Tackle GLIDING This Way

JOHN SIMPSON

Photo: Charles E. Brown, F.I.B.P., F.R.P.S.

1 The author flying 'Min'

To Wally Kahn
with best wishes

Tackle Gliding This Way

John E. Simpson

JOHN SIMPSON

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STANLEY PAUL
London

STANLEY PAUL & CO. LTD
178–202 Great Portland Street, London, W.1

AN IMPRINT OF THE HUTCHINSON GROUP

London Melbourne Sydney
Auckland Bombay Toronto
Johannesburg New York

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First published 1961

This book has been set in Times New Roman type face. It has been printed in Great Britain by The Anchor Press, Ltd., in Tiptree, Essex, on Antique Wove paper and bound by Taylor Garnett Evans & Co., Ltd., in Watford, Herts

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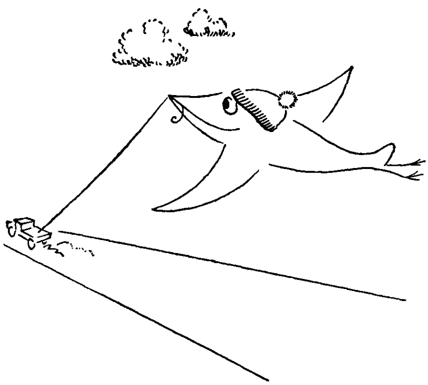


1. The Sport of Gliding

I can still remember the first time I flew in an aeroplane. Apart from the sheer delight of being in the air, there was a feeling of improbability that the thing could be happening at all. I was used to riding along on wheels, and at first I could see the wheels running along the ground. They left the ground, we floated upwards, and I looked out of the window to see what was holding us up. The wings were there, sticking out on both sides, but I could see absolutely nothing that seemed to be supporting us.

Soaring in a glider sometimes seems to me even more improbable. I sit in my little cabin, sailing round and round in circles, in almost complete silence, feeling every now and then a surge of 'lift' underneath my wings. After a time I look down and see that the ground is now a very long way beneath me—things there have become very small and quite grey. I may be joined by a bird, or another glider; it floats alongside me like a fish in a tank, and then perhaps turns away down into the depths. Eventually, of course, I have to return to the real world on the ground and to stop playing at being a bird for another week.

Many have dreamed of flying, but modern air travel is hardly a realization of this dream. Gliding is probably the nearest we shall get to flying as the birds know it.

The more skilled you become in the sport of gliding, the more fascinating you are likely to find it. After a year or two any keen club member should be able to climb to 4000 or 5000 feet on his own in a glider, and fly around at this height for several hours. Or he may attempt a cross-country flight, knowing that he must keep up entirely by his own skill, and may perhaps be able to fly to a point 100 miles or more away.

Very few other exciting and adventurous sports can be carried out so near to your own doorstep. There is no need to travel to distant mountains, snow-slopes, or coral reefs, as we live all the time at the edge of the ocean of air needed for this sport. The best place to get introduced to gliding is at one of the many gliding clubs.

A glider and its pilot are helpless on their own on the ground and need assistance in launching into the air. So, although gliding is an intensely individual sport with great scope for personal skill, determination, and courage, it is also a social activity in which people co-operate in helping each other to enjoy their sport.

Gliding clubs

The map, Fig. 1, shows the position of the main clubs in Britain (1961), which vary considerably in size. Some are very large affairs with several hundred members, numbers of professional employees, and wide facilities of all kinds; others may be much smaller, consisting of only a few enthusiasts who do all the work themselves, and perhaps get even more pleasure from their sport on that account.

In the larger clubs there is flying every day, but the weekends are naturally much the busiest days. So the best time to visit a club is on a Saturday or Sunday, when you can watch the flying and, if things are not too busy, perhaps get a 'joyride' in a two-seater.

Getting into the air

The start of a flight may be by catapult (bungey), winch, car-tow, or aeroplane-tow.

First the glider has to be got to the starting point. It may be towed at the end of a rope behind a car, but as most gliders are fitted with a single-wheel undercarriage it is easy to move them about by hand.

The right places to push and pull are soon learnt—don't push on the trailing edge of the wing, don't lift on the tailplane. The upwind wing-tip must always be held, and a man must always be at the nose when the glider is facing into wind. These simple rules are to make sure that the empty glider does not get blown over by a gust of wind. The glider is not many times the weight of its crew, and

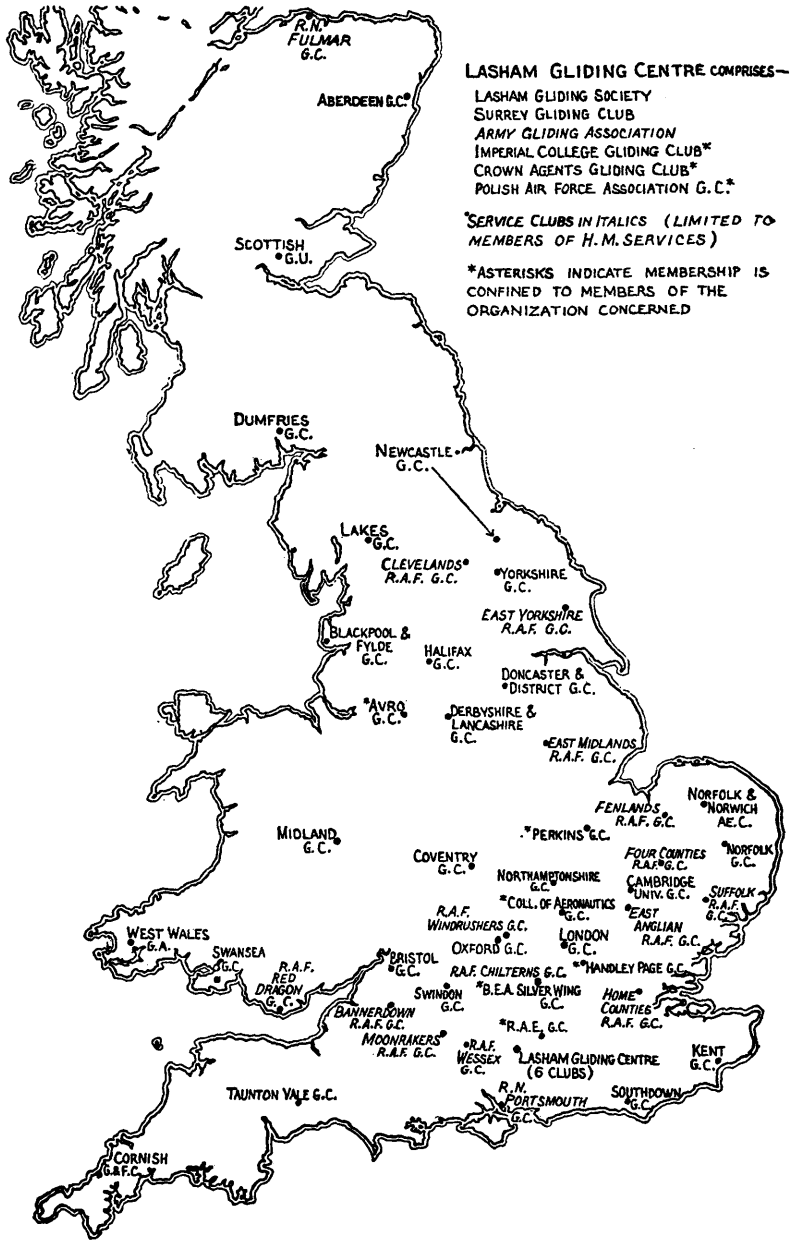


FIG. 1. Map showing British Gliding Clubs

when unloaded it is all too easy to have it blown right over on to its back.

When a glider is 'parked' it is placed at right angles to the wind, with the upwind wing-tip weighted down on the ground.

A *catapult-* or *bungey-*launch simply gets a glider into the air from the top of a hill. Two 30-yard strands of rubber rope are attached in the form of a V to the nose of the glider, and the tail is held firmly. The rope is then stretched by two sets of three or four people running down the slope. When the glider is released it accelerates rapidly and flies forwards out from the hill to the area where upcurrents should be found. As the rope becomes slack, it falls away from the hook on the nose.

In a *winch* launch a steel cable half a mile long attached to the nose of the glider is rapidly wound in by a winch at the far side of the aerodrome. The glider runs forwards on the ground and, when it is going fast enough, climbs just like a kite. The cable is finally released when the glider is almost above the winch. Climbs of 1000 feet are obtained in this way, giving a good chance of finding upcurrents. If none are found, the descent will take four or five minutes.

The *car-tow* is similar to a winch launch. A kite-like climb is made at the end of a wire towed at speed by a car.

For an *aeroplane-tow* the glider is attached behind a suitable 'tug' by about 200 feet of thin rope, usually nylon. The aeroplane takes off, and the glider is towed behind it. The great advantage of this method of launching is that the tug and glider can cruise around until a suitable upcurrent is found in which the glider can be released. When the glider pilot has released his end of the rope the aeroplane dives down and releases the rope at a spot marked on the aerodrome.

All these launches are made into wind. If it is 10 m.p.h. a glider, which needs 40 m.p.h. *through the air* to fly, will have to be towed at only 30 m.p.h. along the ground into the wind in order to become airborne. It would need to be towed at 50 m.p.h. along the ground downwind to reach the same speed through the air.

Types of glider

When you join a club you will be taken up on the launch by an instructor and taught to fly in a two-seater with dual control. The commonest types of two-seater are the T.21, or 'Sedbergh', and the T.31, or 'Tandem Tutor'. In the T.21 you sit side by side and in the

Tandem Tutor, as its name suggests, one in front of the other in separate cockpits.

In gliders used chiefly for training you may fly partly in the open, as in a sports car, with just a little windscreen in front of your face for protection. Most high-performance gliders have a covered perspex cabin, both for efficient streamlining and for comfort. This is essential for the lengthy and high flights which can be made in these aircraft. Climbs of 10,000 feet and distances of 100 miles are by no means achieved only by a few top record-breaking pilots.

All gliders can be dismantled quite easily by three or four people and packed for travelling into special two-wheel trailers designed to tow behind an ordinary car.

In time you will reach the stage of being able to fly solo; you will then be able to make flights of an hour or more on your own, and qualify to fly the high-performance gliders owned by your club.

High-performance gliders are often called sailplanes, and have very long tapered wings. The ratio of the span of the wing to its average width or chord is called the *aspect ratio*, and varies from about 10 in training gliders to 20 in a high-performance sailplane.

The outline diagrams in Fig. 2 (a)–(e) show six of the most popular sailplanes in use today.

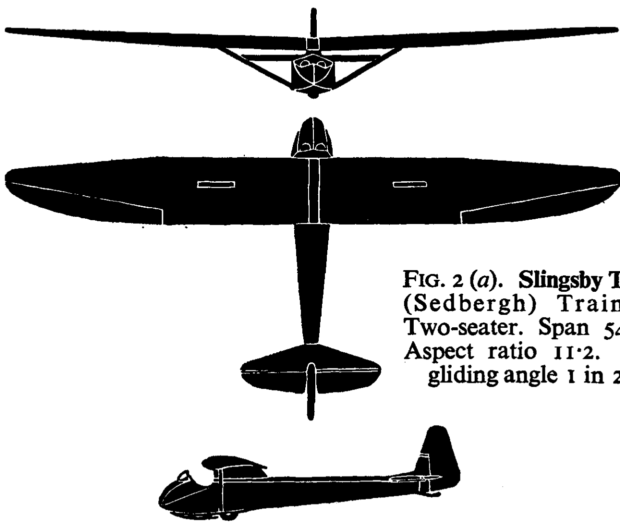


FIG. 2 (*a*). **Slingsby T. 21** (Sedbergh) Training Two-seater. Span 54 ft. Aspect ratio 11·2. Best gliding angle 1 in 21

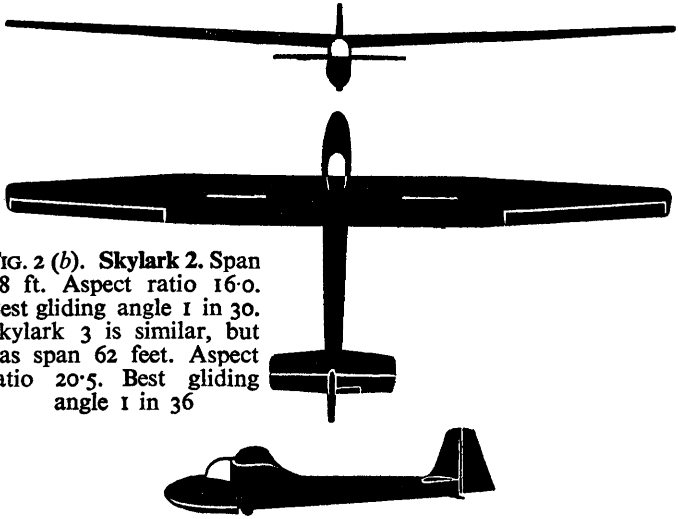


FIG. 2 (*b*). **Skylark 2.** Span 48 ft. Aspect ratio 16·0. Best gliding angle 1 in 30. Skylark 3 is similar, but has span 62 feet. Aspect ratio 20·5. Best gliding angle 1 in 36

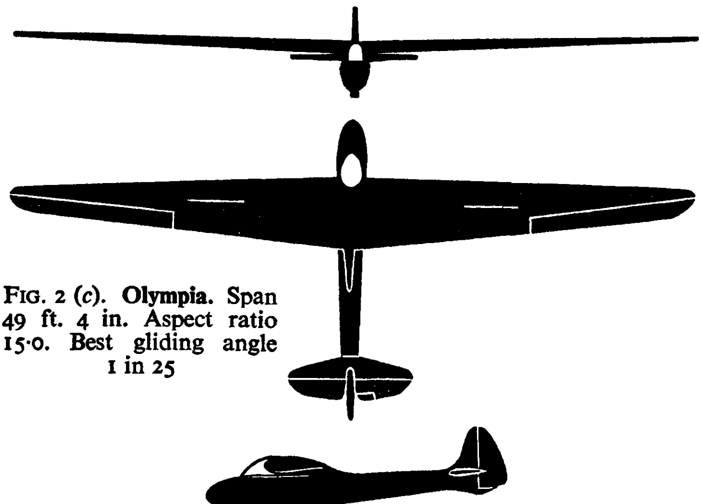


FIG. 2 (*c*). **Olympia.** Span 49 ft. 4 in. Aspect ratio 15·0. Best gliding angle 1 in 25

