THE SOARING PILOT

BY
ANN & LORNE WELCH
AND F. G. IRVING

SPORTING GLIDING has developed far since its simple beginnings in 1922. Now the World's records stand at 540 miles distance, 42,000 feet altitude, and 60 m.p.h. average speed.

The gliders themselves are fine examples of superb design and workmanship, and the technique of using them a combination of individual initiative and scientific knowledge.

The authors have taken a foremost part in the development of British gliding, and this book is the result of many years close co-operation in operating gliders, including expeditions all over Europe which they have made together. Its object is to discuss the modern glider and the technique of using it. They show how this fascinating sport still gives opportunities for great experiment and new ideas. That this is possible to-day at a price which the ordinary person can afford gives gliding a charm which is now irrevocably lost in those other sports which have reached stagnation point in their development.

Ann Welch, one of the authors of this book, has already published, under the name A. C. Douglas, *Cloud Reading for Pilots* which is in its 3rd printing and *Gliding and Advanced Soaring*.

With diagrams and photographs

To Wally and Margaret
with Best Wishes.

Frank [illegible].

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F. G. IRVING

JOHN MURRAY
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CONTENTS

The preface and chapters 1-5 are written by F. G. Irving, and chapters 6-14 by A. and L. Welch. The drawings are by the authors.

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PREFACE

"To the intrepid, very high places exist solely to be scaled; with others, however, the only scaling they attempt is lavished on the armour of preposterous flying monsters."

ERNEST BRAMAH, *Kai Lung's Golden Hours*

OTHER authors with more fluent pens or greater powers of introspection than ours have endeavoured to explain why soaring is a worthwhile occupation. This book does not pretend to deal with matters largely of the spirit, since it is more concerned with technicalities and unashamedly seeks to eliminate much of the witchcraft which is often supposed to inform those who attain success in soaring. The object of doing so is not to reduce soaring to a cold mechanical process, but to attempt to render it just a little easier, to demonstrate that it is largely amenable to a logical approach, in the hope that some readers may be assisted to enjoy with greater facility the rewards of soaring. To our minds, this reward does not really consist of a feeling of satisfaction at having flown some distance by a mixture of trial-and-error and luck, coupled with a sense of relief at having got away with a landing in the only field attainable from two hundred feet. Rather is it the exhilaration of doing something well, perhaps the testing of one's fibre in the privacy of a big cumulus, or the contemplation of beauty. Or maybe that one attains a better sense of proportion in observing how petty man's works appear from an isolated viewpoint a few miles up.

In thinking about the material of this book, another idea has emerged which we have not heard expressed before. We consider here, in considerable detail, the relationship between a man and a particular sort of machine, and in doing so we have come to suspect that if a man achieves some measure of success in using a glider he has gone some way in coming to terms with machines in general—no mean achievement in our civilization.

The soaring pilot naturally treats his machine with some degree of respect; he cleans and polishes it to extract the maximum performance and maintains it with care to preserve its safety and efficiency, and because it is the result of painstaking individual craftsmanship. But essentially it is his servant, a genie capable of taking him to regions where much which is deemed important and desirable to the unfortunate earthbound assumes its properly trivial aspect.

Whilst we are largely concerned with the use of gliders, some mention is made of their design, and here we feel that the benefits of gliding can be great, though difficult to assess. The ability to design things well is probably inborn: it cannot be taught in an academic fashion to any appreciable extent, although the imagination can be stimulated and proper ways of thinking can be fostered. The young engineer usually completes his early training well able to analyse but singularly ill-equipped to evolve a novelty; he enters a world in which he is unlikely to have the opportunity of designing a complete device and making it work. This is particularly true of aviation, where the machine is usually so complex that no one person can deal intimately with more than a small fraction of it, but where it is becoming increasingly important that the end-product should be designed as a coherent whole. Understandably, the ability to co-ordinate the work to produce such an entity is very rare indeed and the price paid for failure is enormous.

Now we would suggest that since a glider is one of the few remaining types of aeroplane which can be fully understood and designed by one man, glider design represents a means whereby an engineer can exercise and develop his talents and initiative in a fashion largely unattainable in other fields. And the rewards, although largely immaterial, must be great. The designer of a good glider will have produced a machine of elegance which will be a source of real enjoyment and lasting experience to those who fly it. The problem of encouraging and training the potential designer is both difficult and urgent: perhaps this is one solution, but perhaps it is too idealistic to interest the politicians.

