SOME THOUGHTS ON NEW APPROACHES TO SOARING

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Recent progress in sailplane aerodynamics has brought quite a few sailplanes to the point where the glide ratio is near forty to one. Among these are RJ-5, Meteor, Elfe M, and the latest to join the ranks, Phoenix. In general the apporach to high performance has followed that laid down for RJ-5, namely drag reduction by extending the laminar regime and by eliminating pressure drag areas.

To exceed the forty to one glide ratio appears to be a difficult task. Perhaps by going to gigantic sailplanes where high aspect ratio can be used without becoming involved with low Reynold's numbers one may make a small step forward.

But it is not the purpose of this paper to discuss small steps where bold steps appear needed. What we wish to discuss then are the new sources of energy which may be used to improve the glide ratio of our contest and record breaking sailplanes.

First, let us look at the process of solar energy extraction as employed in soaring. The sun heats up an area on the ground above where the air will also be heated. Convection starting in this heated air takes place in a narrow column of the atmosphere. It is the sailplanist's mission to circle in this upward moving column of air thereby extracting some of the energy contained in that column. In general the efficiency of this process is extremely low.

Suppose now instead of the sun heating an area on the ground we allow the sun to impinge on the upper surface of the wing. On every square foot of wing area at normal incidence there will be 0.2 H.P. of solar energy collected by any device capable of transforming the solar heat into pressure, electricity or gas generation.

One efficient process for solar energy conversion is photosynthesis. However, at the moment this process is hardly practical for sailplanes.

However, the newly developed solar cells which have an ultimate efficiency of 22% are now available with efficiencies of 11%. This means that a sailplane having its upper surface covered with 140 sq. ft. of solar cells will deliver 1000 watts of electrical energy.

This energy may be used to drive a propeller having an efficiency of say 70% with the result that a little less than one horsepower will be available for propulsion. One horsepower would reduce the power losses on Phoenix at 40 mph from 1.65 HP to 0.65 HP. This means that the maximum glide ratio would jump from 40 to 1 to 93.5 to 1.

Perhaps for the best cross-country sailplane the solar energy had better be used for boundary layer control for in this case penetration will be vastly improved. To achieve a full laminar flow on a sailplane wing such as Phoenix, would require 0.6 HP cruising at 100 mph.

In an OSTIV paper Carmichael (Reference 1) showed the benefits of suction for drag reduction for sailplanes of various aspect ratios. In particular, for a sailplane of aspect ratio equal to 18 the maximum glide ratio would go up to 50 to 1. However, the gains at higher speeds would be most valuable for high speed cruising speed improvement. For example, at 100 mph reducing the drag of the Phoenix by 50% will result in the glide ratio being doubled at 100 mph, i.e. $L/D = 34$.

In order to delay the stall so that a higher wing loading could be used without sacrificing circling speed the Phoenix would require only 0.2 HP of suction power. Cornish (Reference 2) suggested a two-seater in which the observer furnishes the power for suction. However with solar cell power for suction a single-seater can be designed for both low drag and high lift boundary layer control.

Obviously the ideal use of solar energy would lie between straight propulsion at best glide ratio to all out suction for the very low circling speeds and the high cruising speeds. Adjustment of the relative distribution of this power will result in varying the general flight characteristics of the sailplane.

Eventually solar cells will be made so efficient that enough power will be available for level flight. In this case the slow cruising speeds at which minimum power occurs will not be fast enough to win contests or to break records. Then both solar cells and solar energy in thermals must be utilized to maximum cross-country soaring. However, this is a problem that must be deferred while we do research to utilize the presently available solar cells.

Extraction of Energy from Atmospheric Turbulence

Under some conditions next to the surface of the earth, i.e., in the earth's boundary layer, there exists considerable energy in the form of turbulence. Spectral power distributions show that this energy peaks at a frequency of about one cycle per second. This means that the turbulence cells containing the maximum energy are of the order of a span in size.

This being the case it appears that any attempt to extract energy from these cells must be done with a device having a response time at least as fast as one second. The sailplane responds in pitch at such a speed but it really does not have to pitch in order to gain energy from turbulence. Klemperer (Reference 3) has shown in his monumental paper that for energy to be gained by an aircraft flying through a turbulent air mass the sailplane must merely hold a fixed longitudinal attitude. This implies a sailplane with neutral stability. Therefore if we wish to improve the glide ratio of our sailplanes in passage between thermals we merely need to install a weight which can be moved toward the tail so that the center of gravity is moved to the neutral point.

However, such a simple expedient may not under dynamic conditions hold a fixed pitch attitude. In this case a stabilization by means of a rate of pitch gyro coupled to a servo on the elevator would provide the dynamic stabilization.

During the summer of 1958 Dave Raspet carried out some experiments along this line but to date no results are available. Difficulties with the autostabilization scheme still must be solved.

But let us take a look at the potential gains which dynamic soaring offers. In a turbulent environment measured by Lettau (Reference 4) the energy intercepted by a sailplane of 50 foot span at 60 mph