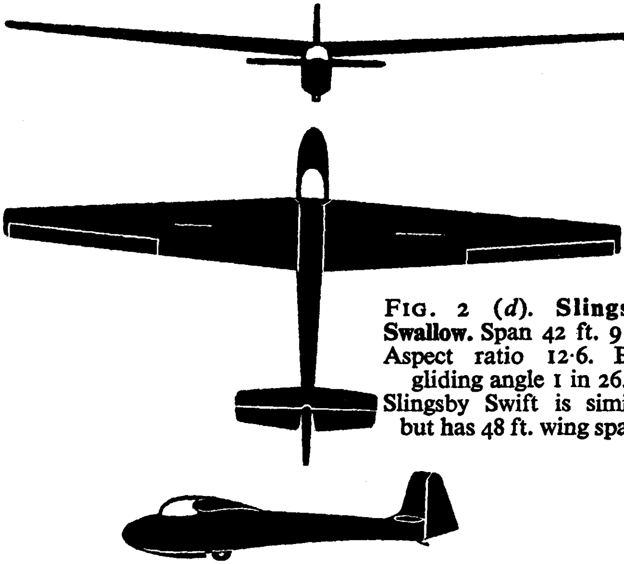


FIG. 2 (*d*). **Slingsby Swallow.** Span 42 ft. 9 in. Aspect ratio 12·6. Best gliding angle 1 in 26. Slingsby Swift is similar but has 48 ft. wing span

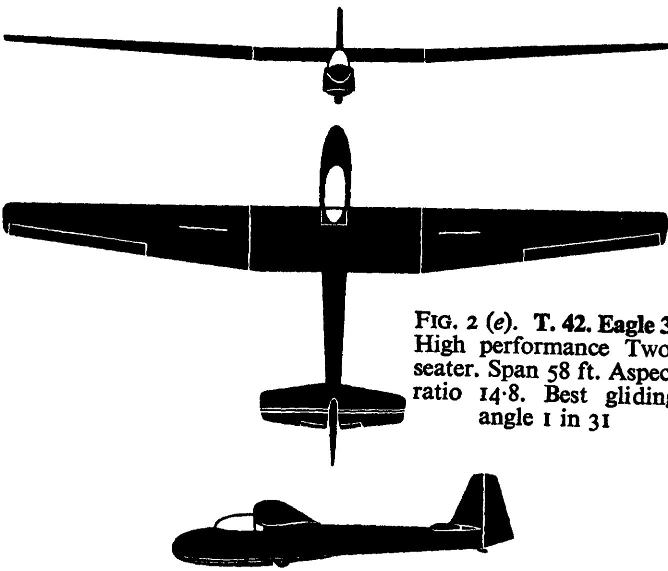


FIG. 2 (*e*). **T. 42. Eagle 3.** High performance Two-seater. Span 58 ft. Aspect ratio 14·8. Best gliding angle 1 in 31

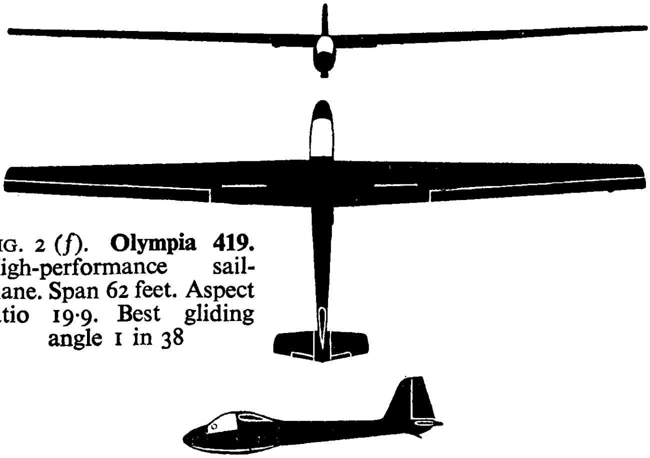


Fig. 2 (*f*). **Olympia 419.** High-performance sailplane. Span 62 feet. Aspect ratio 19·9. Best gliding angle 1 in 38

Most gliders (except the 'super-super' jobs) have roughly the same performance at a cruising speed of 40 knots (about 45 m.p.h.); what really decides whether a glider is a 'high-performance' one is its performance at the higher speeds. For example, the minimum sinking speed of a Skylark 2 is about the same as that of a T.21 (about 2½ feet per second). At 50 knots, however, the sinking speed of the Skylark is still not more than 3 feet per second, whereas the T.21 at this speed will be sinking at something like 6 feet per second. Both gliders will probably be flown in areas of upcurrent at the same sort of speeds but, when it comes to flying in a fast glide to find the next upcurrent, the Skylark is at least twice as efficient.

It is more expensive to build a high-performance machine, and more costly to repair it when damaged. This brings us to the two topics about which I am often asked—safety and cost.

Safety and cost

Gliding is not a dangerous sport, but accidents can happen and, as in most other sports, it is possible to injure yourself, if you are unlucky. It is amazing what the pilot can get away with in a gliding accident. Even when his machine is almost completely wrecked he may get out unhurt except for a few scratches or minor injuries. As

2 At a club on a hill-top

3 Olympia 419

4 Eagle high-performance two-seater

the wooden structure collapses it protects the pilot, and there is no petrol to cause a fire.

It is difficult to give an exact idea of costs, as they vary from club to club and, of course, depend on the amount of flying you expect to do.

One thing, however, should be made clear: gliding is not just a rich man's sport. Members of gliding clubs are not expected to be wealthy. They can usually get the flying they want at reasonable rates by doing the work on the ground themselves, and by flying gliders owned by the club at a hire rate according to the number of launches and time in the air. Glider pilots come from all kinds of occupations; I have met at various clubs doctors, engine-drivers, housewives, engineers, schoolboys and girls, shop assistants, air-line pilots, and many others. In fact the list could include anybody who has sufficient skill to learn to ride a bicycle or to drive a car. Gliding is certainly not a masculine preserve, and some of the best glider pilots in the country are women.

Club courses. A very good way of starting gliding is to spend a week of your holidays at a club on a course. These courses cater for different stages, but most expect to receive complete beginners. The cost of board and flying instruction is something between £12 and £15. Most of the clubs run a series of these courses in the summer, and details can always be had from the British Gliding Association, 19 Park Lane, London, W.1.

After a good week (or two) at a course, you will probably want to join a club. Most clubs charge an entrance fee of between £4 to £5—often reduced to those who have just finished a course. The yearly club subscription is five or six guineas. The cost of a launch varies from club to club, the average being about 4*s.* for a car or winch launch, together with a flight of about 15 minutes. For longer flights the charge comes out at somewhere between 12*s.* 6*d.* and 15*s.* for an hour.

So, by joining a club, you may expect to get quite a lot of fun for as little as £15 or £20 a year (less than the amount many people spend on cigarettes!). If you can afford more than that you can certainly manage to spend it on gliding. You may be able to afford to have your own glider, or to join a syndicate to build or buy one. In motoring you may buy a car that works for as little as £20, or spend £6000, if you have it, on a Rolls. Similarly, in gliding, if you want the advantage of owning your own glider, you may be able to join with several others in buying a secondhand one for as little as

£200 or £300, or, if you have the money, you can spend £2000 on a new sailplane of the best type with full equipment.

How a glider flies

The forward edge of a wing is thick and blunt, gradually tapering towards the rear or trailing edge. In a glider the distance from the front to the back of the wing, called the *chord*, is about 4 or 5 feet, and the *span*, the distance between the tips, is about 50 feet. In the case of a symmetrical airflow over a symmetrical shape, as shown in Fig. 3 (*a*), it is obvious that no upwards or downwards force could be expected. This may be the case in certain parts of the glider, such as the struts (if any) and in the tailplane and tail-fin.

In order to get a lifting force, we shall either have to move the wing at an angle to the air (as in (*b*)), or alter the shape of the wing (as in (*c*)), or possibly both.

Consider a little bit of air arriving at the front of the wings at 'A' in (*b*) and (*c*). This can either go over the top of the wing to get to 'B' at the trailing edge, or it can go underneath. Now the distance from A to B over the top is greater than the distance from A to B underneath. So the air will have to travel faster on top than underneath, and therefore the pressure will be lower on top. The total resultant force on the wing will be the combined effect of the force due to this low pressure on top and the increased pressure beneath, and the force due to the frictional resistance of the air.

Gliders designed to be efficient at only one particular slow speed have quite a concave shape underneath the wing, but more modern types designed to be efficient at a large range of speeds are very much nearer the symmetrical shape. The concave one operates efficiently only at one particular angle to the air-flow, the other is more efficient at a large range of angles.

Sections of these different shapes (or *aerofoils*) have been tested in wind tunnels and the forces at different speeds and angles measured. The total resultant force varies in size and also in the point through which it acts. In a smooth wing it acts very nearly at right angles to the air-flow. It is usual to divide this resultant force into two component forces, one in the direction of the air-flow, called the *drag*, and the other—the one we are really interested in, called the *lift*—at right angles to it. In pictorial representations of these forces, the lengths of the arrow-headed lines are drawn proportional to the sizes of the forces.

It is easy to see that with the use of an engine to pull forwards and counteract the drag, it should be possible to make the wing fly horizontally through the air, provided the lift can be made equal to the weight. This is what is done in powered aeroplanes, and also sometimes in a glider, when towed with an aeroplane, a car, or a

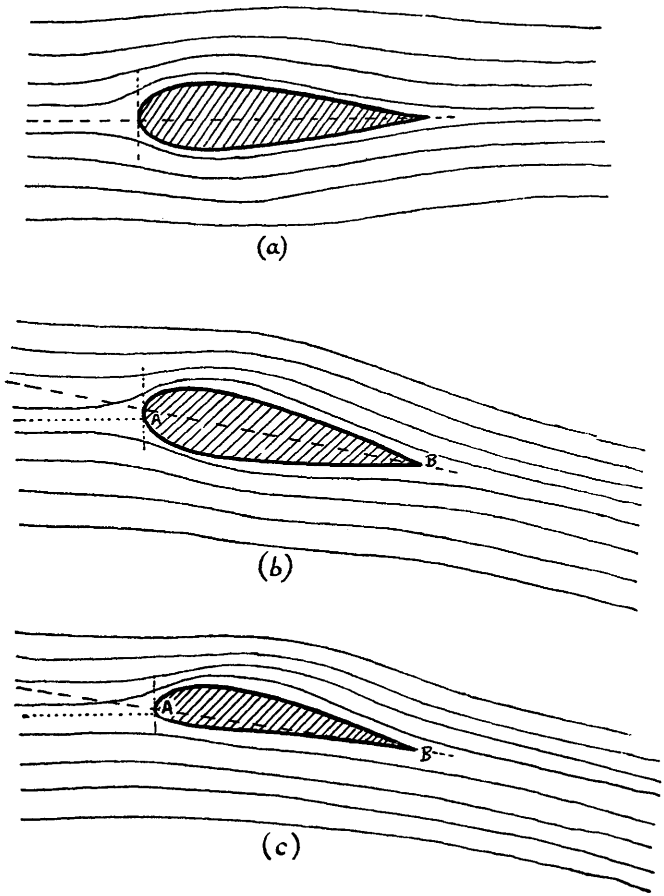


FIG. 3. Air-flow over wings

winch. It will fly along level, with the pull of the engine balancing the drag and the lift just equal to the weight.

In fact, just the same balance of forces is obtained in a motor-car driving at a steady speed along the road. The pull of the engine balances the frictional drag on the car, and the road (provided it is well enough made) produces an upwards force equal to the car's weight.

Supposing there isn't an engine? It is quite possible to get a car to go without an engine, by letting it run downhill. The motive power in this case is clearly the force of gravity, and the greater the 'drag' of the car, the steeper hill you will need to run down at a steady speed.

The same applies to a glider. It has to go 'downhill' through the air all the time. The diagram (Fig. 4) shows how the weight is used to pull it forwards down this imaginary slope, and how at a steady speed this balances the resultant (R) of the lift and drag. By moving the tail controls and altering the angle of the wing to the air-flow, different values of L (lift) and D (drag) will be obtained, and consequently different gliding angles.

Gliding angle or *glide ratio* is measured like a gradient on a road, e.g. 1 in 20 (or 20 : 1) means 1 foot down for every 20 along.

In the diagram the angles 'a' are all the same, and the glide ratio can be seen to be equal to $\frac{L}{D}$. So the flattest gliding angle through the air is obtained when $\frac{L}{D}$ is at its maximum.

In Fig. 4 the angles are much exaggerated for clearness, and the gliding angle is shown as only 1 in 6. In a good modern glider, flying at about 40 knots, the lift may be about 650 lb. and the drag 25 lb. In this case $\frac{L}{D}$ is therefore $\frac{650}{25}$ which equals 26, so the gliding angle at this speed is 1 in 26.

The *sinking speed* at this forward speed of 40 knots must therefore be 1/26 of 40 knots, about $1\frac{1}{2}$ knots, or $2\frac{1}{2}$ feet per second. [In round figures, 6 knots = 10 ft./sec. = 600 ft./min.]

Performance figures

Fig. 5 shows performance curves for the Skylark 2 and 3 sailplanes, built by Slingsby Sailplanes in Yorkshire. The curves show that, for a Skylark 2, the *least sinking speed* is $2\frac{1}{2}$ feet per second, and is attained at just under 40 knots airspeed. At speeds slower than this the sink increases slightly, and then the curve stops altogether!

As you fly slower and slower, you need to put the wing at a greater and greater angle to the air-flow to maintain enough lift. Eventually an angle is reached at which the flow is no longer smooth along the wing, but breaks right away from the upper surface in a series of eddies. This is a *stall* and involves considerable loss of lift. If both wings are stalled together, the glider usually pitches nose-forwards, speeding up and gaining lift again.

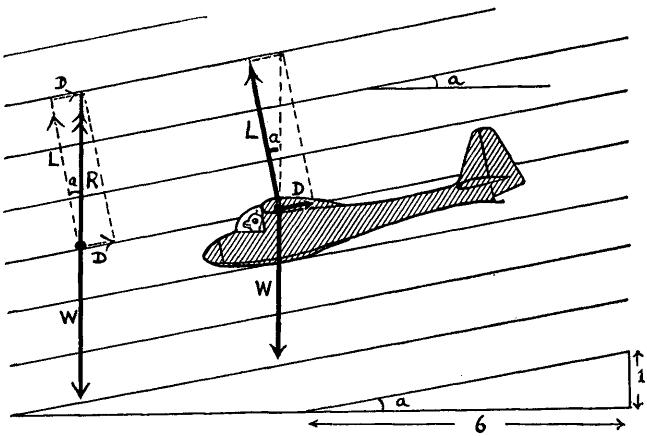


FIG. 4. The forces on a glider

The *best gliding angle* through the air is obtained at a slightly greater airspeed than the minimum sink. From the graph you can see that the Skylark 2 has a best gliding angle of 1 in 30 at an air-speed of 43 knots.

Laminar flow

Some of the drag on a glider's wing is produced unavoidably in the process of making lift. However, a large proportion of the total drag is caused by skin friction. This occurs in a thin layer of air close to the surface—the boundary layer—where the air-flow changes from zero on the wing surface to the full value of the outer flow. Laminar flow in this boundary layer is a smooth flow parallel to the surface.