If this book can be said to have any theme other than the

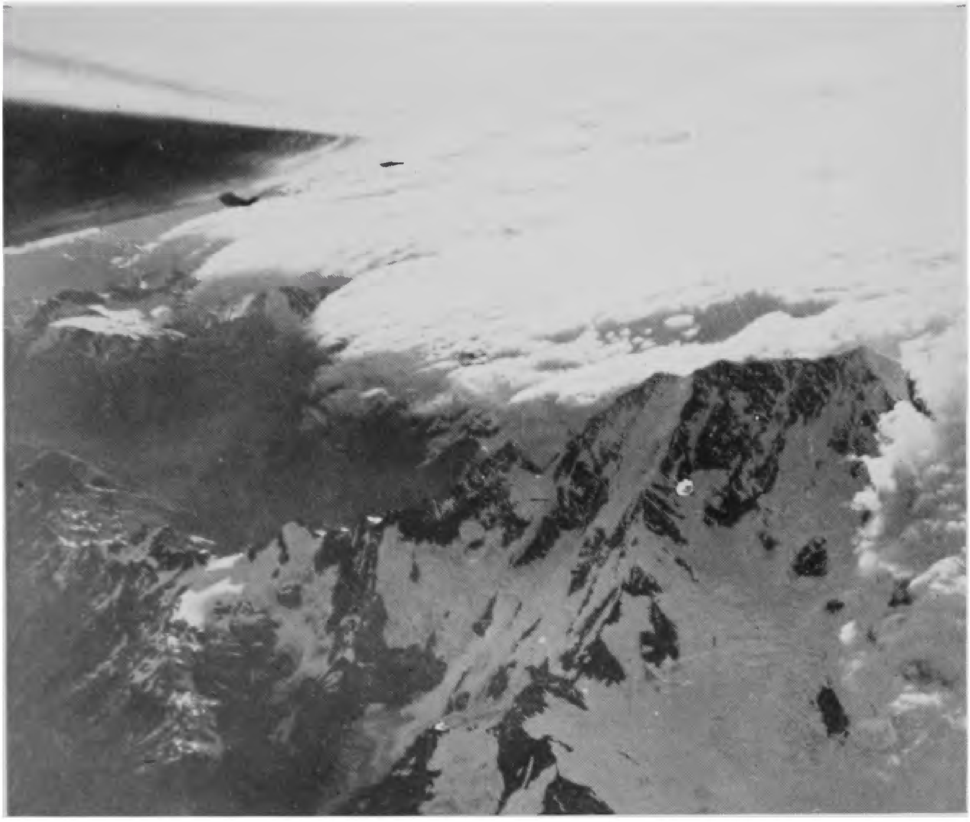
Photo: *MM. Heimgartner of Zurich.*

PLATE. I—*Lake Bianco, Piz Palü, and the Bernina Pass in the Engadine photographed from a Moswey glider.*

The French Breguet 901. A glider of this type won the World Gliding Championships in 1954, flown by G. Pierre.

Photos: Charles E. Brown.

The German H.K.S.I. An experimental high performance glider with laminar flow wings, and tail parachute instead of air brakes. Flown by E. G. Haase in the World Gliding Championships, 1954.



Photos: Philip Wills.

PLATE 3—*Taken by Philip Wills while setting up a new British height record in New Zealand on Dec. 29th, 1954, above Mount Cook.*

The edge of the main cloud mass shows the position of the downgoing part of the wave, and the belt of broken cloud the crest of the next wave. The lower photograph was taken from about 30,000 ft.

Photo: Lawrence Manley (copyright 'John Bull').

The Slingsby Skylark II.

Photo: I. Richards.

The British Olympia. 100 of these were built by Elliotts of Newbury Ltd. after the war, and have been the mainstay of soaring in England for the last 8 years. The Olympia shown here has just had a bungey launch from Camphill.

immediately obvious one, it is to suggest that success in soaring and in handling or designing gliders involves working, thinking and taking personal decisions in simple, logical, straightforward and honest ways. In a world which regards a television quiz as a substitute for thought and the uneasy compromise of a committee as a masterly decision, these are valuable abilities. The authors would not be so immodest as to suggest that they incessantly exercise such abilities, or even that they are capable of doing so to any exceptional degree, but they do hope that this book provides some examples of how they should be applied in the pursuit of soaring.

Chapter 1

SOARING PROGRESS

SOARING as a sport is about thirty-five years old, and represents as yet an infinitesimal fragment of human experience. Various writers have observed that perhaps man's yearning to fly, expressed by poets throughout the ages, has been overrated in that the construction of a glider was technically feasible some two centuries ago, but did not come to fruition until quite recently. Be that as it may, a few tens of thousands of men have now experienced the unique pleasures, beauties, triumphs and frustrations of soaring, finding satisfaction in its subtle blend of art and science. This book is written for those who cannot see a sky of summer cumulus without a sensation "of yearning upward, onward and away ..." It attempts to explain some of the science, and perhaps to convert some of what was previously regarded as art into science also. But first it is useful to consider how soaring has developed, not so much in terms of personalities and outstanding flights but rather in terms of the techniques which made these flights possible.

A little soaring occurred towards the end of the nineteenth and at the beginning of the present century, not so much as an end in itself, but as incidental to the development of flying machines. The names of Lilienthal, Wright, Pilcher and many others are rightly venerated as befits brave pioneers of flying. The first sporting gliding took place just before the First World War at the Wasserkuppe, but Kronfeld does not relate whether any real soaring occurred. However, it demonstrated the value of the site, and when Oskar Ursinus put on his famous hat in 1920 and started a campaign to stimulate soaring, it was there that his centre took shape. The first few annual meetings produced rapid progress in pure slope soaring, from flights of a few seconds in 1920, twenty minutes in 1921 to over three hours in 1922. By then, soaring was being attempted at other hill-sites in Germany and the celebrated meeting took place at Itford, Sussex, which saw comparable flights but produced little real result.

The requirements for a suitable glider were now becoming clear and machines were built, which, although crude by modern standards, were far cleaner than the contemporary aeroplanes. Stagnation then rapidly set in, and although the design of gliders continued to improve, enthusiasm for pure hill-soaring tended to flag. In some measure this was due to the prevailing meteorological opinion on thermals, which declared that "... the wind varies so much in speed and direction that, owing to the resultant turbulence, the extent to which we can make use of up currents is very limited. The vertical wind forces are also not strong enough to enable one to soar by means of vertical currents alone. ... Tests usually show a lift of only 1 metre/sec. ... The skill of our pilots and the manoeuvrability of our sailplanes are not, however, such that we are able to stay in the narrow columns of rising air and gain height by means of tight circles as the birds seem able to to do. In view of this, it appears that man will never be able to soar for any length of time with the help of thermal up-currents. ..." Thus scientifically discouraged, soaring pilots became hill-bound and frustrated, their only outlet being occasional short cross-country flights carried out by hopping from one hill to the next.

