POSSIBILITY FOR A ONE FOOT PER SECOND SINKING SPEED

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Paul MacCready (Ref. 1) made a statement in his talk at the symposium two years ago to the effect that if a sailplane could be built with a minimum sinking speed of one foot per second, it should be possible to stay up in almost any weather. This statement set me off on the study which I will outline in the following paper.

Before going into the problems involved, I would like to make a few comments and ask a few questions about the desirability of such an effort. A one foot per second sink should certainly permit investigation of meteorological conditions hitherto denied to a man-carrying sailplane. On the other hand, there will certainly be places and times where very stable air will deny sustained flight to even such a machine. A further point to consider is that if the low sinking speed is obtained by flying very slowly, there will be the problem of escaping from downdrafts rapidly enough to prevent complete loss of altitude. A slow speed machine will also be limited to days with low or moderate winds due to possibility of damage on the ground and inability to get back to the desired base of operation. In spite of these shortcomings it is still my personal opinion that construction of a special purpose low sink sailplane would be of interest, for there is no predicting what new information will come to light when one is able to explore a regime which has not previously been possible. I would be interested in hearing comments from the many skillful sailplane designers and pilots who will be reading this on whether you feel such an attempt would be worthwhile and what problems you foresee that have not already been mentioned.

Simplest Formulation of the Problem

Before getting into the details that will reveal what the theoretical and practical odds are of achieving the goal, let us step back and look at the problem in its simplest possible terms so that we can make some judgments based on past history and obtain a direction for the detailed study with highest probability of success.

Since glide ratio is simply flight speed divided by sinking speed, we can turn this around and say sinking speed is flight speed divided by the glide ratio at that speed. Both forward and sink speed must be in the same units to get a glide ratio so if we wish to continue with airspeed in miles per hour and sink speed in feet per second, which most of us are accustomed to, we must remember to multiply airspeed by 1.467.

Figure 1 presents the required glide ratio to achieve a given sinking speed as a function of the forward speed. The first approach which we might call the super glide sailplane is, in the light of our present state of knowledge, highly unlikely to succeed. At flight speeds of 40 to 50 miles per hour, typical of speed for minimum sink of our present sailplanes we see that the required glide ratios to achieve a foot per second sink are off the chart. You all know how difficult it is to approach 40 to 1 glide ratio and at least for the present no breakthrough is confirmed.

Since the required glide ratio decreases directly with flight speed, we might be tempted to try a device with a very low flight speed and a low glide ratio. At 10 miles per hour the required glide ratio for a sink of one foot per second is slightly less than 15. The hitch is that a very low wing loading is required to get down to this speed. A recent development known as the Rogallo wing is worth investigation. This steerable parachute can be built for a structural weight of about 0.1 pound per square foot. The configuration has demonstrated a glide ratio of 6 at a C_L of 0.5. If we consider a Rogallo wing of 60 foot span, and a 140 pound payload, we find that while it can fly at the fantastic speed of 13 miles per hour, the sink is still 3.2 feet per second. Thus, it is likely that the best chance for success would be at a point intermediate between the two extremes already discussed. The flight speed should be between 20 and 25 miles per hour and the glide ratio between 30 and 37.

Past History

It might be helpful to spend a few minutes looking at sailplanes that were constructed in the past to see how close our visionary goal has been approached. Figure 2 presents sinking speed vs. flight speed for several values of glide ratio. Some well-known sailplanes have been superimposed on this chart. I had always thought that in the early days of ridge soaring where minimum sink was the only consideration, and structural requirements were not yet well established, that surely some very low sinking speeds must have been obtained. In searching the literature, however, this was not found to be true. The German sailplane development was carried out with rather accurate performance determination of the leading sailplanes. The Sao Paulo of Lippisch was reputed to be the ultimate and at a sink of 1.9 feet per second was the first sailplane to get under two feet per second (Ref. 2). The ultralight Windspiel of Kosim comes to mind, but its sink was also 1.9 feet per second (Ref. 3). The Darmstadt D-30 with its aspect ratio of 33.3 had a sink of 1.8 (Ref. 4). The Horton IV was about the same in spite of being a flying wing and having a moderately

ABOUT THE AUTHOR

Bruce Carmichael is one of America's most respected sailplane aerodynamicists. He holds a B.S. degree in aeronautical engineering from the University of Michigan. His early work was at Mississippi State with the late Dr. Raspet doing low drag boundary layer research, utilizing sailplanes. Then he went to Northrop where he worked in the same field with Dr. Pfenniger, designer of the Swiss Elfe sailplanes. He is now a Hydronamics Staff Engineer for the Aeronutronic Division of Ford.

Bruce's best-known work is his paper "What Price Performance," published in *Soaring* some years ago. He has contributed other technical papers from time to time and, as chairman of SSA's Aerodynamics Subcommittee, was responsible for organizing the first SSA Technical Symposium on on Soaring in 1959.

Bruce is 38, married and has three children. He owns a Schweizer 1-26 sailplane which he soars for pleasure.