Laminar flow occurs at the front edge of all wings, but towards the trailing edge the boundary layer thickens and the smooth flow

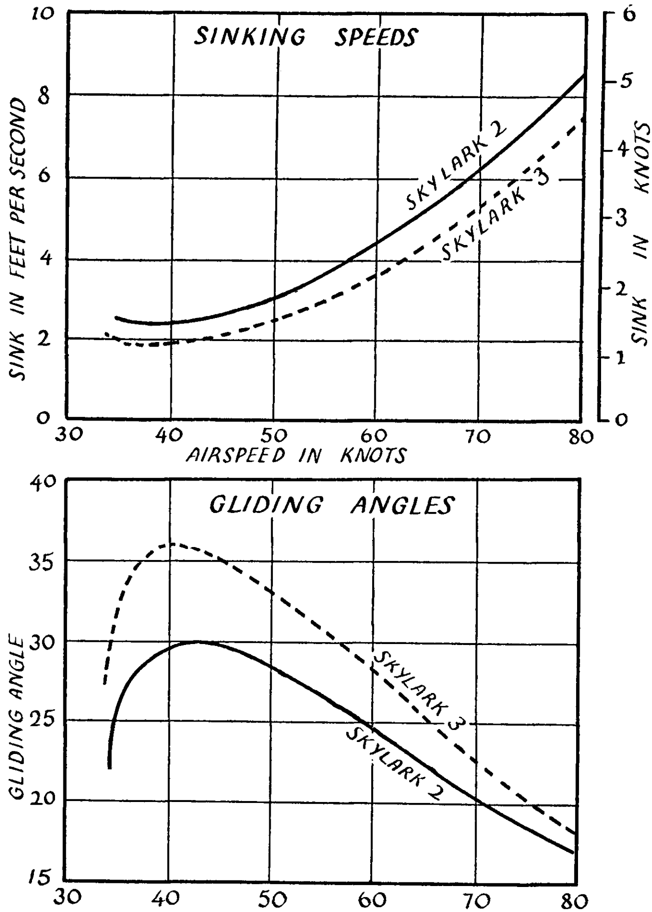


FIG. 5. Performance curves of Skylark sailplanes

breaks down. The flow becomes turbulent, and consists of small random eddies. One aim in wing design is to maintain the flow in a laminar instead of turbulent state as far back as possible over the wing, to reduce surface friction.

Soaring birds achieve this far beyond the efficiency of any of our aircraft. They manage to control the air-flow in the boundary layer, particularly at their wing-tips.

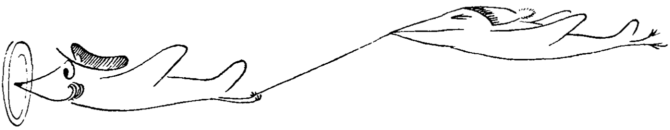
The Skylarks and the Olympia 4 series were all designed to achieve the maximum extent of laminar flow. The special points in wing design are:

(i) A wing section with maximum thickness farther back than in earlier types.

(ii) Reduction of local waviness by special attention to firm maintenance of the designed shape.

(iii) Reduction of surface roughness.

On this last point it has been noticed that rain on the surface will appreciably reduce the performance of a 'laminar-flow' wing.



2. The aircraft

The aircraft

Fig. 6 shows the general appearance of a modern high-performance glider.

The *wings* are usually made in two sections, connected together at the centre. A number of recent gliders, however, have the wing in three sections—a centre section which bolts on to the fuselage, and a smaller tip attached to each side.

The foundation of the wing is the main spar, a laminated beam of spruce about 3 inches by 9 inches at the wing-root, gradually tapering out towards the tip. The shape of the wing is made by a series of built-up girder-like ribs attached to the spar.

In front of the spar, the ribs are always covered with plywood making a rigid torsion-resisting box. In traditional older gliders the rest of the wing is covered with fabric. This is similar to the material used for handkerchiefs and is tautened with dope. In some modern gliders, the whole of the wing is covered with plywood.

Spoilers or air-brakes. All gliders are fitted with some kind of device to increase the rate of sink of the glider when coming in to land. The simplest 'spoilers' consist of wood or metal plates about 3 feet long and 4 inches wide. These are mounted on each side, about a third of the way along the spar on the top of the wing. By pulling a lever one can make these plates stand up at right angles to the wing, thus 'spoiling' the air-flow. Although these plates are quite small, the area over which the lift has been spoiled can be an appreciable part of the wing.

Air-brakes also have this function of 'spoiling' the lift on the wings, but they can also act as speed-limiting brakes.

A 'clean', highly streamlined glider, if dived steeply, will gather speed very quickly. There is none of the 'built-in drag' that many older aeroplanes had with their wires, struts, and square corners to stop a dangerously fast speed being reached. So these dive brakes have been designed to keep the speed below the limit which the structure will stand. With the brakes open it should be possible to dive the glider vertically towards the ground without exceeding a safe speed.

The standard brakes developed by the Gliding Research Institute in Germany (D.F.S.) come out above and below the wing on stout bars hinged to the main spar.

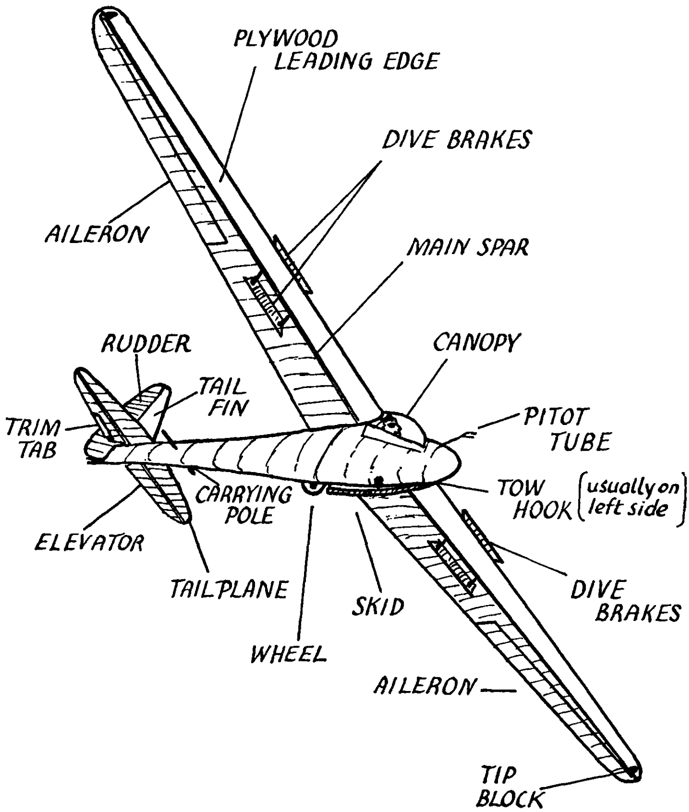


FIG. 6. Parts of a glider

The *ailerons* are the control surfaces mounted in the trailing edges of the wings, near the tips. They are for the control of the aircraft 'in roll', i.e. to keep level, to lift a wing-tip up, or to push it down. They are connected to the control column (or 'stick') so that one aileron goes up when the other goes down. For example, moving the stick to the left moves the left aileron up and the right one down, decreasing the lift on the left wing and increasing it on the right one. This tips the left wing down, and the right one up.

As the glider will rest on the ground with one wing-tip on the surface, a small wooden block is often mounted just beneath the tip to protect the wing and aileron from damage.

The *fuselage* has the seat for the pilot, the landing gear, and the support for the tail unit—the major part for the control of the aircraft.

There are times when it is very pleasant to fly in an open cockpit, with the wind in one's face, and no feeling of being shut up in a box. The popular T.21 two-seater glider used in most clubs can have a covered cabin, but it is usually flown in the open cockpit version. This certainly makes it easier for a beginner to judge the speed at which he is flying. At high speeds there is, of course, a good deal of noise and battering from the wind; I tell my pupils that if they can't hear what I am saying because of the noise, the chances are that I am shouting, 'You're flying too fast!'

If you are to be able to fly at heights of up to 20,000 or 30,000 feet, where the temperature is many degrees below freezing, a covered cockpit is essential. Modern gliders all have a perspex canopy or 'greenhouse' which hinges aside, making it easy to get in (or out in an emergency). This canopy is fitted with a small sliding panel or hinged window, to give clear vision if it is impossible to see through the windscreen owing to ice or very heavy rain.

The *landing gear* consists of one wheel mounted centrally. This is sometimes fitted with a brake. Obviously, one wheel on its own will not hold the glider with its wings level; and, at the start of every flight, a wing-tip runner has to keep the wings level until the speed is reached at which the pilot has control to keep them level himself. On landing, as the glider comes to rest, one side or the other will tip down on to the ground. If there is some wind the pilot can reduce the rate at which it tips, but in any case it will be quite a gentle affair and will not do any damage. Provided the wind is strong enough it is quite easy to hold the wings level after coming to rest.

When the pilot is sitting in the cockpit his weight in front of the wheel will usually tip the nose forward on to the ground. Some of the weight will then rest on the skid. This consists of a springy strip of ash, bolted at the front end, with some form of springing between it and the bottom of the fuselage. Some gliders used to have a row of tennis balls for this purpose, but the normal thing is to have a series of indiarubber blocks. The gap at the side of the skid may be faired in with a canvas strip, and the bottom surface is protected with a sheet of thin steel.

Various methods have been used in more complicated and expensive gliders to improve the streamlining of the undercarriage. These include such schemes as retractable skids and retractable wheels. The simplest refinement is to discard the wheel altogether after take-off and to have a long skid on which the landing can be made. The droppable 'dolly' undercarriage fits on to the skid, and has a small wheel on each side. It is released by the pilot, by pulling a lever when the glider is about 6 or 10 feet off the ground. It is fitted again after landing by two people lifting the tail. The glider is tipped forward on to its nose, and when the tail is high enough the wheels can be refitted to the rear part of the skid.

If you look inside the fuselage of a glider through the little inspection doors you will be able to make out some details of its construction. Apart from the upper part of the nose, which in some gliders is made of fibre-glass, the construction is nearly always of wood. There are two main principles of design. One is to make the fuselage as a kind of plywood tube, with a very close series of oval-shaped frames and comparatively thin fore-and-aft members, or longerons, as in Olympia and Skylark. The other plan is to have flat, girder-like sides, made of heavier members. The strength of this structure does not depend in the same way on the strength of the skin. Possibly the top or bottom may be ply-covered, but the side is covered in fabric like the wings, as in T.21, Eagle and Swallow. The attachment for the towing cable is near the nose, but is not usually right at the front. Some gliders are still fitted with 'nose-hooks' which are perfectly satisfactory for aero-towed launches. It has been found that a glider will climb much more efficiently at the steep angle needed in car and winch launches if the towing attachment is so far back that the line of the cable passes roughly through the centre of gravity of the aircraft. The so-called 'belly-hook' is usually a few inches to one side of the skid on the left-hand side, some feet back from the nose.

British gliders are all fitted with the 'Ottfur' release. The features of this are a positive hold on the towing cable for a pull forwards or downwards, but an automatic release as soon as the pull is at all in the backwards direction.

The *tail unit* of a conventional glider consists of a horizontal surface and a vertical one. There are some gliders, however, which have a 'V-tail' in which there is one unit each side, inclined at an angle of 45 degrees to the horizontal.

The horizontal surface usually consists of a fixed part, the tail-plane, with a control surface hinged to the rear of it. This is known as the elevator and is connected to the control 'stick', which is on a kind of universal joint. Backward and forward movement of the stick controls the elevator. Forward movement of the stick lowers the elevator, raising the tail and tipping the nose of the glider downwards. Backward movement of the stick raises the elevator, pushing the tail down and raising the nose.

In some gliders there is a smaller control surface, mounted in the elevator itself. This is the elevator trim-tab. Its position can be altered by a small lever to the right of the cockpit and it has the effect of providing a lifting or depressing effect on the elevator control itself. Sometimes you will see a trim-tab on both sides. The second one may be connected with the dive-brakes, and arranged to counteract the effect on fore-and-aft control of opening the brakes.

The vertical tail surface consists of a fin, with the rudder hinged behind it. A cable is brought forward from this on both sides and is attached to a rudder bar, or rudder pedals, which are worked by the pilot's feet. Moving the left foot forward moves the rudder to the left, which in turn makes the whole machine yaw to the left. The right movement works of course the other way, and swings the nose to the right.

Plate No. 5 shows the details of the pilot's cockpit. The seat is made of plywood, curved to give support to the back and legs. There should be room for a small cushion to sit on, with possibly one behind. The back of the seat is built with a 'well' to take a back-type parachute.

The *controls* are:

(i) The control column, or 'stick', connected to the elevators and ailerons.

(ii) The pedals, connected to the rudder.

(iii) On the left, the dive-brake handle, which is painted red. Backward movement opens the brakes. In the closed position, fully forward, some kind of lock is provided to prevent their opening accidentally.

(iv) On the right (not visible in the photograph) is the tail-trim lever. Forward movement of this increases the speed at which the glider will fly 'hands-off'. This lever is painted blue or black.

(v) The cable-release knob—this is on the left of the instrument panel, and is painted bright yellow.

(vi) (If fitted) the knob to release the undercarriage; this is painted green.

The bolt or knob for releasing the cockpit cover is on the left and is usually painted red (there is sometimes another one on the right as well).

Instruments

The instruments are mounted together in front of the pilot in a panel which is removable for repairs and adjustments.

The three basic instruments with which every glider is fitted are the Airspeed Indicator, the Altimeter and the Variometer.

Airspeed indicator (A.S.I. for short)

The pressure caused by the air-flow is measured at the *pitot* (French, pronounced 'pea-toe') tube mounted somewhere on the nose of the glider. This may be a thin tube mounted a few inches above the front of the fuselage, or a 'pot-pitot' in a little metal pot sunk into the front of the nose.

This pressure is transmitted by rubber tubing to the inside of a sensitive pressure cell made of very thin metal, and will cause it to bulge outwards slightly. In a cabin glider it is usual to compare this pressure with that in a second *static* tube connected to the instrument. The bulge of the pressure cell is magnified by levers and turns a pointer on a circular scale.

The A.S.I. is not designed to have air blown through it like a vacuum cleaner, but to measure very small pressure differences. It is easy to produce with your lungs 10 times the pressure needed to break the instrument. So *don't* test your A.S.I. by blowing in it. A safe way to test that it is working is to block the end of the pitot tube with a finger, and to rub the tube with your other hand. The heat produced will increase the air pressure enough to register on the instrument.

The altimeter

The decrease of atmospheric pressure with altitude is used to measure height. On the ground the pressure is about 15 lb. per square inch; at the top of Mount Everest, or at the British Altitude Record Height for Gliding (both about 29,000 feet), the pressure is only 5 lb. per sq. in.

The altimeter is just an aneroid barometer with a scale marked in feet or metres altitude. In a sensitive altimeter the long pointer marks hundreds of feet and goes round once for every thousand feet, and the shorter one marks the thousands—in fact very much like the minute and hour hands of a clock. There is a third tiny hand which shows the ten-thousands.