The first major technical development which effectively set soaring free from hills was the variometer of Lippisch and Kronfeld in 1928. A reasonably skilled pilot of to-day can soar in thermals without instruments, but usually only because he can relate the feel of the glider in the thermal to his previous experience with a variometer, and he has considerable understanding of the nature of a thermal. In the absence of such experience, the variometer became a key to an understanding of all types of vertical motion in the atmosphere. In 1929, Kronfeld climbed to over 6,000 ft. in a thunderstorm, landing 90 miles away. His glider, the "Wien", was highly refined by any standards, but the lack of blind-flying instruments and air-brakes rendered such a flight dangerous. Progress was then rapid: Wolf Hirth flew in clear air thermals at Elmira, N.Y. in 1930 and by 1932 German pilots had carried out enough cloud flying, often indulging in spiral dives, to realize that machines specially designed for cloud flying were vital. Enthusiasm in other countries was greatly stimulated by such feats. In England, the British Gliding Association was formed in 1929, and Kronfeld made some excellent demonstration flights in 1930. By 1931, pilots at the London Gliding Club at Dunstable were regularly soaring in thermals.

About this time, the third and so far final form of useful upcurrent was discovered: the standing wave. Nehring had flown in an "evening thermal" in 1926, a phenomenon which was misunderstood for another twenty years or so, and may well have been the beginning of a wave. In 1933, Deutschmann and Hirth flew Grunau "Babys" to 4,600 ft. in the "Moazagotl" wave in Silesia, and in 1937 a height of 7,000 ft. was attained near the Long Mynd, Shropshire. Waves are now known to be very common in this country and, following the experiences of glider pilots, are the subject of intensive study by meteorologists.

During the few years before the Second World War, skill in thermal soaring and cloud flying progressively improved; distances became hundreds of miles and heights tens of thousands of feet. Broadly speaking, the exterior appearance of gliders did not alter greatly during the 1930s, although they became much stronger in order to withstand large gust loads and stability and control were improved. They were no longer designed to give the lowest minimum sinking speed, but to travel as fast as possible on thermal cross-country flights, so that wing loadings became higher. Reliable blind-flying instruments also became available. There was another outstanding technical development: speed-limiting air-brakes. The terminal velocity of a clean glider is about 300 or 350 knots, a quite impossible speed for it to withstand. Given speed-limiting brakes which would reduce the terminal velocity to 100 knots or so, the spiral dive lost much of its danger and pilots could go cloud flying with infinitely greater security. The Second World War bequeathed three assets to post-war soaring in the form of synthetic waterproof glues, a vast fund of knowledge of the properties and design of low-drag aerofoils, and a generation of pilots who were accustomed to the handling qualities of powered aircraft or who had gained experience of modern test-flying methods. There were also minor pickings in the form of cheap instruments and parachutes. Shortly after the war, a

