THE LOW-DRAG SAILPLANE

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The strife for low drag in sailplanes became intensified with the introduction of techniques for geometric control of the laminar boundary layer. By geometric boundary layer control we imply careful reduction of all curvatures, including those in the flow direction as well as those normal to the flow. Where a change in curvature occurs, geometric boundary layer control would require a smooth transition from one curvature to the next. The transition curvature must be such that the curvatures within the transition lie between the curvatures at the extremes.

When such a process of geometric boundary layer control is applied to a surface, be it a compound curve or a cylinder, the magnitude of the pressure gradients due to a flow over that surface will be minimized.

Laminar airfoils are a typical example of geometric boundary layer control. The leading edge of a laminar airfoil is generally an elliptic cylinder. Over the forward portion of the cylinder the pressure drops gradually along the roof of these so-called roof-top airfoils.

The same process of geometric boundary layer control may be applied to a fuselage. The nose should be an ellipsoid with its peak negative pressure rather far back. However, dictates of pilot position on conventional sailplanes prohibit a strict application of this concept.

Now, when we look at small disturbances on the wing or fuselage in terms of geometric boundary layer control, we will see that even a radio antenna on the nose of a sailplane will result in a large increase in drag not because the antenna by itself has high drag but because the antenna disturbs the laminar flow over the fuselage thus raising its drag considerably.

On wings there is an even more in-

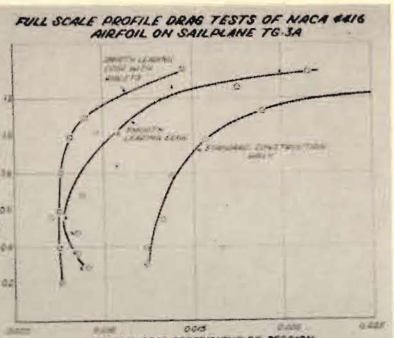
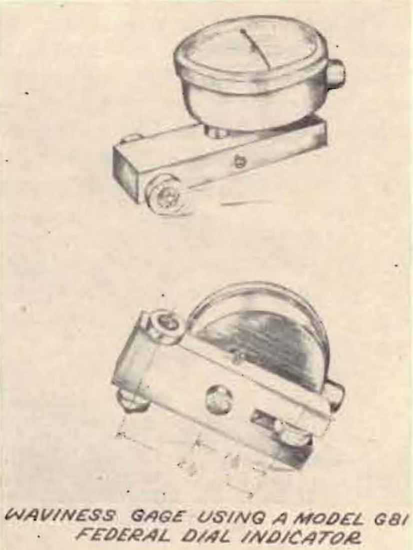


FIG. 1

sidious effect which occurs as a result of surface distortion under load or on wood ships as a result of shrinkage of the leading edge skin. The distortion shows itself as a series of waves either at 45° or normal to the flow direction. These waves cause successive pressure oscillations which in a short distance destabilize the flow so that a turbulent boundary layer is soon developed. Since a turbulent boundary layer at sailplane speeds and dimensions has about four times the drag of a laminar boundary layer one can expect a large drag increase from wings having wavy leading edges.


WAVINESS GAGE USING A MODEL G81 FEDERAL DIAL INDICATOR
FIG. 2

The earliest experimental verification in flight of the influence of leading edge waviness was that of Stephens and Haslam[1] who showed the influence which curvature fluctuations on a wing have on the transition from laminar to turbulent flow. In a later research, Smith and Higton[2] demonstrated on a King Cobra wing that the profile drag could be reduced from 0.0075 to 0.0025 by smoothing the wing.

The first application of airfoil smoothing on a sailplane came to the authors' attention in 1949 at the Southwestern Soaring Meet. Herb Gibbons and Dick Lyon had smoothed the leading edge of a TG-3A at the suggestion of Dr. W. Pfenninger. The senior author made a performance measurement of this sailplane, finding the minimum drag to be 0.016 instead of the usual 0.020. While this was surprising it was not possible by total drag measurements to learn if the profile drag had been reduced or if other improvements were contributing to this low drag. However, in 1951 at the Technical Meeting at Elmira profile drag measurements made in flight on a TG-3A wing in the rough and smooth condition were reported. Figure 1 shows the results of this work. It can be seen that smoothing can reduce the profile drag from 0.0125 to 0.008. Later work showed that if the junction between leading edge and fabric is properly executed the profile drag will go to 0.0075 over a large range of lift coefficient.

Concurrently with the above work, profile drag measurements[3] were made on the sailplane, RJ-5, having a laminar section 632-615. In this study it was found that contouring an already smooth airfoil reduced the profile drag by 0.0025.

The process of smoothing aerodynamic surface consists of filling the surface with either pyroxylin putty or a synthetic rubber aerodynamic smoother. The surface is then smoothed by sanding, using a chalked spline as a rough guide and a waviness gauge, Figure 2, as a final control of the contour.

It should be mentioned again that small disturbances to the boundary layer can cause large drag rises. For this reason the internal release becomes a necessity on high performance sailplanes. The internal release used on Tiny Mite Modification 1954 was suggested by Guy Storer to solve