You will find a knurled knob beside the dial, and turning this rotates the whole mechanism and enables you to set the pointers wherever you like. There are times when you should set the instrument to read height above sea level, but if you are expecting to fly around the aerodrome and land back there, it should be set to read zero at the height of the aerodrome. The difference may be considerable. For example, both the Midland Club at the Long Mynd and the Derby Club at Camphill have their sites nearly 1500 feet above sea level.

You will be taught not to rely on the accuracy of your altimeter to the nearest hundred feet and to disregard it altogether in the final stages of the approach to landing. At all times in rapid climb and descent it will lag a little behind the correct reading, as there is little vibration in a glider to overcome friction in the bearings. A gentle tap may overcome this, and often causes a sudden change of 50 or 100 feet. Don't overdo this, or you may qualify for the unpopular 'Woodpeckers' Club'. You can probably guess what the qualifications are for membership!

Variometers

The variometer is a sensitive rate-of-climb indicator. As the glider climbs, it moves into a region of lower atmospheric pressure, and the variometer measures the rate at which this pressure is changing.

A heat-insulated air container is part of the instrument, and the standard one used is a half-litre thermos flask (just under 1 pint). As the glider goes up, it is moving into a region of lower air pressure, and air leaks out of the container. As it descends, air flows in again. This flow is used to work the instrument.

What is most needed in a good variometer is that it should give an immediate response to an up or down current. It should not, for example, build up pressure after a rapid climb (such as a winch launch) continuing to show Up long after the glider has started to sink.

The *Horn*, vane-type variometer can be made very sensitive to small rates of climb, and can also be designed with what is, in effect, a 'variable leak' to avoid building up misleading pressure differences.

The *Cosim*, pellet-type, indicates climb by a green pellet rising alongside a scale, and sink by a red pellet.

Electric variometers

These have been in the experimental stage for some years, but are now coming into more general use.

The air-flow to and from the container changes the resistance of two detector elements in an electrical circuit. The current flowing in the circuit is displayed on an ammeter dial calibrated in units of climb and sink. The range of the readings can easily be altered by changing the circuit slightly with a switch.

The air-flow is not needed to do mechanical work to move a pointer as in other types, so an electric variometer can be made which has very little lag.

Total energy variometers

The normal instrument shows the rate at which height is changing, but does not allow for temporary increased losses or gains of height due to increases or decreases of speed.

A total energy variometer 'irons out' changes in variometer readings solely due to changes in air speed. These changes are almost unavoidable in rough rising air, when the corresponding climbs and dives appear in the readings of a normal variometer. The latter will not give a true picture of the best points if the speed of the glider is changing there.

The total energy variometer, however, shows the combined effect of change of height and change of speed (i.e. change of total potential and kinetic energy). This is done by using a venturi tube mounted near the pitot head, which produces a suction—a drop in pressure of exactly the same amount as the increase in pressure obtained in the pitot head to work the A.S.I. This venturi is connected to the container of the variometer, and changes in the pressure due to speed will cause air to flow in and out of the variometer, so reading 'Up' or 'Down'.

As a result of this, at any instant when the glider is changing speed, this kind of variometer shows the total sink (or climb) the glider would have if flying steadily at the speed shown at that instant.

The pressure changes which work a total energy variometer have also been obtained by having small tubes leading from little 'blisters' mounted on both sides of the fuselage, near the nose.

It is necessary to fit the system with a drain cock, to prevent water being drawn into the instrument. This is likely to happen during descents in heavy rain; opening the tap will protect the variometer, which will then work without the total energy refinement.

Compass

A compass is needed to find your direction when in cloud, or on a cross-country flight.

A great deal of the time that you are in a glider is spent circling, and a compass cannot be expected to show the direction you are pointing all the way round, unless the turn is very slow indeed. However, a modern type of compass, in which the moving part is pivoted on a fixed axle instead of on a point—the Cook compass—goes a long way to overcoming this difficulty.

Errors of the compass may be numerous; one of them—'Magnetic Variation'—is at least a definite thing which can be allowed for.

Magnetic North in Britain at present varies from about 7 degrees west of true North in the south-east to about 10 degrees in the north-west. The compass reads from 0 to 360 degrees, measured round starting from north in a clockwise direction, so the simplest way to deal with the Magnetic Variation when flying in Britain is to remember that the magnetic compass reads 'high' and that you always have to add nearly 10 degrees to the true direction you had planned from the map. To take a very simple example: if you want to fly west, which is 270 degrees true, you will need to fly at 280 degrees on the compass.

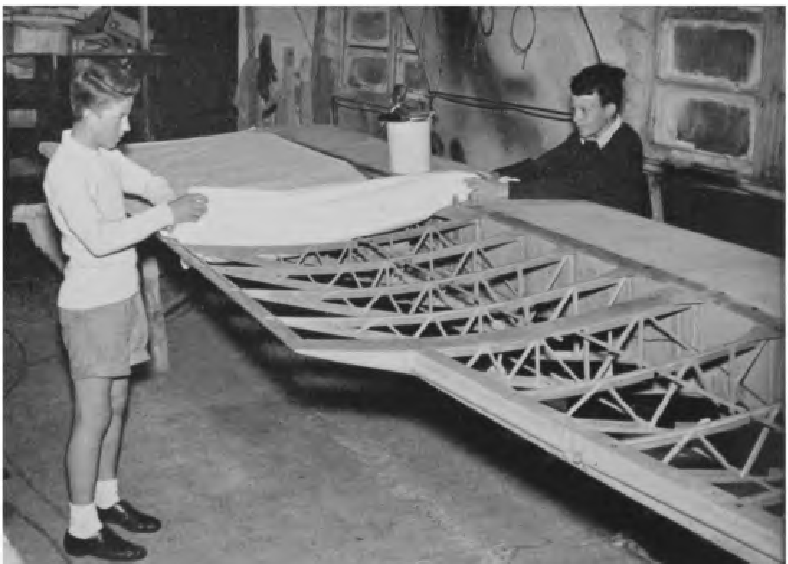
Blindflying instruments

Instruments are essential to enable a glider to be flown 'blind' in cloud, and there are two different instruments which are used. The *turn-and-slip* is the simpler one and can be used alone. Modern

5 Instrument panel

6 CONSTRUCTION OF T.21

Above: Rubbing down fuselage. *Below*: Fabric on wings



practice in gliders, as more suitable instruments have become available, is to use an *artificial horizon*, with a turn-and-slip as a reserve.

Both these instruments use a gyroscope, rotated by an electric motor. Dry batteries are used for the turn-and-slip; heavier accumulators are usually needed for the horizon.

Turn-and-slip indicator

This shows you the rate at which the glider is turning, and also whether the turn is being properly made.

The spinning gyroscope is mounted in a little cage, and held by springs so that it rotates about a horizontal axis pointing left and right. As the glider—and hence the instrument—turns, the axis of the gyroscope is turned about a vertical axis in the glider. The rotor 'resists' this and starts to precess, that is, to rotate about an axis at right angles to the other two. As a result, the little cage is tilted over to one side, operating a pointer which shows TURN.

The slip or skid part of the instrument is much simpler, and consists either of a pointer connected to a kind of pendulum or of a steel ball in a curved glass tube filled with liquid. When the glider is flying straight and level the ball is naturally in the middle. In a properly made turn it should stay in the centre.

Artificial horizon

The display of this instrument consists of a little model aircraft fixed in the centre of the dial and, behind it, a movable cross bar which represents the horizon. The horizon bar is linked to a heavy gyro which is suspended in gimbals with axis vertical, and is always maintained in the same position in space.

The movement of the little aeroplane (fixed to the instrument, fixed to the glider!) relative to the horizon bar shows both the nose of the glider and the angle of bank just as they would be seen in clear air.

The artificial horizon is much easier to learn to use than the T. & S. Indicator and makes accurate instrument flying possible, but it has disadvantages which make it inadvisable to rely on this instrument without having the T. & S. installed as well. In most models, tilted too far, say over 45 degrees, the horizon bar topples and takes several minutes to get itself back working again. The moving parts are caged by a special knob when not in use; this is essential when the glider is taking off and landing, or doing aerobatics.

Barographs

The purpose of a glider barograph is to give a record of the altitude at any time during the flight, and it is calibrated to read in feet up to 20,000 or 30,000. Barographs for gliders are similar in principle to those which are used to show a curve of atmospheric pressure; a pointer traces a curve of varying pressure on a drum which is rotated by clockwork.

As there is a chance of the ink's freezing in a very high flight, the trace is usually made by a stylus resting on a smoked chart.

A barograph chart of an interesting flight is always worth having, and is needed for any test or record in which altitude has to be certified.

Oxygen

As you climb to great heights, the air pressure steadily reduces, and it is quite possible in a glider to reach the stage when you can no longer absorb enough oxygen by normal breathing.

Lack of oxygen has at first similar effects to those caused by excess of alcohol. The pilot feels pleased with life and thinks he is doing very well, but he gradually gets more and more ineffective and eventually becomes unconscious.

You must have special oxygen breathing apparatus if you are expecting to spend any length of time above 10,000 feet. The air you breathe must be enriched with oxygen in increasing quantities up to the height of about 40,000 feet, above which even pure oxygen will not be absorbed in sufficient quantities to keep you alive. A pressure cabin is needed above this height. Several pressure-cabin gliders have been designed, but up to the time of writing none has been flown.

A popular system is that of the *open circuit*, continuous-flow type, such as that made by Normalair Ltd., of Yeovil. This consists of a cylinder of compressed oxygen, a flow selector on the instrument panel, and a mask with a rebreather bag into which the oxygen is fed.

When breathing IN you inhale oxygen from the bag and supplement it by air drawn in through a vent hole. When you breathe OUT, the first part of the exhaled air, which has a large proportion of unused oxygen, is captured by the bag and the rest of the gases are blown out through the vent. During this exhalation a further supply of oxygen is collecting in the bag.

A system which has certain advantages at greater heights is the *diluter demand* oxygen system.

In this system a good face-to-mask seal is essential, as the principle is that the slight negative pressure as you inhale opens a valve, which automatically supplies oxygen and air in the correct proportions according to altitude. You breathe out to the atmosphere through a valve on the mask, which does not admit any air when breathing in.

Parachutes

Some people are surprised to see a glider pilot wearing a parachute, but it is now a standard piece of equipment for any serious flying. Although it is most unlikely that a parachute will be needed, there is one most important eventuality against which a parachute is carried as 'insurance'. This is the chance of structural failure, which could be caused either by a particularly fierce thunderstorm or by a collision.

A parachute is not usually worn for short flights round an aerodrome in a training glider, but is always carried in a high-performance glider. It is worn on your back and fits into the special recess in the back of the seat. It is simple enough to use—get well clear of the aircraft and then pull the rip-cord firmly. The bag will spring open, the little pilot parachute will pull out the main canopy, there will be a jerk and you will be hanging upright in your straps. As you approach the ground, keep your legs together and when your feet hit the ground, relax and roll over sideways.

The chances that you will ever need to use your parachute are very small indeed, but if the day does ever come, you will be very glad indeed that you have got it with you!

Trailers

A trailer is a necessary part of the equipment of every high-performance sailplane. When dismantled, each glider fits into its own trailer, wings and tail down the sides, and fuselage in the middle.

Glider trailers have two wheels, and the chassis and towing arrangements are similar to those of the normal caravan—a 2-inch ball-hitch, over-run brake, and fittings for lights.

Some simple trailers are of open design, something like a boat trailer, but most trailers used in Britain are covered in plywood or hardboard. This gives protection to the glider, which may spend a good deal of its life in its trailer when not actually being flown.

Rigging and derigging

A modern glider is designed so that it is easy to take it from its trailer and put it together, or to dismantle it.

The fuselage can be rolled out on its wheel, with a handling bar fixed near the tail end. Each wing can be carried by two people.

The Olympia was one of the first gliders to set good standards of easy and quick rigging; it can be assembled by three people in less than 10 minutes. The wings are hinged to the fuselage by two pins pushed through fittings at the root ends. Next the tips are raised, bringing the two ends of the spars together. These are then united by screwed taper bolts. The aileron and brake controls are connected by quick-release 'pip' pins.

The tailplane is held down by a screwed bolt in the centre, and a pip-pin connects the elevator control.

Fairings in the centre section and in front of the tail-fin complete the job, and, after a careful 'daily inspection', your glider is ready for use!

Building a glider

Glider construction may sound a very ambitious undertaking for an amateur, but assembling a glider from a kit is quite possible for the handyman. For some years now, Slingsby Sailplanes Ltd., of Kirbymoorside, Yorkshire, have supplied kits of parts to enable amateurs to construct their own aircraft, and a number of gliders have been built in this way.

These kits are arranged so that anyone who has reasonable skill as an amateur with tools can build the aircraft. All the major structural details such as spars, frames, and ribs are built by skilled aircraft workers and arrive with the kit complete and ready to assemble into the components. Perhaps two-thirds of the work of building the glider has been done in the kit; the work required by the builder is the final assembly of each main component and its fabric covering and treatment. The jigs required have to be built by the constructor but these are fairly simple, and are described in the instructions.

No particularly specialized tools are needed; the essential ones include—for woodwork—plane, chisels, tenon saw, spokeshave, hammer, screwdrivers, hand drill and bits, pincers, pin-punch.

There is very little metal work to do, but the following will be needed—hacksaw, pliers, set of spanners.

You will also need an oil-stone, try-square, spirit-level, plumb-line, rule in inches and millimetres, and CLAMPS (and more clamps).

Contents of the kits

Fuselages—frames, bulkheads, fin spars and fin ribs, complete and assembled with fittings. Formers, bearers, laminations, etc., ready made. Longerons, stringers, and members cut to size. Fittings required in the final assembly. Plywood and fibre-glass skins rough-cut to size ready for fitting. Cables and control components. Bolts, nuts, screws, washers, etc. Glue and hardener. Fabric for covering. Finishing for cockpit.

Wings—spars, sub-spars, and formers, complete and assembled with fittings. Ribs ready-made, members, and stringers. Fittings. Plywood skins rough-cut ready to size for fitting. Fibre-glass fairings, control cables and control components. Bolts, nuts, screws, washers, etc. Glue and hardener. Fabric for covering.

Tail units—details much the same as for the wings.

Glue and glueing

As nearly all the components are joined together by glue alone, it is vital to understand the proper use of glue.

The glue supplied with the kits is Aerolite 300 or 306. Aerolite 306 is a white powder which, when correctly mixed with water, becomes Aerolite 300, a clear treacly liquid. This glue is a synthetic resin, a kind of plastic which remains liquid until it is brought in contact with a catalyst or hardener. The usual hardener is a mauve liquid; there are other hardeners coloured green (faster) and amber (very fast).

Joints must be made so that they fit. If they do not they must be chiselled, sandpapered, filed and planed until they really do fit. When you are making a joint, the glue is applied to one surface and the hardener to the other. If the joint is between spruce and plywood it is preferable to apply the glue to the spruce and the hardener to the plywood.