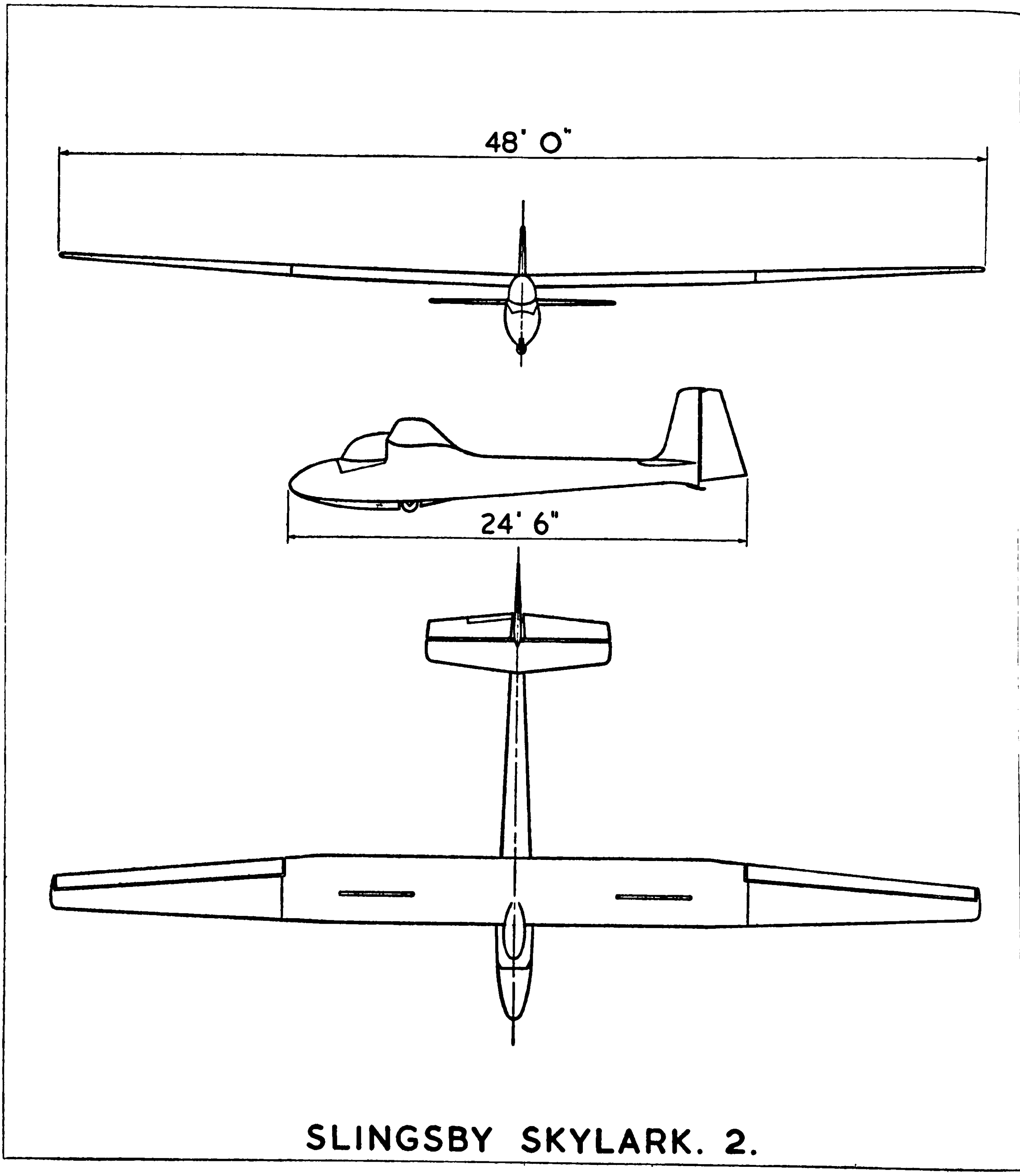


FIG. 1—*General Arrangement of Slingsby "Skylark II".*

large number of "Olympias" were built by Elliotts of Newbury, by redesigning the "Meise" to satisfy British Civil Airworthiness Requirements, and these machines have formed the mainstay of club soaring since then. In the meantime, of the various post-war types designed by Slingsby Sailplanes, two have been quite outstanding and a third, the "Skylark II" (see Fig. 1), has very great promise. There is no need to enlarge here on the virtues and triumphs of the "Sky", which represented something near the ultimate development of the classic 60 ft. span formula (Fig. 38). And although it does not pretend to be a high-performance machine, the T.21b "Sedbergh" deserves mention as being probably the best two-seat trainer built to date. Strong and docile, it is the backbone of modern British training methods, and is first-rate for local soaring by virtue of its low sinking speed at a very slow airspeed.

In the new generation of low-drag sailplanes, as exemplified by the "Skylark II", the accent is on simplicity of construction and good handling qualities. It is of interest to compare these times to reverse a 45 degree banked turn at 1.4 times the stalling speed: "Weihe", 5.6 secs.; "Olympia", 4.2 secs.; "Skylark II", 3.9 secs. Whilst the day of plastic gliders produced like ash-trays is not yet with us, there is increasing use of glass-reinforced resin for many parts with awkward curvatures.

The future development of gliders and soaring depends on three factors: the intensive study of what Dr Raspet terms "low-loss aerodynamics", an even greater recognition of the importance of sensible engineering, and increased knowledge of how to use atmospheric energy. No doubt such ideas as automatic boundary-layer suction will be incorporated and pressurized gliders will penetrate high into the stratosphere. Potentially, a glider is capable of far greater heights than the conventional aeroplane, since its low wing loading enables it to operate at a much lower Mach number. Thus a glider flying at an equivalent airspeed of 60 knots at 60,000 ft. would have a true airspeed of 195 knots and a Mach number of only 0.34; the true rate of sink would be say 10 ft./sec. There is no reason to suppose these figures to be fantastic in the light of present knowledge of waves.

However stimulating such thoughts may be, these achievements are likely to be somewhat remote from the average soaring pilot, and it is worth considering his future needs. Thermal soaring has developed to such a state that only the period of time per day for which thermals last and the performance of the glider limit the distances achieved. As a result, great attention has been paid to designing gliders for maximum average speed under given conditions (see Chapter 3) and one suspects that there has been a tendency to lose sight of the other factors. If, on a given day, a pilot were to fly a machine giving a better rate of climb in weak thermals than the best-average-speed machine, his average speed would be less for most of the day, but he would be able to get going sooner and land later: he might well go further. Such a machine would be valuable in club operation, where income depends on hours flown, since the utilization would be increased. Now the requirements for such a machine are that it should have a low sinking speed but, even more important, should be able to perform tight, slow circles, to stay in the strongest part of the thermals. Some calculations by B. H. Carmichael* indicate that the latter requirement has more influence than the former, and leads to quite a big machine with a surprisingly low aspect ratio, about 55 ft. and 10 respectively, in order to keep the wing loading down. For a single-seater, the wing loading would be under 3 lb. per sq. ft. Now although these calculations naturally involve various assumptions which may not be accurate in practice, it is interesting to observe that the best size and aspect ratio for this purpose correspond almost exactly with the Slingsby T.21b. In practice, one might make some concession to cross-country performance by putting up the aspect ratio to 12 or so. The loss in average cross-country speed under most thermal conditions compared with the optimum cross-country glider of the same empty weight (and hence same cost) would be about 1 knot or so. Naturally, one would use a modern aerofoil section and a generally clean design.

So perhaps there is some merit in thinking in terms of a modern equivalent of the "light-wind soarer", on the lines of Fig. 2. It all depends on your idea of fun.

* "Soaring", May-June, 1954.

