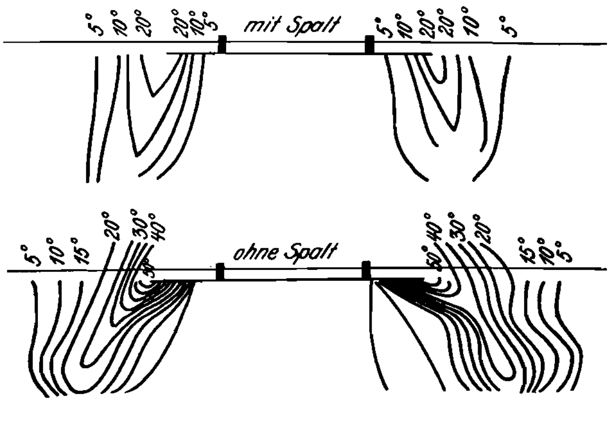

Fig. 5. Curves of equal deflection from undisturbed flow. Above, with a gap under the spoiler, and below, no gap.

and it has been found that this may be reduced if a gap is provided between the flap and the surface of the wing. This gap also serves to prevent sudden and harsh action of the brakes, and improves the flight qualities. This effect is shown in Figure 5. If the total height of the brake is designated by h, the gap should be at least .15h if it is to be effective, and not more than .35h if the drag increment due to the brakes is not to be too greatly reduced. A normal value would be .25h. Spoiler brakes used on military aircraft are often vented with horizontal or vertical slots, or circular holes, but the slight additional reduction of buffeting and operating force accomplished by this means is not considered worth while in the case of sailplanes which operate at relatively low speeds.

It should be realized that the gap does not completely eliminate turbulence, and therefore care should be taken to place the flaps in such a spanwise position that neither the elevators or ailerons lie in their wake. Fortunately, this is usually easy to do on sailplanes, due to their great span, and the drag of the brake is insensitive to spanwise position.

The selection of the optimum chordwise position for the spoilers is somewhat more complicated, as the change of lift, pitching moment, downwash, lift curve slope and zero lift direction all vary to a certain extent with chordwise position, although it affects the drag increment only slightly. As might be expected, the effects of top and bottom surface brakes are quite different, and it is in an attempt to achieve a satisfactory compromise between these variables that the total flap area required is usually divided between the upper and lower surface of the wing.

The variation of drag increment with chordwise position is shown graphically in Figure 6. It will be seen that at $C_L = 0$ the drag will be a maximum if the flaps are at .2C from the leading edge, and that the drag of upper and lower flaps are about equal. The drag of upper surface flaps increases, and that of lower surface flaps decreases, with incidence. Generally speaking, however, it may be said that the effect of chordwise position on drag increment is only of secondary importance.

It is also known that the drag of spoiler brakes varies approximately as the sine of the angle of deflection (i.e., as the projected area) and directly as the wing thickness. This latter variation is shown in Figure 7.

Figure 8 indicates the variation of brake flap lift coefficient, $C_{LB} = \Delta C_{Lbk} \cdot \frac{S}{S_{bk}}$, with chordwise position for upper and lower surface flaps. At rearward positions the effects of upper and lower surface spoilers are equal and opposite, but as they are moved forward the lift curve slope changes with little change in zero lift, so that the loss in lift due to the upper flap becomes much greater than the gain due to the lower one. In general, lower surface flaps increase the lift, most of all when at the trailing edge, and upper surface flaps cause a decrease in lift. These effects cannot always be added, however, except with trailing edge flaps, and often a combination results in a greater loss of lift than an upper flap alone. Changes in the angle of attack for zero lift, $\Delta\alpha_0$, are quite small for this type of brake, and are reduced by the gap.

The change of trim when spoilers are extended is due partly to a change in wing pitching moment, and partly to a change in downwash. The latter effect is approximately proportional to the change in lift, but may not affect the trim very greatly unless the tail lies in the spoiler wake. The maximum change in wing pitching moment, ΔC_M, occurs with flaps at .2 C, and is zero for both upper and lower surface flaps at about .5 C. The lower flaps produce a nose down moment if forward, and nose up if aft. The reverse is true of upper surface flaps. The effect of combining upper and lower flaps is not always additive, and may cause a greater change in pitching moment than the use of one alone. Moment changes are reduced by a gap. These relations are shown graphically in Figure 9, in which C_{MB} may be defined as

$$C_{MB} = \Delta C_{M\,1/4C} \frac{\bar{c}}{c} \sqrt{\frac{S}{S_{bk}}}$$

where c is the mean wing chord, and $\bar{c}$ the wing chord at the spoilers.

With the above information it is possible to choose the optimum position for spoiler flaps, for which the drag increase will be reasonably large and the effects on lift and trim negligible. It is usual to make the upper surface flaps slightly smaller than the lower ones, perhaps 45% to 48% of the total area. The upper flaps are then placed between .45 C and .50 C, and those on the lower surface between .50 C and .55 C.

Care should be taken in the installation of brakes on wings designed to have a nearly uniform lift distribution, as there is then a possibility that extension of the brakes at low speed may cause a breakdown of flow over a large part of the wing, such as the entire mid section between brake flaps, with resulting increase in sinking speed much greater than desired. This will not happen on normal wings, however.

The stressing of brake flap installations is not difficult. In designing the flaps themselves it is usual to consider that the limit load corresponds to the total drag increment due to the flaps acting uniformly over the flap area. This is conservative, as 25% to 40% of the total drag is actually due to increased induced drag. The ultimate load will be the limit load multiplied by a factor of 2.

$$\text{Limit load} = C_{DB} \cdot S_{bk} \cdot \rho/2 \cdot V^2_{bk}$$

As the drag loads balance out in normal installations