As soon as the glue meets the hardener, setting begins. The surfaces are brought together in the right position and pressure applied until the joint has set. At 60°F. with the mauve hardener this takes five hours. The wood surfaces must be clean; after sanding don't even touch the surfaces with your fingers. When glueing plywood it is especially important to sand the surface thoroughly to make a good joint, as the process of manufacture tends to close up the pores of the wood.

Applying pressure for glueing

The pressure required to hold the parts in contact while the glue is hardening is not very great, but it is essential that the surfaces should be in close contact over the whole area to be glued. There are four main ways of ensuring this:

(i) *G-clamps*—these are available in various designs and sizes and are suitable for fixing members to frames and holding splices in members.

(ii) *Nipper clamps*—these are small spring clips, obtainable from Slingsby Sailplanes and other sources, and are used for clamping gussets and small section members.

(iii) *Weights*—can be used for applying a static load to a joint and should be used only for small parts such as gussets.

(iv) *Tack strip*—is used for clamping ply-panels and fibre-glass, and you will need a great deal of this. Pressure is applied by small nails which are hammered into the joint through a thin strip of wood about $\frac{5}{8}$ in. × $\frac{1}{8}$ in. section.

When the joint has hardened, the wood is pulled off and the nails withdrawn.

Splicing

When it is necessary to join wood members or plywood, this must be done by means of a splice. This splice must never be less than 12 to 1.

In ply the veneers form a useful guide to the accuracy of the splice, as it can easily be seen if the 'contour lines' they form are straight or not.

During splicing care must be taken to see that full wood-to-wood contact is obtained over the entire area of the splice.

A well-made splice has the same strength as the material; a badly made splice cannot be relied on to have any strength at all.

The making of 'Min'

My own experience in woodworking until a few years ago had been mostly in such jobs as making bookshelves and simple fitted furniture for my home, and I tackled my first glider construction job with some misgivings. These later turned out to be quite unjustified.

This job was to build a T.21 two-seater at a public school, with about a dozen boys, aged 14 or 15 years.

We had the advantage of a large workshop, with heating, and a very complete set of woodworking tools. We started with the kit for the rudder, because it is fairly simple and does not take many hours. Further, the constructional features include examples of the method found in the larger and more expensive components such as the tailplane and mainplanes. Progress was checked by a B.G.A. inspector, who was shown parts of the structure (such as plywood boxes) before they were closed in.

During this assembly we learned a good deal about wooden aircraft construction for a very small outlay. As we came to understand glueing methods, accuracy of assembly and alignment, importance of grain direction, selection of timber and plywood, and the locking of nuts on bolts and things of this nature, we became more fit to tackle the slightly more elaborate structures, the tailplane and elevator.

After that we were ready to undertake the much bigger job of the fuselage assembly. With the drawings and a schedule of the stages we were able to puzzle out the sequence of operations and eventually had the satisfaction of getting this large structure off its wooden framework jig.

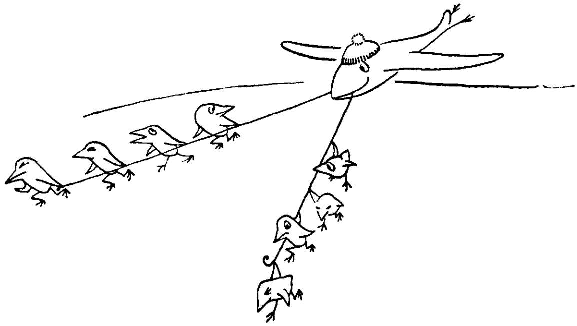
In our case, at this point we were lucky enough to have the wings presented to us, ready assembled 'in the white', i.e. finished ready for fabric and dope.

To complete the aircraft we had to fix the fabric to all components where required, and to finish the treatment with dope. In all good painting jobs most of the work is in the preparation of surfaces, and we all wore our fingertips away with hours of rubbing with wet-and-dry emery cloth.

The final stage was to spray on a flame-coloured dope; with the School crest on the side the glider was at last complete.

After careful weighing to establish the position of the centre of gravity, a B.G.A. inspector gave the official certificate of airworthiness and we were ready to fly.

I made the first flight with ballast in the second seat, just a climb to about 50 feet and a glide straight forward. After that circuits were flown, and a dive to the safe maximum speed of 92 knots. She was named 'Min' in a televised ceremony in which she had her nose sprayed from a soda syphon, and the fifteen constructors were soon learning to fly her. We had all gained a lot of pleasure from the year and a half's work on the undertaking, and had much more appreciation of what there is inside a glider and how it is designed and made.



3. First Flying Lessons

After some time on the field, helping others to fly, your own turn to fly will come. Your first flight will probably be in a T.21, the side-by-side two-seater of 54 ft. wing-span in use in most clubs in Britain.

This first trip will be 'air experience' with the instructor flying the glider. You go as a passenger and get used to the feeling of being in the air, hearing the noise the aircraft makes, and seeing the attitude of the nose in flight. You sit next to the instructor and can easily talk to him and see what he is doing. The controls are duplicated, the two sticks and two pairs of rudder bars move together—one set of instruments can be seen by both pilots. The cable release and brake lever may or may not be duplicated.

Step in over the cockpit side, preferably on the side with the wing-tip on the ground. Step on to the seat and then sit, the stick between your legs (this is possible for a girl in a skirt, but easier in trousers). Cushions may be needed for comfort, including one, sometimes, behind your back so that you can be sure of reaching the rudder pedals easily. Fix the harness which holds you firmly in your seat.

The cable arrives—it has been brought to you by other volunteer members who are working so that you can fly!

Cockpit check

The cockpit check is a very simple affair compared with that before taking off a large airliner—the check of which may take several hours, whereas in a glider it takes less than a minute. It is, however, just as important that it should be regularly and conscientiously made.

First the wing will have to be lifted and the glider held level by the member who is going to run with the tip at the start of the launch. Then:

(i) *Harness*—should be done up!

(ii) *Controls*—check for correct operation in the right sense. Give full movement and look at the control surfaces to see if they are operating. Elevator—aileron—rudder. If you cannot see these surfaces when strapped in, ask a reliable member to check for you as you move the stick and pedals.

(iii) *Undercarriage*—there is usually nothing to be done. The main purpose of this check is to remind yourself of the type of landing gear in the glider you are about to take off, so that you don't forget to take any necessary action after leaving the ground if the undercarriage has to be dropped or retracted.

(iv) *Brakes*—check the operation and make sure that they are locked before take-off. Numbers of pilots have taken off with brakes closed but not locked. As soon as the glider gains speed unlocked brakes are likely to suck open; this is often not noticed by the pilot and may lead to a dangerous situation when the glider fails to climb normally. The spoilers of the T.21 do not need locking, and are kept closed by a spring.

(v) *Cockpit cover*—is it locked? If it is not, it may quite likely blow off in flight. Apart from the obvious discomfort, it may cause damage to the tail as it blows away. This check may apply to a T.21, as there is a version with a removable canopy.

(vi) *Instruments*—the altimeter should be set either to zero or to the height of the aerodrome above sea level. The former is the appropriate one in the case of a training flight round an aerodrome.

(vii) *Trim*—check operation of tail-trimmer and set for take-off; in the case of an aero-tow it will be set well forward. Check that the weight of the pilots is between the limits given on the placard in the cockpit.

(viii) *Release*—the cable should not be attached until the other checks have been completed. The holder of the cable says, 'Open', and you pull the knob so that he can put the ring in position. When he has it in position he says, 'Close', you let go of the knob, and the cable is secured.

Check that the small ring is free to rattle. If it is bent out of shape it *may* jam and fail to release. Check the back-release action by getting your helper to pull the cable backwards until it comes off. Have the cable put on again.

You are now ready to take off (assuming the checks were satisfactory), and need another helper (or the same one!) with a signalling bat or lamp. You ask him: '*All clear above and behind?*'

It is not safe to take off with another glider landing close by.

(i) It may not keep straight if flown by a pupil and may even fly across your take-off path.

(ii) You may not be able to keep straight yourself on the take-off, and may collide with the other glider.

(iii) You may have to abandon the take-off and land to one side or the other. It will be dangerous to do this if someone is landing just behind you.

If all is clear, the first order to the signaller is '*Take up slack*'. The winch or car starts slowly, gathering up any slack in the cable, so that it can then accelerate away without any snatch or jerk.

When the slack has all been taken up and the glider is just beginning to move forward, the order '*All out*' is given, and you are towed away.

Signals may be given by bat or signal light. A bat is waved below the horizontal for 'Take up slack', and above the head for 'All out'. It is held straight up above the head for 'Stop'. If two bats are used, one is waved up and down for take-up slack, and both together for all out. They are both held straight up for stop. If lights are used, a slow flash is given for take-up and a quick flash for all-out. A steady light means 'Stop'.

You now accelerate forwards along the grass or runway and float off the ground. You will notice the ground appears to drop away rapidly beneath you as the instructor raises the nose and puts the glider into a steep climb. You won't be able to see much in front of you during the climb, except sky, so look over the side and try to spot features on the ground below. When you reach the end of the field, and seem to be almost above the winch, the nose will be put forward, the cable dropped, and the glider will then be in free flight.

So far you will have been flying at about 40 to 45 knots (55 is the maximum allowed for a T.21 on the launch), and the speed will now be reduced to about 35 knots. The windscreens will protect you from the main 'blow', but you will feel quite a strong air-flow rushing past. Apart from this, there will be very little feeling of forward speed, as by now the ground is about 1000 feet below you.

There may be some feeling of up-and-down movement. A glider does not always 'glide' smoothly along like a sledge on perfectly smooth snow. Unless it is an especially calm day you may feel some invisible 'bumps' such as you would feel in a small boat on waves or in a car on humpbacked bridges. You can't see the bumps coming, so don't be surprised if, instead of a bump up being followed by a bump down as on water-waves, you feel perhaps three up followed by two down. You will not be taken for your first flight on a rough day, but there are days when it feels almost as if you are falling through 'holes in the air'—formerly described by the quite expressive term 'air pockets'.

Next the glider will be turned one way or the other, eventually to return near the start for a landing. You will not be surprised to find that this is done by leaning the aircraft over to the side to which you want to turn; you have done this yourself many times beforehand on a bicycle.

Don't try to keep your head level with the ground, but let yourself lean over with the aircraft, so that you are still upright in your seat.

If you don't find any upcurrents, you will reach the ground again after four or five minutes. When you are down to 300 or 400 feet you will see that your pilot has got you quite near the landing point. After a final turn about the height of tall trees, you will glide in over the aerodrome boundary and see the ground coming upwards to meet you. You will now seem to be moving much faster and, after skimming the ground for a short distance, you will feel the wheel touch the ground and the glider will soon come to rest. One wing will then tip gently over sideways to the ground. After landing you stay strapped in until the 'ground crew' arrive to help move the aircraft.

The first part of your first flying lesson is over. However, most clubs give two or three training 'circuits' in succession, so, when you have wheeled the glider back to the start with one or two helpers, you may hope to get in again for another flight.

This time you will have the chance of flying yourself for a fair part of the flight. The take-off and landing will be done by the instructor.

You will probably be asked to do the cockpit check yourself—the various items are repeated aloud—and you will give the instructions to the batsman. These instructions are given only by the pilot and not by any bystander, with the exception of 'Stop' which can be given if necessary by anyone. If the 'Stop' is given by someone else, you should immediately release the cable, to make sure of stopping in case the winch driver does not see the signal in time.

Effects of controls

After release at the top of the launch, the instructor will show you the effect of the controls. Look ahead at the horizon, and watch for movements of the nose of the glider. If you press the stick forward, the nose will go down and the speed will increase, you will feel more air-flow, and hear the glider making more noise. As you ease the stick back, the nose will come up and the speed will decrease.

This control is quite sensitive, and the faster you go the more sensitive it becomes. You will have felt the same effect on the controls of an ordinary bicycle.

After having tried this, you will try the effect of moving the stick sideways. You remember that this controls the aircraft 'in roll', i.e. enables you to keep the wings level or to tip the glider over to one side or the other. Pushing the stick to the left pushes the left wing down and raises the right wing; stick to the right pushes the right wing down and raises the left wing.

As you have dual controls connected together, it is important to know which of you is actually flying the glider. When you are to do the flying yourself, the instructor will say, 'You have control,' and lift his hands up well above the controls. When he wants to take control again he will say, 'I've got her,' and you should take your hand off the stick.

The stick should be held gently in your right hand. Even if you are normally left-handed, you should learn to fly right-handed, as there are several other controls to be operated from time to time on your left-hand side.

It is obviously impossible for you to work the elevator while the instructor works the ailerons, so you will now have to have entire control of the stick to try to keep the glider straight and level at a constant airspeed. If you cannot feel exactly when you are level, try checking with a quick look towards the wing-tips to see if they are both the same height above the horizon. If the glider starts turning in one direction it is almost certainly because the wing on that side has been allowed to drop.

You will also be shown the effect of the rudder. You will see how pushing on the left foot makes the nose slide to the left, and the same action on the right makes it slide to the right.

As the nose slides to the left you will sense the glider skidding sideways, and will feel the air blowing on your face from the right. This sideways air-flow from the right can be corrected by applying rudder on that side. The main use of the rudder is to correct these sideways movements of slipping or skidding, and it is a mistake to think of the rudder as the main turning agent. It is rarely used on its own, but almost always a little application of rudder is needed in the same direction as a sideways movement of the stick.

There is no need for intense concentration. Some people seem to have the feeling that if they relax for a second the glider will immediately turn upside down! In fact the glider is quite stable, and will probably fly itself better without your hand on the stick on a calm day. You will soon learn to ignore very small irregularities in the air, which are dealt with by the natural stability of the glider. Don't waggle the stick about all the time, but try to make smooth, definite movements as required in the right direction. After a few lessons the movement in the correct sense becomes an automatic reflex action.

Flying straight and level

You should soon be able to achieve this. Looking well ahead at a fixed mark near the horizon, try to control your vehicle in all three dimensions in which it moves.

(i) *Keeping the wings level.* If the left wing drops, move the stick gently to the right and apply a little right rudder. When the response begins to be felt, start centralizing the controls, so that when the aircraft is level again the controls are once more central. Carry out these movements to the left, of course, if the right wing drops.

(ii) *Pointing in the right direction.* If the nose swings to the right, it is probably because the right wing has dropped a little. You need to apply a little left bank and left rudder until you are almost pointing back on the mark, and then straighten up and centralize once more.

(iii) *Keeping correct airspeed.* Judge the attitude of the glider by where the nose or windscreen cuts the horizon. If the nose begins to move up on the horizon, ease the stick forward a very little and try to hold the nose at a slightly lower angle. When the attitude is steady, check the airspeed by the air-flow on your face, and the noise and the Airspeed Indicator. Beware of 'chasing' the A.S.I. with the stick; you will find it very hard to attain a steady speed by this means. The instrument can be valuable, however, in giving you a check on your speed when you are flying at a steady rate.