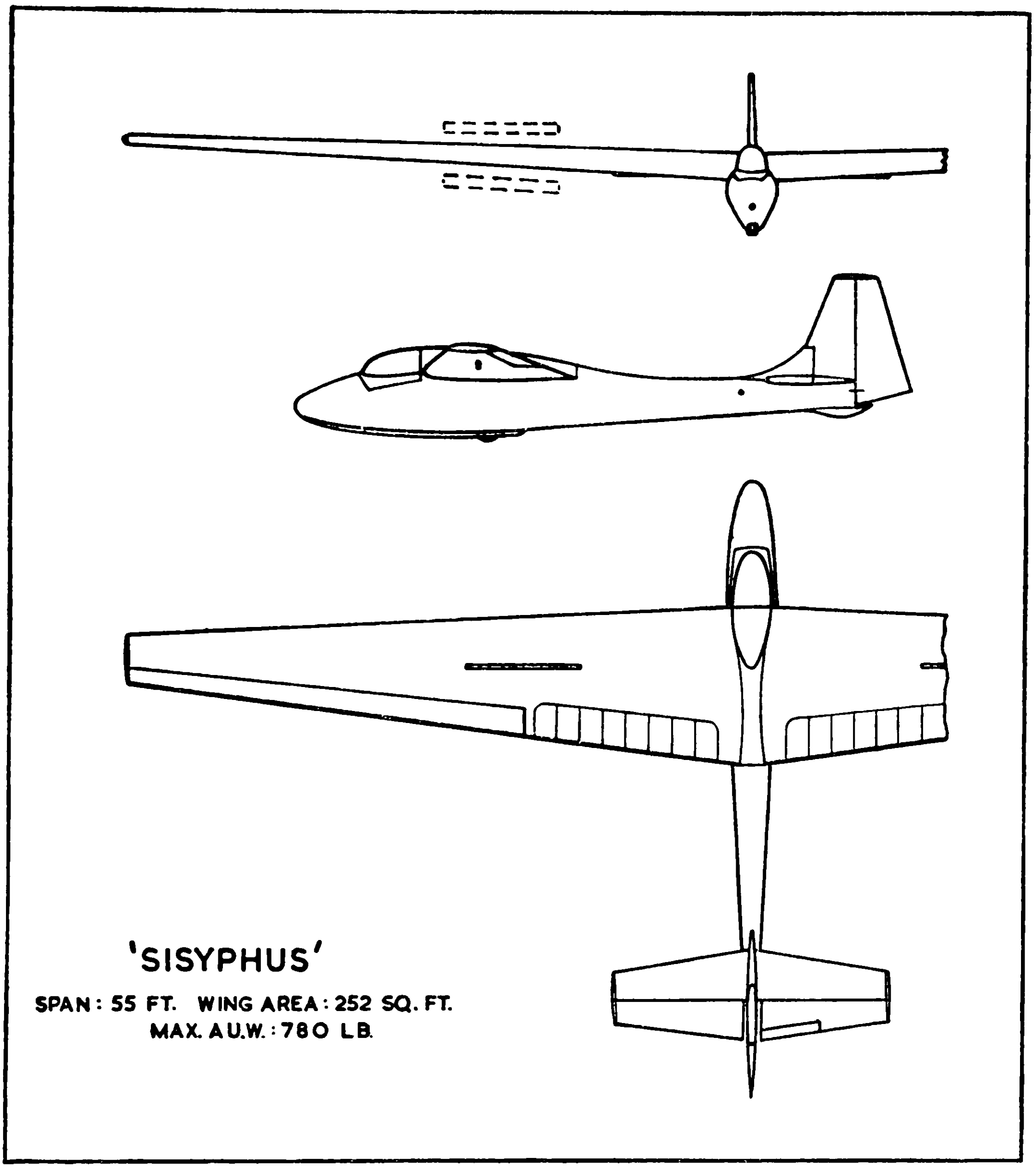


FIG. 2—*General Arrangement of a glider designed primarily to give the best rate of climb in thermals.*

Chapter 2

GLIDER DESIGN

THIS chapter is written from the point of view of the soaring pilot who is concerned with flying a satisfactory glider, either as a private owner or a member of a club. It does not deal with one-off specialized designs although these obviously have a valuable function in stimulating progress and training designers, as witnessed by the D-30 and RJ-5. Nor will structural design be specifically mentioned, except when it is involved in other considerations. It is hoped that a theme will emerge from this chapter: that whilst performance is important, since it is the *raison d'être* of the glider, it is not all-important. Good aerodynamic performance is only one of the attributes of a satisfactory glider, since the overall performance may be regarded as a synthesis in which the qualities of the glider and the skill of the pilot are combined. The nature of soaring flight is such that the skill of the pilot is still, and doubtless always will be, of prime importance and it follows that a "good" glider is one which enables him to apply his skill to the best advantage. Safety, comfort, simplicity, pleasant flying characteristics, ease of ground handling and maintenance all contribute to this and are just as essential as a good polar curve. All too often does one encounter designs to which immense care and ingenuity have been applied to minimise the aerodynamic losses, but which fall short of being practical soaring machines due to a neglect of this principle.

Whilst good aerodynamic design can hardly be said to be easy, it is essentially a fairly straightforward technical problem, but translating it into good engineering is quite difficult. This difficulty is not peculiar to glider design, of course, but applies to almost any useful man-made object from pots and pans to motor-cars and airliners and much has been written on both the practical and philosophical aspects of the matter. It will suffice to observe here that apart from being a competent engineer, the glider designer must be able to visualize the various circumstances in which his machine will be used, he must be able to scan previous experience with a discerning eye, rejecting what was found to be bad, and he should ideally have at his disposal some of that ill-defined attribute called inspiration. Then he may be able to produce a machine in which the pilot will instinctively feel happy at first acquaintance and which he will rapidly come to regard subconsciously as an extension of himself.

Although the best aerodynamic lay-out may be somewhat varied to suit local conditions, the qualities of a glider which lead to this happy result do not differ from one country to another so much as is commonly supposed, since glider pilots are of much the same physical and mental characteristics the world over. This chapter is therefore devoted to the examining of some of those features of glider design which directly affect the pilot and to presenting some opinions of the authors, who are strongly inclined to the view that refined aerodynamics, good handling, comfort and mechanical reliability are not mutually incompatible. There are also some notes on aerodynamic design which partly overlap and should be read in conjunction with Chapters 3 and 5.

