HIGHER CRUISING SPEEDS

by Daniel R. Zuck

EDITOR'S NOTE: *Cruising speed is increased and gliding angle is decreased—made flatter—by increasing the wing loading. This is very mysterious to the layman and provides a subject of much discussion among sailplane designers. Mr. Zuck has explained in terms which may be understood with very elementary scientific training, just how this is possible. His method of determining performance will be of interest to engineers. Even though the mathematics may be too much for the average reader, the significance of the results will be plain to everyone.*

Most soaring enthusiasts secretly aspire successfully to challenge the international distance record now held by Russia, and established in May 1937, with a distance of 405.29 miles.

With this in mind, it will be interesting to analyze certain results of the 1938 National Soaring Contest—the most successful to date, with respect to repeated long distance flights. The longest flight covered an airline distance of 225 miles and the highest duration of all cross-country flights was 7 hours and 26 minutes. The highest average course speed (based on the shortest line from take-off point to point of landing) was 33.2 miles per hour. Most of the longer flights averaged pretty close to 30 miles per hour (course speed).

If an average course speed of 33.2 miles per hour is to be used as a basis for comparison, a duration of 12.2 hours will be required to equal the distance record. The longer flights averaged close to 6 hours and 45 minutes, but if 7 hours and 26 minutes is used as good measure for a basis of comparison, the average course speed will have to be increased to 54.5 miles per hour to fly 405.29 miles.

It is the purpose of this article to show how these higher cruising speeds may be obtained without losing the benefits of low sinking velocities, namely by the use of ballast that can be removed while in flight.

PERFORMANCE CALCULATIONS

Cross-country soaring glorifies several simple equations in aerodynamics which should be understood and properly correlated when speaking of higher cruising speeds.

Given:

(a) Glide angle Θ, for a given angle of attack

$$\Theta = \tan \Theta = \frac{Kx + Kp}{Ky}$$

(b) Velocity at a given glide angle

$$V = \sqrt{\frac{w \cos \Theta}{Ky}}$$

(c) Sinking velocity for a given glide angle

$$Vs = V \sin \Theta$$

DEFINITION OF SYMBOLS:

Ky = Lift coeff.
Kx = Drag coeff.
Kp = Parasite drag coeff.
a = Angle of attack in degrees
Θ = Glide angle in degrees
w = Wing loading in lbs./sq. ft.
V = Glide velocity in m.p.h.
Vs = Sinking velocity in ft./sec.
AR = Aspect ratio

$$L/D = \frac{Ky}{Kx + Kp}$$

$$L/Dw = \frac{Ky}{Kx}$$

To illustrate the function of the foregoing equations, a hypothetical sailplane will be presumed with which are given:

Wing loading	3.75 lbs./sq. ft.
Parasite drag coeff. (with respect to wing area)	.00000366
Airfoil	N.A.C.A. 2409
Aspect ratio	18.6

All the necessary work to illustrate this example has been completed and is given in table form for convenient observation. Table I contains the progressive steps involved when solving for the angle of glide. Table II shows the effect of increased wing loading on speed and minimum sinking velocity.

First, the equasions will be discussed and then their use in the determination of the values of Tables I and II will be explained.

Obviously, there is nothing new about them. Most of the more serious-minded have spent much midnight oil in drafting specifications from them. But a brief resumé of these equations and their simplicity of operation may be helpful for those who are prone to deploy generalities, and yet in the stilly night persist in tossing on a restless pillow to piece together a super-extra-special soarer.

In equation (a), the glide angle Θ is a function of the inversed ratio of overall lift to drag. Therefore, each time the lift can be increased with no increase in drag, or the drag can be decreased with no decrease in lift, the ratio of L/D is increased and results in reduced glide angles. An infinite increase in the L/D ratio will result in an infinite reduction of the minimum glide angle.

The velocity squared, equation (b), is a function of the product of the cosine of the glide angle and the ratio w/ky:

$$V = \sqrt{\frac{w}{Ky} . \cos \Theta}$$

$$V^2 = \frac{w}{Ky} . \cos \Theta$$

Increasing w in this equation results in an increased V or speed along an identical glide path. Note that this does not impose any influence whatever upon the angle of glide.

Examination of equation (c) reveals a suspected unfortunate relationship between equation (b) and equation (c).

By substitution:

$$Vs = V \sin \Theta = (\sqrt{w . \cos \Theta}) . \sin \Theta$$

If increased wing loading results in increased velocity along an identical glide path and increased velocity results in increased sinking velocity, then, for any one given glide angle, sinking velocity and glide velocity must vary directly as the square root of the wing loading. Since a high glide velocity is desirable, but not a high sinking velocity which it entails, it is evident that either a compromise must be met or means for varying the wing loading must be had. This leads to the art of free ballooning in which the sinking velocity is controlled by means of ballast. The theoretical advantages of the use of ballast in sailplanes will be demonstrated later.