Bruce Carmichael was born and reared in Iron City, Michigan. Possessing a keen interest in aviation, he sallied forth from this small mining town on Michigan's upper peninsula to take up his studies in aeronautical engineering at the University of Michigan. After graduation in 1946, and a tour of duty in the navy, Bruce joined Chance Vought Aircraft in Connecticut where he was responsible for much of the preliminary aerodynamics on the Chance Vought "Cutlass."

In 1948, he moved to Texas with Chance Vought and while there, became active in soaring with the Texas Soaring Association. Through his understanding of the immaculate aerodynamics required for good soaring flight, Bruce quickly became known as one of our leading sailplane aerodynamicists.

Late in 1949, Bruce joined Goodyear Aircraft Corporation in Akron, Ohio, and in 1950 was appointed to the Scientific Committee of SSA. In July 1952, he joined Dr. Raspet at the Engineering Research Station, Mississippi State College, where he is engaged in extensive research on boundary layer control and many other projects.

Many of Bruce's papers have been published in our own Soaring Magazine and in the I.A.S. Review. Others have been translated into foreign languages and published abroad. This paper, which is one of his most recent, will prove useful to our sailplane designers in choosing the configuration most suited to the performance they desire.

WHAT PRICE PERFORMANCE?

by B. H. Carmichael
Aerophysics Department, Mississippi State College

This study, like many before it, had its origin in a rather casual discussion on the favorite item of talk of most soaring enthusiasts, namely, "That high performance sailplane that we are going to build some day." Some two years ago, Del Lewis, now of Temco Aircraft, and the author, started to lay out a design for a high performance ship. In trying to freeze the design, we rapidly came to the conclusion that we had insufficient information to make a decent compromise between high performance and economic, geometric, and operational practicability. Such questions as the following arose: What is the order of importance of the various flight characteristics which make up sailplane performance in the all important matter of high effective cross-country speed? How near can the performance of a ship of reasonable span approach that of one in the "monster" category? Having compromised on a span, what is the optimum aspect ratio to use with that span?

The questions raised in the above paragraph called for computations of circling as well as straight flight performance. Some estimation of typical thermal structure had to be made since the study was principally concerned with thermal cross-country soaring typical of most contest work in this country. Finally, since a wide variety of wing dimensions were to be studied, it was necessary to consider the effect of Reynolds number on the aerodynamics as well as to evaluate the effect of the geometry on the weight of the sailplanes considered. It was decided to vary the span from 30 to 90 feet in 10 foot intervals and to vary the aspect ratio from 10 to 30 in intervals of 5. This gave 35 planforms to consider and as shall be seen was not quite enough to complete the study.

Weight Considerations

The author had been discouraged from making such a long study for years for the simple reason that adequate weight data were not available. Since so many of the sailplanes of the past had been of the type which "just happened" rather than been designated to specific strength requirements, a correlation of their weight against geometry was doomed to failure. The publication of Reference 1 removed this obstacle. It that reference was presented an excellent correlation of the empty weight of numerous German sailplanes with widely varied geometry all designed to the same strength requirements. The following formula for empty weight per unit normal load factor is taken from this work:

$$\frac{W_e}{n} = 13.23 + \frac{b^3}{1760\,(t/c)^{1/3}\,(AR)^{1/2}}$$

where:

W_e = empty weight pounds
n = ultimate normal load factor
b = wing span feet
t/c = thickness/chord ratio
AR = aspect ratio.

It is seen that the span plays a very strong role while the thickness ratio plays a more minor role than might be expected. The fact that the empty weight decreases as the aspect ratio increases might at first seem strange. One must remember that with fixed span the area decreases as the aspect ratio increases, and that although the weight per square foot of wing area is increasing, the total wing weight is decreasing.

Gust Loading Criteria

It has been standard German practice in the past to design high performance sailplanes to 8 G ultimate normal load factor. This was used in