Cockpit Layout

Since the pilot hopes to spend many hours at a time sitting in the cockpit, its comfort and convenience are obviously vital. Unfortunately, the human frame does not conform to a standard specification, so that the cockpit must be large enough for a big man without losing sight of those of slighter build—in both the literal and figurative senses. Ideally, the rudder pedals would be adjustable and the seat position would be variable, both horizontally and vertically. In practice, cost dictates a simpler arrangement and the pilot usually has to adjust the seat by means of cushions. It is well worth having a specially tailored seat cushion giving proper support under the thighs, since few things are more trying than paralysis due to excessive bearing pressure on the seat during a long flight. Various seating positions have been tried, from the prone pilot looking downwards, through the bolt-upright to a psychiatrist's-couch reclining posture, the more extreme positions being unhappy compromises between comfort, view and small frontal area. If one takes the view that genuine comfort and good visibility are worth some small extra fuselage drag, a satisfactory attitude is with the legs nearly horizontal and the body sloping backwards somewhat. The harness straps must then be arranged to meet low-down on the body, to restrain the pilot from sliding forwards through them and to give adequate support for negative loads. Various diagrams of the "average man" are available showing the hinge points of the conventional body (and—gruesome thought—the centres of gravity and weights of its various members), but they should be regarded as giving only the roughest guide. The only real test of cockpit comfort is made by causing pilots of different shapes and sizes to sit in it.

The width of the cockpit is frequently inadequate, since it seems to assume that a lightly-clad slender figure is prepared to sit precisely on the centre-line for long periods. Again, another two or three inches of width may increase the drag by some trivial amount but will prevent the sense of frustration which attends sitting on an inaccessible packet of cigarettes. These may seem small matters, perhaps expressed rather facetiously, but the effect on one's peace of mind and body during a long flight is very real.

It goes without saying that the primary controls should come readily to hand and foot and should be movable through their full travels without any sensation of discomfort or strain. Similar requirements apply to the secondary controls, and in this respect cockpit layouts are often unsatisfactory. The air-brake lever, for example, frequently causes discomfort to the left leg and it may even lead to a restriction of the stick travel in this sense. An air-brake lever which folds towards the cockpit side can be very satisfactory. Another important control is the tow-release knob, which in this country is painted bright yellow and is located near the left-hand corner of the instrument panel. Since failure to release may lead to great danger, it is quite apparent that this control must be plainly visible, easily reached, and of such size and shape that it can be grasped by a gloved hand so as to apply a large pull-force. All this is quite obvious, but one still encounters machines with release knobs between or under the pilot's legs, or in a dark corner under the instrument panel, perhaps only an inch in diameter, sometimes painted black. If there is more than one tow hook, the same knob must operate both simultaneously.

The pilot must also be able to reach the instrument panel to adjust the altimeter and operate switches, and the windscreen should be arranged so that he can wipe condensation off the inside surface.

To prevent the entry of water and cold draughts the cockpit must be properly sealed with the canopy closed, and ventilation should be deliberate rather than fortuitous. A good arrangement consists of a ventilator just in front of the cockpit cover and therefore in a region of local high pressure. The air is regulated by a sliding strip of transparent material, which also admits light to the instruments. At least one clear-vision panel must be installed in such a position that the pilot has sufficient view to land the machine even if the rest of the canopy is covered with water or ice.

Sufficient space should be provided to stow all the miscellaneous property carried by the pilot, such as maps, computers, food and drink. It also follows that the cockpit floor should be continuous so that such articles cannot fall into the control mechanism. The bottom of the stick should also be faired to the floor and seat by means of a suitable flexible gaiter.

A completely detachable cockpit canopy, as opposed to one which is hinged, has considerable nuisance value and is liable to be easily damaged. The method of securing the canopy must be positive and arranged so that it cannot be inadvertently undone, but on the other hand it should be possible to jettison the whole canopy in emergency, and if needbe a handle fixed to the fuselage should be provided above the instrument panel to assist the pilot in baling-out. All projections which might cause injury to the pilot in the event of an accident must be adequately padded. Fig. 3 shows the cockpit of the "Skylark II".

Flying Qualities: Longitudinal Stability and Control

One of the major improvements in sailplane design in recent years has been in the provision of greatly improved stability

