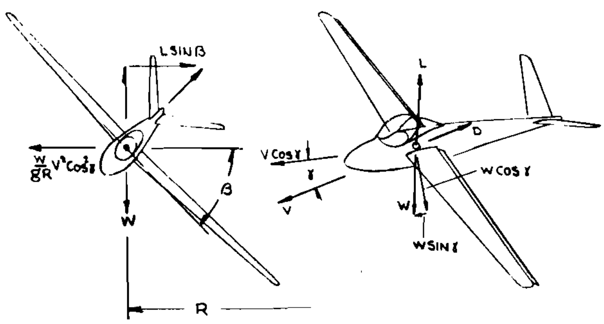

FIGURE 1
SPIRAL GLIDE EQUILIBRIUM FORCES

This paper is written to stress the importance of spiral glide performance and to demonstrate the powerful effect of full-span flaps in this maneuver. Theoretical derivation of the equations for estimating the minimum turning radius and sinking speed in a spiral glide is presented. Sample performance polars for a small span sailplane equipped with full-span external trailing edge flaps have been included to illustrate the influence of such an arrangement on glide and spiral glide performance. The theory is considered first.

In analyzing the forces in a spiral glide, reference is made to Figure 1. Symbols employed in the derivations and equations are:

L —Wing lift normal to free stream velocity
D —Airplane drag parallel to free stream velocity
W —Airplane gross weight
R —Turning radius
B —Angle of bank
V —Flight path velocity
γ —Angle of attack
C_L —Wing lift coefficient based on wing-flap area
C_{DA}—Airplane drag coefficient based on wing-flap area
P —Mass density of air
g —Acceleration of gravity
S —Wing area

Equations for equilibrium in the spiral glide are simply:

$D = W\sin\gamma$ (1)
$L\cos B = W\cos\gamma$ (2)
$L\sin B = WV^2\cos^2\gamma \div gR$ (3)

Dividing expression (1) by (2) and arranging terms we have

$\tan\gamma = D \div L\cos B$ (4)

Altitude lost in one complete turn of a spiral glide will be 2Pi R x Tan γ. From this it is obvious that the minimum loss of altitude will correspond to $R\tan\gamma$ minimum. Let us write for $R\tan\gamma$

$$R\tan\gamma = \frac{WV^2\cos^2\gamma}{gL\sin B} \times \frac{D}{L\cos B} = \frac{WV^2\cos^2\gamma}{g(\frac{P}{2}SV^2C_L)\sin B} \times \frac{C_{DA}}{C_L\cos B} = \frac{2(\frac{W}{S_2S})\cos^2\gamma}{g\frac{P}{2}(\frac{C_L}{C_{DA}})\sin 2B} \quad (5)$$

From (5) $R\tan\gamma$ is seen to become a minimum when C_L^2/C_{DA} is at its maximum and B is 45°. $\cos^2\gamma$ can be considered equal to 1.0 for small angles of glide. A more precise expression can be had by substituting $\tan\gamma = C_{DA}/.707C_L$ and

$$\cos^2\gamma = \frac{(.707\,C_L)^2}{(.707\,C_L)^2 + C_{DA}^2}$$

and simplifying the result we get:

$$R_{min} = \frac{.707\,(\frac{W}{S})C_L}{g\frac{P}{2}\left[1+\frac{1}{2}(\frac{C_L}{C_{DA}})^2\right]C_{DA}^2} \quad (6)$$

Equation (6) expresses Rmin in terms of the wing