Medium turns

In order that you can be actually flying the glider yourself as much of the time in the air as possible, your instructor will probably already have told you to push one wing down a small angle and hold it there, and then later to level off again and you will have found yourself staggering round the aerodrome circuit in a series of swoops. It is now time to start doing some properly controlled steeper turns, finishing in some definite direction.

Before starting any turn always *have a good look round.* The commonest cause of accidents on the roads is turning right without giving proper warning. In the air you are also not alone. You are not quite so likely to run into anyone else, but as the penalties for even a slight collision are so much more severe, you cannot be too careful about this point! Always make it the routine first part of every turn—'Is it clear to turn? Am I going to cut across the path of another aircraft?'

To take a corner on a bicycle, it is essential to lean over to the side of the turn. For efficient high-speed turns in a car it is necessary to have the road banked. The higher the speed and the sharper the turn, the steeper is the angle of bank needed. On a motor-cycle you can even find a suitable track to make a vertically banked turn—such tracks are used in the 'Wall of Death' stunt.

In any kind of vehicle, for a certain rate of turn at a given speed, there is only one correct angle to bank. In the air you have the advantage that you can select just the amount of bank you need. You should never feel the uncomfortable sideways force that you experience in a car when cornering too fast for your angle of bank.

You should learn to do a turn in three parts, going in, staying in, and coming out.

Going in. Look round; then in a left turn move the stick gently to the left, together with a little rudder in the same direction, until you have the required angle of bank.

Staying in. Keep the angle of bank constant with the ailerons. Keep the nose in the correct position on the horizon with the elevator. Prevent slip or skid with the rudder.

Incorrect use of the rudder will mean that the glider travels partly broadside through the air; you then feel an air-flow in your face from one side or the other. Correct this by using rudder on the side the draught is coming from.

Look round frequently during the turn.

Coming out. Use the stick and a little rudder to take off bank. As the aircraft becomes level, centralize the rudder and stick and use the elevator to keep the airspeed correct.

To fly well, either straight or in turns, you must become *horizon-conscious.* It is no use looking close in front of you when trying to drive straight a motor-mower or a tractor; you must look at the far hedge. In a glider you must transfer your attention and focus to the *horizon,* and not concentrate on the instruments or the details of the nose. Beginners who have not learnt to do this often 'see the horizon tilting'.

This feeling is understandable, for your sense of balance can tell you little difference between flying steadily in a properly made turn and flying straight and level. (Except for a slight increase in pressure from the seat.)

Keeping your eyes on the horizon, you soon get used to the proper interpretation of the horizon's always being level, with yourself and the glider tilted over at various angles.

In a good turn a point in front of you in the glider—for example a part of the windscreen—should slide uniformly along the horizon, neither rising up into the sky, nor boring down into the scenery beneath.

Stalls

The lifting force needed to support a glider at different speeds is obtained by moving the wings through the air at different angles. If the angle to the air-flow is increased more and more, the lift will not go on increasing indefinitely. When a certain angle is reached the lift suddenly decreases and the drag gets much bigger.

What has happened is that the air is no longer flowing in steady streamlines past the wing surface, but has broken away from the top surface into an irregular series of eddies. The wing has *stalled.*

If you gradually pull the nose up and lose speed, the controls, particularly the ailerons, will become very ineffective. You may feel some slight buffeting of the tail behind you, and eventually as the stall is reached the nose will drop quite sharply. As the glider dives it will regain speed and unstall itself, and you can regain normal flying attitude. If you keep the stick back another stall will happen, possibly much more violently than the first.

So there is no particular skill needed in practising stalls! The point is that 100 or 200 feet may be lost in a stall, so there must be no question whatever of stalling accidentally within 200 feet of the ground. If for any reason you find yourself flying too slowly, the glider may become stalled, and it is important to recognize the onset of a stall and to correct it.

Spins

If both wings are stalled equally, then the glider will unstall itself straight ahead, but in the case of a partly one-sided stall, there is the possibility of a *spin* developing.

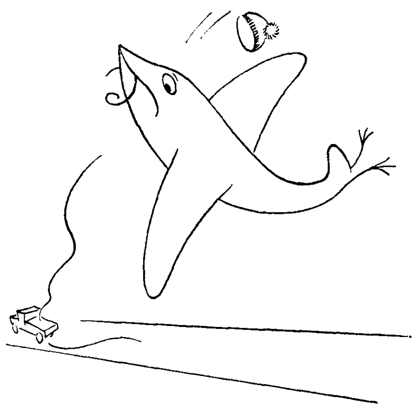
One error in correcting a stall is to try to raise a wing which is falling by the normal use of ailerons.

Suppose the left wing is falling, then stick to the right will raise the right aileron, slightly reducing the steep angle of this part of the wing. The left aileron will go down, further increasing the angle of the already stalled wing. The effect then will be that the left wing becomes more stalled and the right wing less stalled. The glider will fall round and down to the left, the right wing will swing round and travel through the air much faster than the left, increasing the difference between the lift on the two wings. You now have conditions for the stable 'spin', in which the glider makes a steep spiral descent, losing height rapidly.

The most likely way to get into a spin—and with careless flying, people *do* get into spins accidentally—is to have the glider already swinging round in a turn, the airspeed getting slower and slower, and more and more rudder being applied. As the nose drops, and the speed of rotation increases, the natural thing to do is to pull back the stick to bring the nose up.

As this 'natural' action will merely make things worse, it is necessary to practise the correct action, which should be learnt by heart—'Full opposite rudder—slight pause—stick steadily forwards until the spin stops. Centralize rudder, and ease out of the resulting dive.'

Your training will probably concentrate on dealing with *incipient spins*; that is, in recognizing that a spin is just starting, and stopping it quickly by the correct action before it has time to develop fully.



4. Up to Solo

The launch

Training flights start for most pilots in this country with a car or winch launch, so I shall leave the description of how to do bungey-launches and aero-tows until later in this chapter.

A *car launch* can be divided into five stages—ground run, take-off, initial climb, full climb, and release.

(i) *Ground run*

As the 'all-out' is given and you begin to move forwards, for the first few yards the wing-tip runner will be able to keep your wings level. After he leaves you, unless the wind is quite strong, you may have to make firm, coarse movements of the ailerons and rudder to keep the glider rolling straight and level. Application of rudder should be used firmly to keep you straight; when the wheel is still on the ground the rudder really will make you change direction, not just make you slip or skid as when in the air.

The glider may have been resting before the take-off with its tail on the ground, or more likely with the nose forward and the skid on the ground. In either case the object is to get yourself rolling smoothly forwards on the wheel alone. You do not want the skid rubbing on the ground in front; with the nose in this position enormous speed will be needed to get you off the ground. You do not want the tail-skid dragging on the ground behind; in this position the glider is likely to float off the ground with the nose up in the air, going much too slowly.

(ii) *Take-off*

Having got the glider rolling steadily along on the wheel alone, you wait until the speed has increased enough for the glider to float off the ground on its own in this attitude.

(iii) *Initial climb*

On floating off the ground, you do *not* just pull the stick hard back and rocket upwards! That is the only definite statement about stick positions I shall make. Whether you have to push or pull depends on the type of aircraft and on various factors in the same aircraft from flight to flight. The plan of what you are trying to do, however, can be quite clearly stated. It is to increase the angle of climb as quickly as is safe, allowing for a sudden loss of power.

The most likely cause of loss of power is a cable break. As a cable break when climbing steeply may involve a loss of height of 100 feet while regaining speed, it is obvious that you should not be climbing steeply until you are at least 100 feet up.

(iv) *Full climb*

The stages so far into which I have divided the launch all pass smoothly from one to the other, and so, by 100 feet, the climb should have been progressively steepened to the angle which it is hoped to hold to the top of the launch.

During the climb, the aircraft is kept straight by keeping the wings level, except sometimes in the case of a slight cross-wind. In this case, if the wings are kept level, then it may be quite all right for the glider to drift a little sideways, but the cable may drop well away from the runway. If it is essential to avoid this, it can usually be done by keeping the windward wing down a little throughout the launch.

The speed is mostly decided by the speed the car is travelling and, of course, the speed of the wind. However, increasing the angle of climb has the effect of increasing the airspeed of the glider, as it then travels faster round the arc of a circle with the car at its centre. The speed must not be allowed to get too fast, as heavy loads may be put on the aircraft. In extreme cases in which the maximum placarded speed is being exceeded, you must release and abandon the launch, and not rely on the emergency 'weak link' in the cable which is provided as a safety precaution.

If the launch is a little too fast, it is quite a common thing to experience a rhythmical pitching or bucking towards the top of the launch. This can usually be stopped by easing the stick forward a little and holding it steady there. It is difficult to correct the effect with rhythmical movements of the stick—this almost invariably makes things worse!

(v) *Release*

As the car slows down near the end of the runway, you feel a sudden reduction of airspeed. Now is the time to lower the nose to the usual flying attitude, and then release the cable. You should have been flying with your left hand close to the yellow knob, so pull it firmly twice, to make sure the cable has gone.

Winch launch

There is very little difference from the pilot's point of view between a winch and a car tow. Anyone who has learned to fly on one type of launch will quickly learn the other method.

The chief differences are at the beginning and the end. The winch gives a much greater acceleration at the start than the car. In a car launch it is obvious when you reach the end, you can feel a sudden slowing down. It may be a little more difficult at first to know when you have reached the top of a winch launch. You cannot always see the winch during the climb, but you can see some landmark on the ground to one side, level with it. Towards the end, the rate of climb will be much reduced, and the downwards pull on the nose will increase. A good driver will shut off power to tell you when to release.

Cable breaks

A cable break during a winch or car launch is easily recognized. There is a sharp cracking noise, the aircraft jerks, and the airspeed begins to fall off.

The first thing to do is to lower the nose quickly to a safe attitude, build up normal speed again, and fly forwards in normal flying attitude.

The second thing is to release the remains of the cable. It is essential to do this, as there is no means of telling whether you

7 T.21 approaching (first solo flight)

8 BUNGEY-LAUNCH

Above: Skylark 2 ready. *Below*: Skylark 3 dropping the rope

have only a foot or two of cable hanging from the nose, or perhaps anything up to 1000 yards of it.

The third thing is to decide where to fly next. This depends on the height you have, and the size of the landing ground.

The decision *may* be quite easy. If you are only 50 or 100 feet above the ground, go straight ahead, using brakes as necessary. If you are above 400 feet, there should be no difficulty in doing a normal circuit, unless the wind is very strong indeed.

The more tricky decision has to be made when you are too high to land straight ahead in the aerodrome, but in doubt whether you are high enough to do a circuit. In this case turn left (or right), and then while flying cross-wind decide either to turn back again into wind and land straight ahead, or to turn on left and complete a circuit.

A similar problem occurs when passing traffic lights at cross-roads in a car. You approach at green; will the lights change to amber? If they change well before you get to the line, then you clearly must stop before you get there, and will not go across. If you are a good half-way over before they change then there is again no doubt, and you should get over safely. The tricky decision is the one that has to be made quickly when the change happens just as you reach the line: are you to stop quickly, probably just beyond the line, or to go on and just get across? (This is complicated by the fact that the cars the other way will probably start before the green light!)

Every time you pass traffic lights in a car, you rapidly pass through these stages. Every time you climb on the launch in a glider you quickly pass through stages when different action will have to be taken if the cable breaks.

Approach planning

In your first few flights, after you have practised any special exercise, your instructor will probably have told you roughly where to turn, and arranged that you arrive at about the right place for a landing. As soon as possible you will want to start planning this yourself.

You will not get very far if you try to fly a glider 'by numbers', such as (1) turn left at the church at 600 feet, (2) fly down the main road to the garage, (3) turn left again, (4) after 20 seconds ease the stick back gently to land. Every approach is different from the previous one, and although good circuit judgment only comes with practice, you will find it a help to have some general principles to go on.

One basic fact to bear in mind is that, although it is comparatively easy to lose height in a glider, it is not possible to gain height quickly at any time at will. You must fly within gliding distance of the field; there must be no question of undershooting.

For beginners, the '45 degrees angle rule' is a help in this connection. You do not have to keep within the boundaries of the field if you are at a good height; by this rule, at the height of one mile (5280 feet), you would allow yourself a mile distance from the aerodrome. It is not hard to judge such an angle, but remember that this rule alone will not save you from clipping off television aerials and tops of trees.

Immediately after release get your airspeed settled, and then, if you are not in a thermal, turn about 45 degrees to the right or left. The correct way will mostly depend on which side it is the easiest to make the final approach. For instance, the boundary may be less obstructed on one side than on the other. It is not a good plan to cross the launch-line later on in the flight.

A good launch to 1000 feet should give some scope for your training manœuvres and for thermal hunting. If you do find a thermal, you will drift downwind somewhere near the aerodrome boundary, out of other gliders' way, and in a position to make an approach and landing if necessary.

The approach planning proper starts by getting yourself at a height of 500 or 600 feet somewhere near the area marked in Fig. 7. Flying downwind in this area you look at the landing point. If you think you are too high, you edge out a little to widen the circuit. If you think you are too low, then you edge a little inwards towards the aerodrome.

The object is to arrive at a height of about 300 to 400 feet in an area near the downwind boundary of the field so that you can fly a 'cross-wind leg' from there.

At the beginning of this cross-wind leg you should do three things:

(i) Increase your speed.

(ii) Disregard the altimeter from now onwards.

(iii) Put your hand on the brake lever, ready to use the brakes when required.

Again consider your position in relation to the landing ground. Look down and see if your angle from it is getting shallower or steeper. If it is getting shallower, you are undershooting, and should turn in at once and land before you reach the spot you had previously planned. If the angle is getting steeper, you are overshooting. This can be dealt with by edging the cross-wind leg out a little, and also by application of brake. A little brake only should be applied at first until you are quite sure of the steady effect it is having on you.

In the ideal approach the final turn into wind is made as you come into the line of your planned landing path. This turn should be completed by at least the time you are down to 100 feet. Don't look at the altimeter at this stage, but judge this height as 'the height of tall trees'.