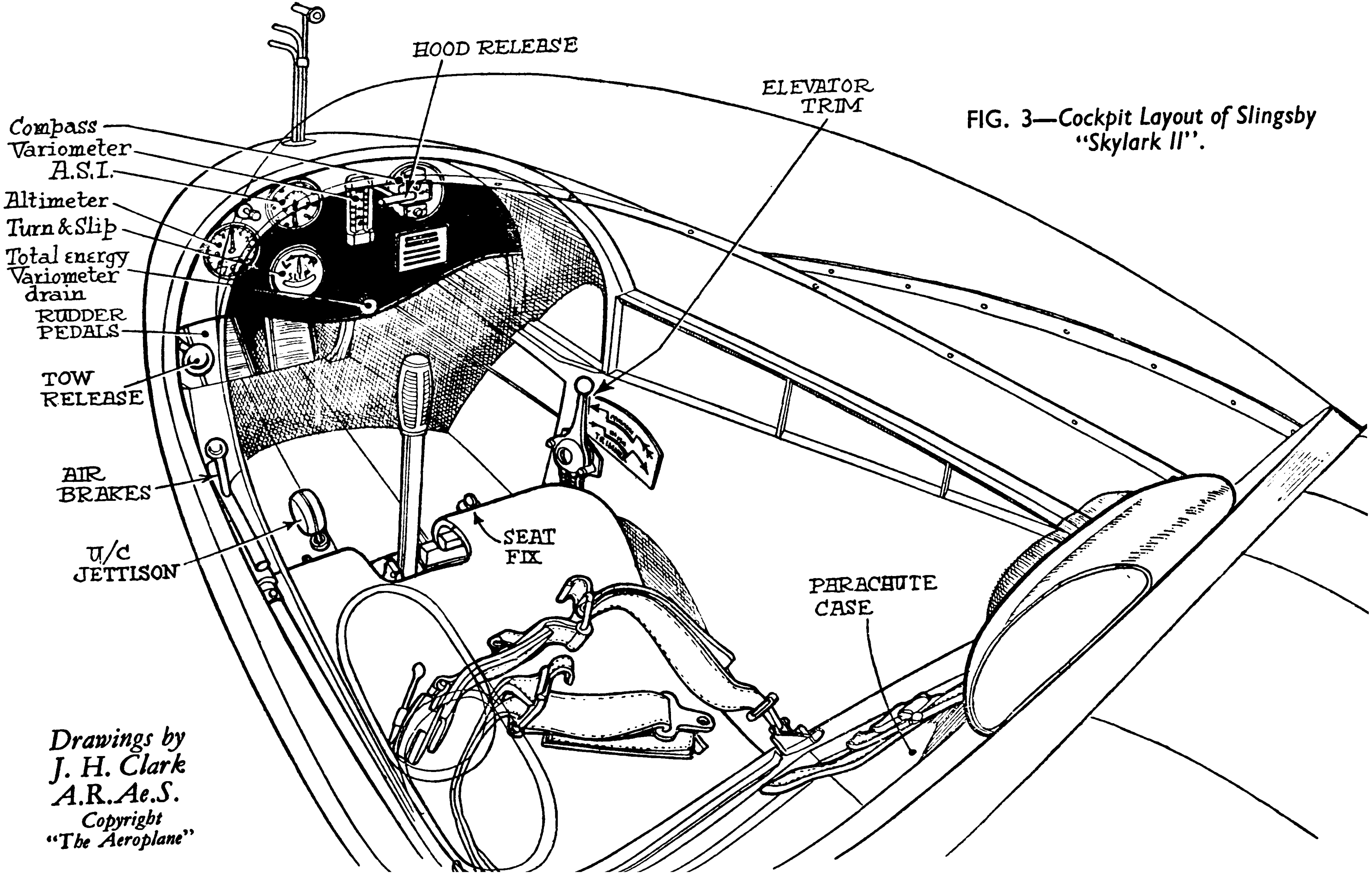


FIG. 3—Cockpit Layout of Slingsby "Skylark II".

Drawings by J. H. Clark A.R.Ae.S.

and control; indeed one marvels at the courage of those early pilots who flew in turbulent clouds in gliders whose flying characteristics would now be quite unacceptable, with inadequate instruments and no air-brakes.

Longitudinal stability and control was placed on a sound practical basis largely by the work of Gates and Lyon in this country. Plenty of data is available, and there is no difficulty in obtaining satisfactory longitudinal characteristics. As explained in Chapter 5, a conventional glider may be just acceptable with zero stick-fixed stability, provided that the stick-free stability is still positive, and for a glider whose stick-free neutral point is aft of the stick-fixed neutral point this condition may well determine the aftmost position of the centre of gravity. Once a glider has been built, the stick-fixed neutral point position cannot be easily modified but the stick-free neutral point can be readily altered (see Chapter 5 for an explanation of these terms). The stick-free neutral point can be moved aft and hence the stick-free stability increased for a given c.g. position by incorporating a weight or spring in the elevator circuit tending to pull the elevator down, by fitting a geared tab working in the same direction as the elevator, by means of horn balances and to a lesser extent by other means. The effect of a weight in the elevator circuit, usually due to the weight of the elevator itself, is frequently encountered as a result of deliberate or fortuitous lack of mass-balance. If the elevator weight moment is small this effect is generally useful, but a weighty elevator may produce unpleasant characteristics, since inertia forces will be fed back to the stick and an appreciable change of longitudinal trim occurs when a turn is initiated.

A weight in the elevator circuit also effects the "stick force per 'g' " as well as the stick-free stability. If one considers a pilot pulling-out of a dive, the elevator having no balance, the force applied to the stick not only depends on the air-loads on the elevator but is further increased by the effect of the increased normal acceleration. Since springs are not influenced by acceleration, they do not affect the stick force per 'g'. This quantity is a measure of the manoeuvrability of the glider and although it is not currently measured in flight tests, it might well be desirable to do so. At present, there is insufficient evidence to suggest a suitable figure, but 3 lb. per 'g' feels rather uncomfortably low. On the other hand it should not be too high.

In the past various gliders (e.g. "Rhonadler") have been fitted with all-moving tailplanes and in the absence of a geared tab this leads to zero stick-free stability under all conditions, which is undesirable. The addition of a geared tab moving in

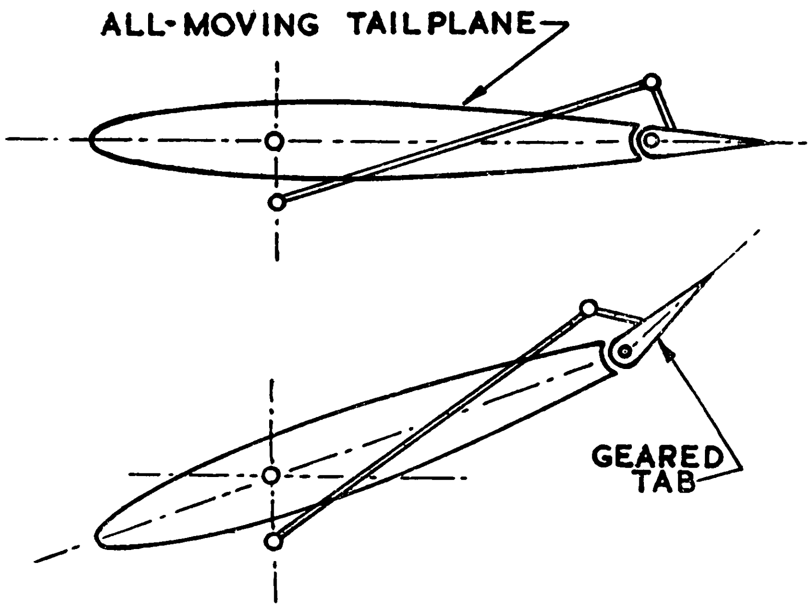


FIG. 4—*All moving tailplane with geared tab to give stick-free static longitudinal stability.*

