course, represents an ideal situation with no sink between the thermals: a similar diagram can be drawn to show the corresponding situation when flying through sinking air. In practice, the pilot uses a best-speed-to-fly ring on his variometer, and alters his speed as he flies through sinking or gently rising air. Unless there is some major atmospheric phenomenon in progress, such as a large cumulo-nimbus the overall effect of the minor ups and downs between the thermals is not very great. On the balance, continuity requires that the air between the thermals must be sinking, and this will result in a slight overall loss in performance.

Now the best-speed-to-fly diagram is quite general: it depends only on knowing the cruising part of the performance curve and the achieved rate of climb. It is not valid to add the minimum sinking speed shown on this diagram to the rate of climb and suppose this to be the thermal strength, because the rate of sink shown in straight flight is appreciably less than that actually obtained when turning in a thermal. Also, if one has a variable-geometry glider, one may be working on quite a different performance curve when circling. Even so, the diagram is valid if one takes the *achieved* rate of climb and draws a tangent to the *cruising configuration* polar.

Now with a *given thermal strength,* one desires the greatest rate of climb (i.e., a low minimum rate of sink when circling) and the greatest cruising speed.

In both circumstances (climb and cruise) one desires a large span to reduce the induced drag, and a small wetted area to reduce the profile drag. But in general, we are faced with a compromise: we would like a low wing-loading when climbing, so that the forward speed is not too high. There is no point in rushing about in large circles around the thermal instead of within it. Also, we would like the highest possible wing-loading when cruising in order to put up the cruising speed.

The compromise involved in designing a fixed-geometry glider consists of choosing such a combination of aspect ratio and wing-loading as will optimize the overall performance under given condition. Enormous volumes of paper have been covered by such calculations, which obviously depend on the nature of the thermals, variation of glider weight with geometry and the influence of other limitations (e.g. fixed spans). There are as many ideas on how to optimize the design of a glider as there are designers.

It would seem that, having once built a glider on the basis of some such optimization, it is a fairly inflexible device. It is only at its best under the particular thermal conditions assumed in the first place. This is so, but there is still some ability to suit its characteristics to changing conditions by altering the weight and, anyway, the optimum is not very critical. For a given glider, there is an optimum weight for each thermal strength.

What we would really like is a glider of low wing loading for climbing in thermals, and of high wing loading for flying between them. In the absence of an anti-gravity machine, we can only alter the weight once (by jettisoning water ballast). In any case, carrying ballast usually gives relatively little advantage, because large changes of weight are required to produce much effect.

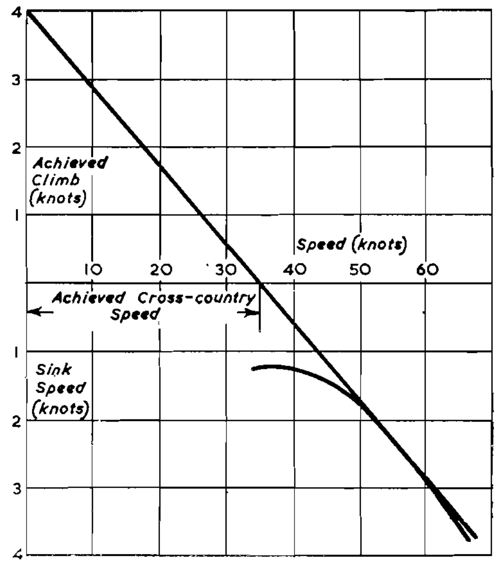

Fig 1 How to find the best speed to fly between thermals and the average cross-country speed, given the performance curve of the glider and the achieved rate of climb.

A practical alternative is to vary the geometry of the glider, by altering the span or mean chord. This enables us to adjust the wing-loading and drag in different phases of flight. Decreasing the span for cruising seems the less desirable process because it increases the induced drag. It is more efficient to achieve the same area change by reducing the chord, leaving the span unchanged. The effect would then be as shown in Fig. 2.

This diagram leads to a very interesting result. Let us suppose that we prescribe the low-speed configuration of the glider. Then, for a given thermal strength, the rate of climb is fixed. Now assume that we can make the cruise configuration more or less what we want. In the limit, when the cruise polar is very far to the right of the diagram, the slope of the tangent AB will be nearly $(D/L)_{min}$. It therefore follows that the average cross-country speed (corresponding to OB) will tend in the limit to:

$$\text{Rate of climb} \times (L/D)_{max}$$

This value is very significant, for it represents the ultimate value we can ever achieve without introducing other sources of energy (e.g., solar cells). It is, of course, an unattainable result, but we might measure

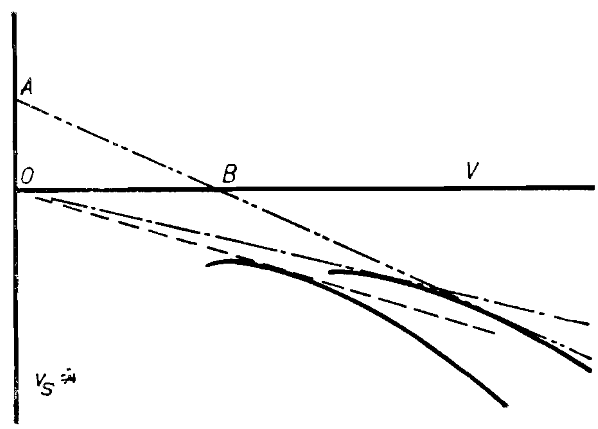

Fig 2 Effect of decreasing chord when flying between thermals. The "cruising" performance is indicated by the right-hand curve