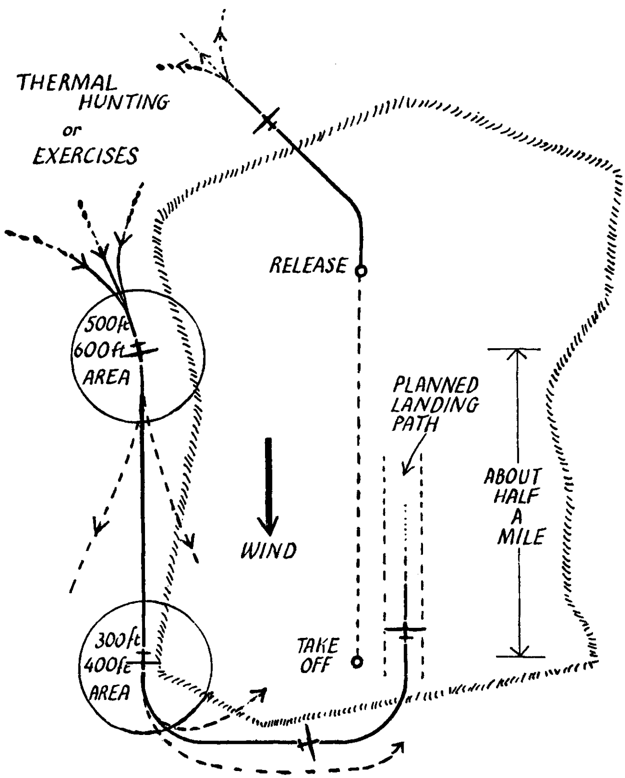


FIG. 7. Approach planning

If the wind is strong, the final leg should be made inside the aerodrome boundary, but otherwise the turn will have been completed just before reaching the boundary.

You will now have a steady straight glide for some distance until you arrive close to the ground ready for the actual touchdown. The brakes will probably be full open, or nearly so; it is best not to alter their position during the final stages, except for some special reason, such as getting too slow, or a bad bounce.

If you reach the line of the landing path very much too high, then you will have to alter your plan. Turn away from the boundary a little and fly on past the line. You will then be able to turn back and approach in a short cross-wind leg as if from a circuit in the opposite direction. Do *not* turn your back on the field.

The landing

As you near the ground, keep the wings level, the speed steady, and look well ahead. Look towards a point about two glider-spans in front. When you are about the height of the top seat in a bus, begin to 'round out', that is gently to reduce the rate of sink by steady backwards movement of the stick. Try to keep the glider flying just above the ground as long as you can. Eventually it will sink on to the ground in the landing attitude.

When you touch down, you will still be running forward at quite a speed, so keep straight and level by coarse movements of the controls—if you allow a swing to develop at this stage you may find it impossible to stop it as the effectiveness of the controls dies away.

If you check the sink too late, you will hit the ground in flying attitude and may bounce off again. If you check too soon, i.e. too high, then you may find the glider flying too slowly quite a height from the ground; you will stall several feet up and then be liable to drop rather hard. If you check too suddenly, then the glider will rise again away from the ground.

Landing may seem difficult the first few times, but it is an art that is soon learned with practice.

The secrets of learning to land are:

(i) A long steady glide in, looking in the right place.

(ii) The first gentle checking control movement made in plenty of time to see the effect obtained, and thus to know whether to increase or delay further easing back to make the correct 'round-out'.

Effect of wind

Some people find it hard to realize that if the wind is perfectly steady, then the way the glider flies *through the air* is completely unaffected by it. Flight upwind and flight downwind are indistinguishable, except by reference to movement of the ground beneath.

A glider flying at 40 knots airspeed on a day with a 30-knot wind will travel at 10 knots over the ground when flying upwind, and 70 knots over the ground when travelling downwind. This is of course the idea behind the usual practice of taking off and landing into the the wind. During this 30-knot day, all the time the glider is in the air, whatever is it doing, the actual lump of air it is flying in at any time is drifting in the downwind direction at 30 knots.

Cross-wind landings

It is not possible to land a glider safely when going sideways to a 30-knot wind. However, landings may have to be made when the glider approaches the ground in a line not exactly straight into wind, and consequently with some sideways drift across the ground. This drift must be eliminated at the instant when the actual touchdown is made.

One method is to neutralize the drift by slipping sideways towards the side from which the wind is coming. This can be done only by holding the wind down on that side, and it is not easy to do this safely in a large glider whose wing-tips are near the ground, even in level flight.

The other method involves swinging the nose of the glider away from the wind direction just before the ground is touched. If done smoothly to the correct extent, this can eliminate any sideways sliding of the undercarriage across the ground, but it will involve drifting away from the original line of the approach.

Flying in strong winds

The basis of the trouble here is that it is not in the nature of strong winds to be steady! In a wind of an average speed of 30 knots, there are likely to be gust variations in speed of 10–15 knots. When flying through sudden variations of this sort, the glider is quite likely to be accidentally stalled, unless quite a large reserve of speed is kept.

Another obvious risk of flying in a strong wind is that of misjudging the circuit, finding yourself too far downwind behind the boundary, and being unable to get back to the field.

The main risk in operating gliders in strong winds has been shown to be the chance of damage while they are being handled on the ground.

Wind gradient

You will have noticed that on an open sea-beach, or on a mountain-top, the wind usually seems to be strong. You are getting much more of the full force of it in these cases. The effect of houses, trees, and other obstructions is to slow down the wind in the lower layers, and above them the wind is much stronger. *Wind gradient* is the term for the rate at which the wind increases with height.

The wind gradient is noticeable only in the lowest 300 feet or so, and is usually most marked in strong winds about 150 feet above the ground. The wind speed does not change very rapidly with height above 1000 feet.

Let us take an example in which the wind speed at 300 feet is 30 knots, but only 10 knots just a few feet above the ground. Flying into wind, the glider descends the last 300 feet fairly rapidly. As it comes down quickly into a layer where the wind is less, this sudden wind change causes the airspeed to drop off. In this example, if the aircraft is held in a steady gliding attitude, it will arrive at the ground with 20 knots less airspeed than it had at 300 feet. This danger can be avoided by lowering the nose progressively during the last 300 feet to make sure that the glider maintains a safe approach speed.

The rapid sink of a glider approaching the ground in a strong wind gradient has to be experienced to be believed. The effect has been expressively described as 'the clutching hand'.

Bungey-launch (Catapult)

I have already described how this launch is arranged; what the pilot has to do is very simple indeed.

There will usually be a fairly strong wind, as this type of launch is off the top of a hill with the object of hill-soaring. As soon as the glider begins to move forward you should ease back a little on the stick to get the tail down, and remove friction on the ground due to the skid. The glider will run forward a few feet on the wheel and float off into the air. As the speed continues to increase, the glider will tend to climb. It must not be allowed to do this, as the launching rope will then fall off the nose-hook while still under tension, and 'ping' forwards on to the bungey crew. This will certainly discourage the crew from pulling so well another time, and may even injure its members. Even worse than that, it will leave you with your nose up in the air, cut off from the energy that should have been available to you from the stretched rope.

So, as soon as the glider is a foot or two above the ground, press forward to stop it from climbing. In the early stages of the launch you will remain only a few feet from the ground, gaining speed from the pull. As the ground now begins to drop away beneath more steeply, you will fly out away from the hill and the rope will drop off.

All this time, of course, you have been keeping the wings level with the ailerons.

As a beginner, you may find it all happens much too fast for you to be able to sort out all the stages I have described. However, when you have done a few launches yourself, you will find out that this is a delightful way of being launched. Perhaps you may then feel like doing your part in supporting an old custom which seems in danger of lapsing. This is to shout down, 'Thank you', as you pass over the bungey crew whose efforts have launched you.

Aero-tow

An aero-tow is very easy to do on a calm day, but may be difficult on a turbulent day with strong upcurrents.

About 200 feet of nylon rope are used, attached to a release hook at the tail of the aeroplane. A 'tugmaster' is appointed, who stands near the aeroplane to relay signals to the tug-pilot, and can stop the take-off if anything is wrong. When the 'all-out' is given, the aeroplane starts off at full throttle. The wing-tip runner may have to run some way on a windless day. As he lets go, aileron control should be obtained and the glider will soon be airborne.

You will reach flying speed before the aeroplane, but should not allow the glider to climb. Hold it down two or three feet above the ground and wait until the aeroplane gets off. As the aeroplane leaves the ground and begins to climb, let yourself climb too, so as to be still very slightly above the tug, with it appearing about half a wingspan below the horizon. (*See* Plate 10.)

You will be travelling fast, so the controls will be very sensitive, and there will be a tendency to climb, which should have been reduced by forward trim before take-off.

If you get too low, it is simple to climb gently up into position again. When you are low, you may find the slipstream of the tug gives considerable turbulence which may make it hard to keep the wings level.

If you are too high, come down with some care. A steep descent will cause a large bow in the cable. Unless you are careful, this will eventually take up suddenly and shoot you forwards, making a larger bow than before. Descend gradually until almost in the right position; then just before the rope comes tight dive a little more to ease the shock.

Turns should be made quite gently by the tug, and are easy if you are careful to start turning at the same rate, and to stay straight behind, neither cutting off the corner, nor swinging outside.

On a rough thermal day a tow may be hard work. As the tug flies into a thermal, it suddenly bobs up in front of you. If you immediately take action to climb up to the same level as the tug, then you will very soon find yourself much too high as you climb in the thermal yourself about three seconds later.

An experienced tug-pilot can tow a beginner into a good thermal and leave him there, but you will want to learn when to decide to release yourself. The variometer can help, provided you can get a fairly steady reading. Don't forget to allow for the fact that you must subtract the combined total of the average tug-climb and your normal sinking speed from the vario reading. Any reading less than 10 ft./sec. is not going to mean much after you have subtracted the rate of climb of the tug and your expected sink through the air after release.

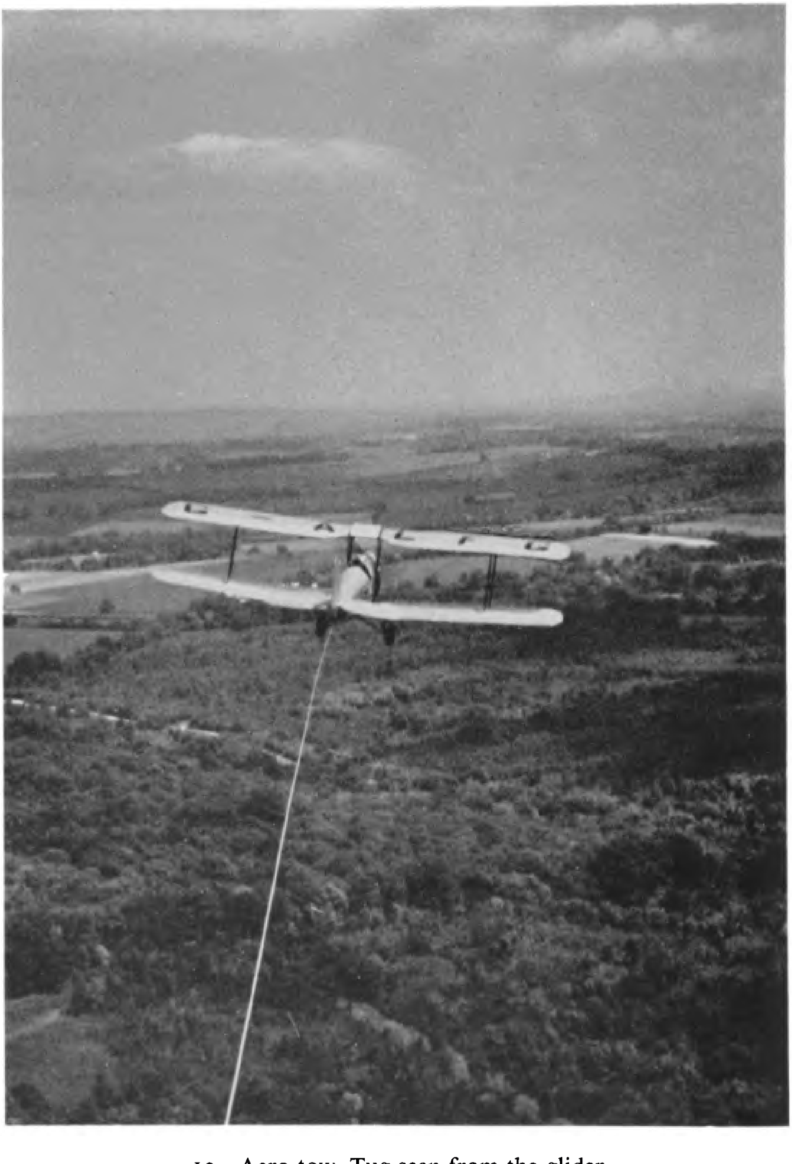
There is not usually any means of communication between the glider and the tug, but there are some standard simple signals for use in an emergency.

If for any reason the tug is in trouble, the pilot can signal the glider to release by a vigorous waggling of his wings. This must be obeyed at once by the glider pilot. The most likely causes of trouble are engine failure in the tug, or the glider taking off with the air-brakes open. These are not likely things to happen, but if they do occur, very quick action is needed to avoid an accident.

In the unlikely event of the glider being unable to release, the pilot should fly well out to the left side and waggle his wings. The tug can then tow him above the aerodrome and release him there, leaving him to get down with the cable hanging below. This can be done safely, if the approach is made a little higher than usual.

It is not a good thing to use air-brakes on a tow. The only occasion when they will be useful is if a descent has to be made on tow.

9 Aero-tow (Tiger and Skylark 3)



10 Aero-tow. Tug seen from the glider

Solo flying

When you can fly reliable circuits without being prompted by your instructor and can cope safely with spins and cable breaks, it is time for you to take the tests for the first gliding certificates. To do this, of course, you have to fly solo, which is allowed only if you are over 16 years old.

It is quite impossible to give any simple answer to the question—'How many flights shall I need to solo?' I have never sent anyone solo in less than 25 circuits, and twice that number is more usual. An experienced instructor will know when you are ready to fly by yourself and when you reach this stage you will be allowed to do so. It is a mistake to think of it as a specially awesome occasion, or as the stage when you officially know all about how to fly!

You can get a lot of entertainment learning how to fly with an instructor; you can continue to enjoy yourself finding out much more still on your own.

The ideal way to do your first solo is for the instructor to get out, and for you to fly the two-seater right away on the same sort of flight as the previous one, with ballast instead of the instructor. At many clubs, however, it is the practice to convert straight away to a single-seater for first solo flights. This should cause no difficulty if you are carefully briefed about the differences from the two-seater.

Until you have much solo experience you will have two-seater check-flights with an instructor before further solos and later when converting to other more advanced types of aircraft.

A, B, and C Gliding Certificates

The qualification for the 'A' is a solo straight glide of more than 30 seconds, with a normal landing. It is now usual to do a complete circuit for this test.

For the 'B' you have to make two flights of more than a minute each, with a turn to the left and one to the right.

The 'C' is the first certificate for soaring. The flying test consists of staying up for at least five minutes above the previous lowest point reached.

There is also a short written examination on Air Law, to ensure that you are a safe person to be let loose in an aircraft away from your home aerodrome. Forms have to be certified by an official observer, usually a club instructor, and a small fee is paid to the B.G.A. A little booklet with your photo in it, something like a car driving licence, is issued. Small badges are available, showing one, two, or three seagulls on a blue background for the A, B and C respectively.

Air Law affecting gliding

Before the test for the 'C' certificate you should study a booklet on this subject prepared by the B.G.A. Here are some of the more important points from it.