the same direction as the main surface (i.e. in the anti-balance sense) does provide some stick-free stability (see Fig. 4). If two otherwise identical machines have horizontal tails of the same size and plan-form, one being of the conventional fixed-tailplane-moving-elevator type and the other of the all-moving tail and geared tab variety, the latter can be arranged to give a stick-free neutral point which is further aft than for the former by suitably arranging the hinge point, tab size and gear ratio, although the stick-fixed neutral point will be the same in both cases. Conversely, for a given stick-free stability, the all-moving tail can be made smaller but it is doubtful whether this process can be taken very far due to the reduction in stick-fixed stability.

Rate of Roll

There is no doubt that a good rate of roll combined with small lateral stick forces is a great asset in a glider. Not only is the glider more readily controlled in rough conditions without undue pilot fatigue, but locating and staying in the best part of a thermal is made easier. In recent designs, the attainment of a good rate of roll has been facilitated by the use of low-drag aerofoils, since in order to achieve a good surface finish the plywood covering is frequently extended to the rear spar, greatly increasing the torsional stiffness of the wing. The previous generation of gliders with the classical 'D'-nose torsion box suffered from a low aileron reversal speed and the rate of roll fell off appreciably at high speeds. Calculation shows that for a given aileron area and angular deflection, a better rate of roll is obtained by making the aileron span large and the chord correspondingly small, even to the extent of using full-span ailerons, although this tends to introduce constructional difficulties. A convenient type of aileron, used on recent British designs, is shown in Fig. 5. Being hinged at the top surface, there is no appreciable gap, and the lateral stick forces are pleasantly light when using a 2:1 differential.

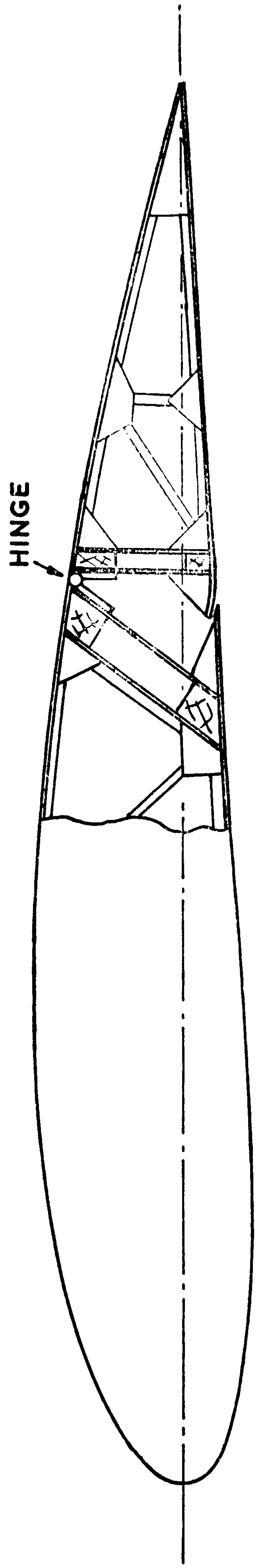


FIG. 5—Aileron hinged at upper surface.

Lateral and Directional Stability

A surprising number of types of glider have been built with inadequate weathercock stability and inadequate rudder power: one can only suppose that the designer sketched out an aesthetically satisfying fin and rudder and hoped for the best. Inadequate weathercock stability renders accurate flying very tiring, particularly in rough thermals. In the past there was also a tendency to provide excessively light rudder forces, so that the controls were lacking in harmony. The "Olympia" showed that there was no real difficulty in providing good characteristics in these respects, and more recent British designs have continued the trend towards bigger fins and rudders.

Not only must the weathercock stability be adequate, but it must be suitably related to the lateral characteristics. For the "Skylark II", the calculated value of l_V (a non-dimensional measure of the rolling-moment due to sideslip) is -0.081 at a lift coefficient of 1.0 and n_V (yawing moment due to sideslip) is 0.040. These are fairly average values for those gliders which are generally agreed to feel pleasant. It is virtually impossible to achieve spiral stability at the higher lift coefficients, so that it is invariably necessary to "hold off bank" in slow turns. Recent designs have rudders without any aerodynamic balance, in order to provide reasonable pedal forces, but such rudders have a tendency to give reversed forces in sideslips and spins.

Air-Brakes

For cloud-flying gliders, air-brakes which will limit the terminal velocity to something less than the placarded never-exceed speed are essential. It should be remembered, however, that a brake has not yet been devised which will not ice-up, and it is still possible to be deprived of their use when most needed, since they may be rendered immovable when shut by water freezing in the mechanism. They are very prone to ice-up when open; but this is not dangerous in itself, although it may involve an unpremeditated and rapid loss of height. The practice of opening the brakes at intervals when in cloud to free them from small amounts of ice is therefore of doubtful value, since it may accelerate icing. Clearly, a reliable method of de-icing is

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