tracted, or there is a leakage from the lower to the upper wing surface because of the pressure difference. Both conditions are avoidable, however, and it is not always advisable to go to 70% chord or even deeper with the brakes. The optimum position, especially if flaps follow, is probably in the region of 50 to 65% chord, because the laminar boundary layer is relatively thick and the critical-roughness height correspondingly large here. This position also leaves plenty of room for building the brakes as the profile is still fairly thick. In order to reduce the leakage problem the upper and lower brakes should be accommodated in separate chambers and the hole for the tie rod in the dividing wall sealed. Flush fitting of the

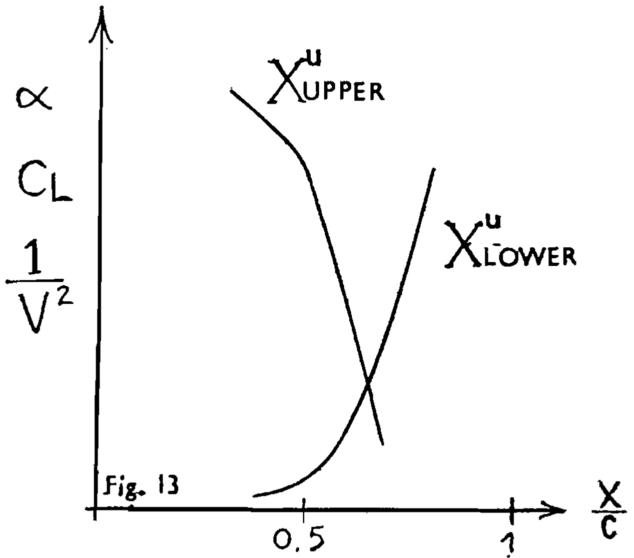

Figure 13

brakes will, because of the wing bending, probably only be achieved by using an elastic sealing strip attached to the top of the brakes. The maximum allowable vertical slit between the strip and the wing surface is about .02 to .03 inches. If possible the top strip on the brakes should also act as a seal for the brake chamber as it is normally in a positive pressure gradient with the result that air tends to flow in at the back of the brakes and out at the front.

Flaps and ailerons give rise to special difficulties because of the small Reynolds Numbers. A large amount of experimentation is still necessary before a really good solution can be given. From the constructional point of view, however, the downward moving flap is particularly prone to flow separation, and the kink in the upper contour accentuates this danger considerably. Separation caused by aileron deflection not only reduces the rolling moment but also creates a larger drag which increases the unwanted negative roll-yawing moment (aileron drag).

One is able to accept this detrimental effect of ailerons by arguing that the ailerons are used only part of the time and even then with mainly small deflection angles of about 5°. Wings with flaps, however, have more permanent deflections of $+10°$ to $-15°$ and the performance of the flaps at these large angles becomes important. The very limited success of the earlier types of sailplanes with flaps is proof enough that the use of flaps does not automatically ensure better performance, but that specially developed profiles are necessary. (See Ref. 2.) Without a doubt the question of flap profiles on sailplanes has only been touched on here and there and further developments are to be expected.

FUSELAGE

It is astonishing to see how little effort sailplane designers expend on drag reductions of the fuselage in comparison with the effort put into laminar wing profiles. Yet a very simple calculation, as can be seen from Figures 1 or 2 (June *Soaring*), shows the considerable influence of the fuselage drag at high speeds. Two possibilities offer themselves: the maintenance of laminar flow in the front part of the fuselage, and the reduction of surface area of the tail unit. The first alone can reduce the drag to one half that of the fully turbulent fuselage.

Reynolds Numbers of about 6×10^6, up to which it is easy to maintain laminar flow with the aid of a weak negative-pressure gradient, are reached in the region of the wing leading edge when flying fast. One has, of course, to choose a suitable form with a smooth and impervious surface. Because of this one has to do without pitot probes, ventilation systems, towing attachments, skids, drainage holes, removeable canopies and other above-critical roughnesses in the front part of the fuselage. Such requirements do not present serious difficulties and are already met in several sailplane designs. The D-36 of the Akaflieg Darmstadt was the first sailplane which realized most of these thoughts.

One problem does, however, remain; that of the pilot getting in and out of the sailplane. Despite all one's enthusiasm for the perfect aerodynamic shape, one has to allow the pilot sufficient safety and comfort.

In many new designs, however, little thought appears to have been given to the flush fitting and sealing of the hinged portion of the canopy. Instead one gains the impression that the solution has been sought in using minimum fuselage cross-sections with supine pilot position and extremely long canopies. On closer inspection one finds that all the requirements for turbulent flow are met and it becomes clear that false reasoning, confusing elegance with good aerodynamics, has taken place. So far as their drag is concerned these fuselages are no better than conventional forms such as that of the K-6.

* * *

There are various sailplanes with the canopy form illustrated in Figure 14. Because of the re-entrant angle where the canopy meets the fuselage the laminar boundary layer separates in the central longitudinal section, and this inevitably leads to a turbulent vortex round either side of the canopy. This turbulent region then hits the wing root and a secondary loss, far greater than the skin-friction losses on the sides of the canopy, occurs in the wing-root region, especially in low-speed flight. In other words, a smaller re-entrant angle only reduces the quality of vision without yielding any aerodynamic advantage.

If one really places value on obtaining a substantial improvement, one should be consistent and regard every detail through the eyes of a boundary-layer engineer. The fuselage is not allowed to have kinks in either cross-section or, particularly, in longitudinal section: this means that a faired-in canopy form is a must. The canopy, that is the transparent part of the fuselage, should, for practical reasons, consist of a built-in portion in the front, and of a removable portion.