Directional and Longitudinal Stability in A CANARD GLIDER

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Presented at the 1945 Motorless Flight Conference

In the March-April issue we covered the general development of the sailplane from its beginning until the present. (THE EVOLUTION OF THE SAILPLANE, by J. A. Simpson). With this article by Robert Lopez we point to what may be the next step. All aircraft must have control surfaces. Their proper location is the key to the problem.

It is necessary as an introduction that reasons underlying the desirability of a Canard type aircraft as a glider be mentioned.

When one gets the soaring bug in his blood and proceeds to design a glider which will remain in the air and will travel to predetermined cities or localities, one becomes thoroughly familiar with the importance of the drag on performance. Its sources are numerous and for some basic items cannot be avoided. However, by close inspection and with a careful study of these sources, improvements can be accomplished.

After fiddling around for a good many days on choice of airfoil, C.G. location, aspect ratios, etc., it will be apparent that L/D ratios of from 30 to 33 are about the ceiling that can be reached with a conventional type of glider. What is principally meant by conventional type of glider is one that obtains longitudinal stability through a down-load on the tail. In powered airplanes, the drag of the tail is of such magnitude that its effect on performance is negligible. In a glider where performance is a function of L/D and V_z (sinking speed), the contribution of the tail to the total drag cannot be ignored. The difference between a lifting tail and a conventional tail affects the L/D as follows: $\frac{L+L'}{D+D'}$ in the first case and $\frac{L-L'}{D+D'}$ in the second. To have a quantitative idea of this effect, figures from the stability computations of a particular glider will be taken:

At the attitude of $(L/D)_{max.}$ for $C_m = O$ (trim)

$$C_{Lw} = .460 \qquad C_{Lt}\frac{S_t}{S_w} = .063$$

$$C_{Dw} = .0086 \qquad C_{Dt}\frac{S_t}{S_w} = .002337$$

$$C_{Dfw} = .00114$$

$$L/D\ (\text{conventional tail}) = \frac{.460 - .063}{.01207} = 32.8$$

$$L/D\ (\text{Canard}) = \frac{.460 + .063}{.01207} = 43.3$$

This particular comparison was made from the stability data of a Canard. The tail lift coefficient in a conventional configuration, however, could be reduced to even O at $(L/D)_{max.}$; then the figure of $L/D = 32.8$ would increase to 38. This, of course, assumes a rigid control on the C.G. location that will allow trim at $C_{Lt} = O$. It is quite obvious that such a control is extremely difficult to obtain in actual practice.

At this point a quick analysis of a conventional glider with lifting tail is of interest. Stability can be obtained with an up-load at the tail by proper tail length and tail surfaces. The C.G. is then located back of the a.c. so that positive moments created by the lift about the C.G. are nullified by negative moments due to the tail forces. The locus of the resulting moments along the flight range will yield the desired negative slope.

Considering that glider performing a pull-up or pull-out maneuver, the fact that the C.G. is located back of the a.c. will mean a critical up-load at the tail, the magnitude of which will depend on that rearward C.G. location. In reality, the C.G., by itself, does not make the up-load critical. The mass distribution and the moment of inertia about the Y axis are the important factors. Nevertheless, C.G. location is an indication of mass distribution.

The critical up-load at the tail is developed at the beginning of the pull-up maneuver for a particular elevator deflection function. In general, this up-load designs the tail even in a forward C.G. location configuration. The mechanics involved in finding this up-load are beyond the scope of this paper and it is felt that the method is a familiar one to most aeronautical engineers and, consequently, the effect of rearward C.G. on the design of a tail can be fully appreciated.

The fact that lifting tail gliders are rare, if existing, is also due to the reasons that it can be difficult to have an arrangement which will permit a substantially rearward C.G. location and that for adequate stability a sizeable increase in tail length and/or tail area is necessary.

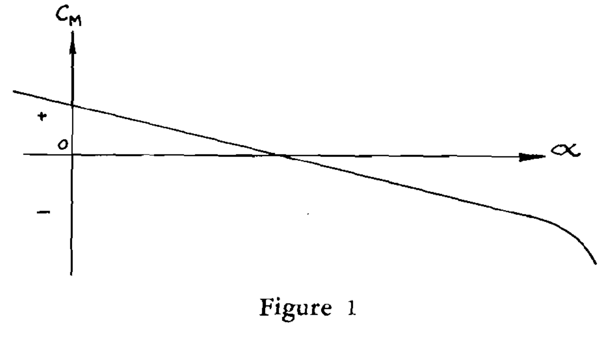

Figure 1