(1) Restrictions on where you may fly

Prohibited areas consist of a number of small circular areas, mostly in the neighbourhood of atomic stations. They usually extend from the ground up to 2000 or 4000 feet. Flying below 2000 feet within 5 nautical miles of certain of the largest airports without permission by radio is also prohibited.

Control zones and airways

You may fly in these areas in fine weather, provided you keep clear of cloud. The precise requirements to be observed are:

(i) Horizontal visibility at least 5 nautical miles.

(ii) No cloud within 1 nautical mile horizontally.

(iii) No cloud within 1000 feet above or below the glider. (These are known as Visual Meteorological Conditions.)

A Purple Airway is an airway set up for a journey by a member of the Royal Family. The conditions are as above, but you should keep out altogether within 30 minutes of the expected time of passing of the aircraft.

Aerodrome traffic rules

These rules apply to areas extending up to 2000 feet, within 3000 yards of aerodromes. If you need to be in these areas, you should make a left-hand circuit, except in certain special cases.

When proposing to land on an aerodrome, you should be sure that it is not one for which prior permission is needed, and should understand the ground signals in the signal square. You should land in the direction towards the head of the landing T. If there is not a T, land into wind.

(2) Rights of way

If you have the right of way, you should maintain your course and other aircraft must keep out of your way (but not by passing over or under you).

If two aircraft are on converging courses the aircraft which has the other on its right must give way. If the approach is head-on, both must turn to their right.

Overtake on the right, except when hill-soaring, when you must overtake between other gliders and the hill.

Landing. The lower glider of two approaching to land together has the right of way.

Power craft officially have to give way to gliders, but when a glider meets a large, fast aeroplane which is hard to manœuvre, common sense should be used. In any sort of traffic, common sense and intelligent anticipation are more useful than insisting on your rights.

Don't forget that in a glider you have to give way to balloons!

5. Gliding Weather

Will it be a good day for gliding?

The sort of weather we want naturally depends on the kind of gliding that we hope to do.

Training circuits can be made in any reasonably clear weather, preferably in a wind of not more than about 15–20 knots. Visibility is quite important—in the early stages a clear horizon viewed ahead is a great help—and it is quite easy to lose your bearings on a murky day, even above a well-known aerodrome.

Hill-soaring needs a steady wind blowing in the correct direction up the slope, with the hills well clear of cloud.

Thermal soaring does not need a strong wind, but needs a certain amount of sunshine. Rising convection currents of hot air are started from the ground by heat from the sun, but whether on any day these currents will be strong or extend to a great height depends also on the temperature at different levels in the air. When a glider pilot falls down a drain through looking too anxiously at the sky, or rushes rudely away from his friends at weather-forecast time, it is because he is trying to gain information about conditions present in the air-mass overhead or soon to arrive.

What we all want to know on any day is whether the atmosphere in the layers in which we hope to fly is stable or unstable—i.e. if a lump of air is warmed and starts rising, will it slow down and fall back again, or will it increase its speed and go on upwards?

Picture a 'bubble' of warmed air, about the size of a large gasholder, starting to rise from the ground. As it rises, the pressure reduces; the bubble expands and therefore cools. If, however, there is a very rapid rate of fall of temperature with height in the atmosphere, then the bubble may still be warmer than its surroundings and will therefore continue to rise.

So, for thermal soaring, we look for air with a large rate of fall of temperature with height, or a high 'temperature lapse rate'.

Air-masses

There are large areas of the earth's surface where the temperatures and humidity are about the same, and as the air-masses from above these areas move away, they have fairly uniform properties. As they travel, they will be modified, especially in the lower levels.

The simplest classification of air-masses is into *polar air* and *tropical air.*

Polar air comes to us from high latitudes, and as it travels southward it gets heated in its lower levels. It is therefore likely to be unstable, with good convection and good visibility.

Tropical air comes from lower latitudes, and is originally very warm from the surface upwards. As it travels northward it gets cooled in the lower levels, and therefore becomes stable. Convection cloud is unlikely, and visibility is poor.

Anyone who spends much time out of doors must recognize the broad difference between life in polar and tropical air. Surface temperatures alone are not the test, but the keen glider pilot will be able to tell what air-mass he is in as soon as he wakes up in the morning. The chief test is probably visibility; the most definite example of polar air is sparkling 'April weather', with showers and bright intervals.

Inversions

Particularly after a clear summer night, the ground may have cooled so much that the temperature increases for the first 1000 or 2000 feet instead of decreasing with height. An *inversion* of the normal temperature lapse rate has been set up.

Any air rising in this layer will rapidly meet warmer air, and find itself cooler than its surroundings. An inversion thus will not let any thermals pass, and acts as a 'convective lid'.

When you are climbing on the launch, a strong inversion is quite easily detected. In an open-cockpit aircraft the air can sometimes be felt getting warmer on your face. At the inversion level on a sunny day a clear haze-top can be seen all round the horizon. Owing to the convective lid, dust particles cannot be dispersed upwards, and can be seen as a white haze when one is looking towards the sun, and brown when one is looking away from it.

There are two other main reasons for the formation of inversions as well as the cooling at lower levels due to radiation on clear nights.

Inversions are also caused by subsidence of air all round a high-pressure area (anticyclone). As the air gradually sinks round this region it may become warmer than the air below it. A third way in which inversions are formed is by a large layer of warm air gradually sliding up above cold air. This occurs at a warm front, which I shall describe in a moment.

A clear sunny day may start with an inversion in the layers of air close to the ground, but by about 11 a.m. this should have been overcome by surface heating. The temperature reached will not be entirely regular, and surfaces such as houses, roads, cornfields, will get hotter than woods and marshes; water will hardly change its temperature at all. Hot air will gather round the 'hot-spots' and every now and then float up away from the ground in an enormous bubble, or in a series of bubbles, forming a column of air.

If there is still an inversion at perhaps 2000 feet, then these bubbles will slow down and spread out at this height. These conditions sometimes remain all day in fine, hot, summer weather (an 'anticyclonic blight' to a glider pilot), and some indication of them can be got from the haze line, and from the absence of clouds.

Cumulus clouds

If, however, the air is unstable to the height of several thousand feet, then these thermal bubbles will continue to rise through the surrounding air. As they get higher, they will increase in size and go up faster.

There is still no definite sign of the thermal to be seen, unless it is so strong that it is full of dust and straw and bits of newspaper. But when the air is cooled so much that it is saturated with water vapour, cloud will begin to form, and the top part of the thermal will become visible—as a small cumulus cloud. If you are flying nearby, you will see all the flat cloud-bases at the same level, and white cloud-masses billowing up above, like enormous puffs of 'smoke' from a railway engine.

Watching cumulus clouds is a very profitable spare time activity

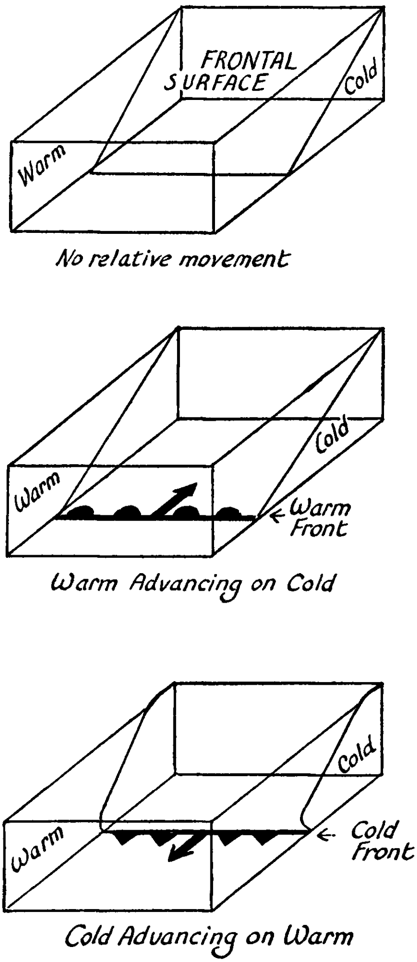


FIG. 9. Movement of fronts

for a glider pilot. Try to guess whether a cloud is still rapidly forming, or nearing the end of its life. With practice you can learn to distinguish the firmer, growing cloud from the fluffy, ragged, dissolving cloud which no longer has a useful upcurrent.

Fronts

A warm and a cold air-mass can lie together, separated by a frontal surface, at which only a slow mixing will take place. The frontal surface will cut the ground along a line called a *front*.

If the warm and cold air are moving at different speeds, then the warm air will be forced upwards near this frontal surface. If the warm air is advancing on the cold, then we have a *warm front*, and if the cold is advancing on the warm, then we have a *cold front*. *See* Fig. 9.

In both cases enormous quantities of air are gradually lifted upwards, with cooling and formation of cloud.

Nearly all our cloudy, rainy weather comes associated with fronts, so it is important to understand what may be expected from the two different sorts of fronts.

Warm front

The passage of a warm front is fairly easy to follow from signs in the sky.

The first visible sign is high feathery *cirrus* cloud, in various forms, but always delicate and fibrous, without any dark shading. These ice-crystal clouds may be formed at other times, but if they steadily increase above the horizon from the south-west, becoming more and more solid, then there is little doubt about the approaching front.

The next stage is the formation of ice-crystal cloud all over the sky in a thin layer. This cloud is called *cirro-stratus*. Sometimes it appears only as a thin haze, but it can be identified by the appearance in it of a *halo*. This is a large whitish ring round the sun with a radius about half that of a rainbow.

The medium-height clouds, which are not made of ice crystals, are given names starting with the prefix 'alto'. The next to appear is *altostratus*, a featureless layer-cloud through which a 'watery sun' can still just be seen.

The warm air is not always entirely uniform in properties, and some layers may be more moist than others. The general effect is a

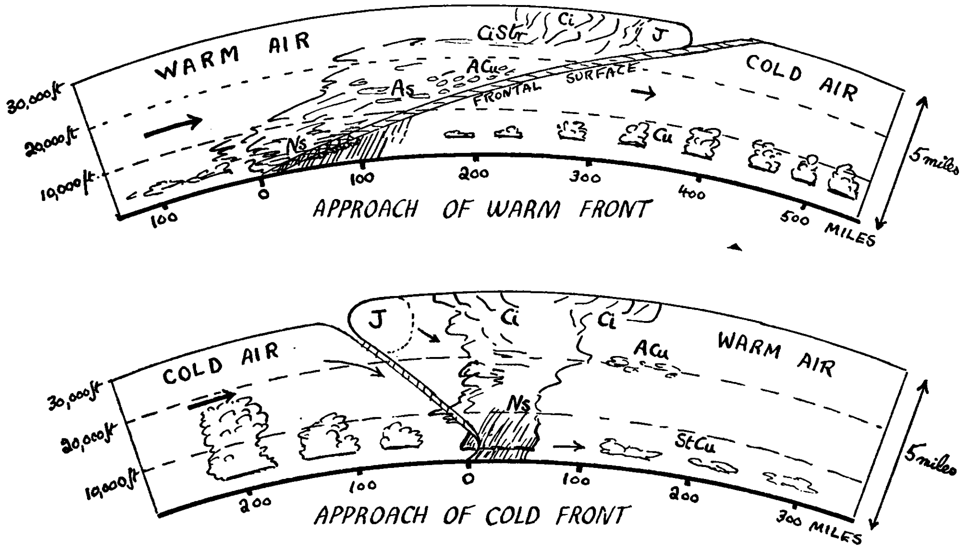


FIG. 10. Warm and cold fronts
(N.B. Vertical scale about 20 × horizontal)

continual thickening and lowering, but in fact usually there are gaps and different layers in the clouds. There may even be a certain amount of convection in the medium cloud. This will be very weak, but may be firm enough to make the familiar pattern of 'mackerel sky' or *altocumulus*.

Eventually the clouds will be thick enough to form rain, which falls from *nimbostratus* or *fractostratus* clouds.

While these changes in cloud have been going on, there have also been changes in wind direction. The wind has increased and backed (changed in an anti-clockwise direction) from west to south-west or south. It has probably been necessary to change the launching direction on the gliding field before the rain and low cloud have arrived to stop gliding altogether.

If you look at a barometer or, much better, a barograph, you will see that the pressure has been falling more and more steeply. When the front arrives, i.e. when the warm air-mass reaches the ground, the trace will level out. Also the rain will cease temporarily after the front is through.

The first frontal cirrus clouds are at about 5 miles height, and owing to the curve of the Earth they are not likely to be visible more than about 100 miles away. Your thumb held upright at arm's length covers an angle of about 5 degrees, and cirrus up to the height of your thumb above the horizon is about 60 miles distant. As the slope of the front may be about 1 in 100 (often less steep) the actual warm front at the ground is probably at least 400 miles farther away, with a rain belt one or two hundred miles to come before it arrives. Fig. 10 shows a likely arrangement of the clouds near warm and cold fronts.

Cold front

A cold front, formed by cold air advancing behind warm air, is different from a warm front in many ways.

A warm front is continuous and slow, and fairly consistent in behaviour. A cold front is more vigorous and violent, with a slope about three times as steep. Cold fronts are more intermittent and generally more variable in behaviour. The cloud will be spread over less area, the rain will be of a more showery type, and there may be thunder.

There is a downwards movement of the air along the frontal slope, and this has the effect of warming and drying the air, with less formation of cloud. In fact, after the 'clearing-up shower', a sudden line of clear sky can often be seen in the distance, and then a clearance rapidly arrives.

There is a rapid veer of wind (clockwise change from south-west to north-west) and the barometer starts to go up.

A slight bulging forward of the cold air occurs not far from the ground—the so-called cold front 'nose'. This is due to surface friction, and may be at about 1000 to 2000 feet. This situation of cold air above warm air is a highly unstable affair and may produce a dramatic dark line of *cumulonimbus* cloud. You may be able to see this very dark line (dark because of the great thickness of cloud above) rushing towards you, with shreds of cloud lower down, tearing up into the mass above.

The violent upcurrents at the front can temporarily reverse the wind direction on the surface, and as it passes there will be strong gusts of wind on the ground. So look out for any gliders which may be out of doors at the time.

The weather map

You can tell from this the wind strength and direction, how the air-masses and their fronts are connected, and how they are travelling.

The map has as its basis contour lines of equal atmospheric pressure, or *isobars*. The pattern of these isobars may show circles with HIGH or LOW marked in the centre, probably with thick arrows to show their direction of movement. The winds are also shown by little arrows, which indicate direction and strength.

You will see that the winds don't blow straight 'down the hill' into the LOW (or depression), nor straight away from the HIGH (or anticyclone). The effect of the rotation of the earth is to make any wind blowing in the Northern Hemisphere swing off to the right of its path towards the lower pressure.

To illustrate this, a simple experiment can be done on a gramophone turntable. Have a sheet of white card on the turntable and put a small pool of coloured water near the centre. If the 'record' is run at 78 r.p.m. (or faster!) the water, as it is flung out towards the edge will run off in a spiral curve.

If you use treacle instead of water, you will find it flows out almost straight towards the edge. In the case of the treacle, the internal friction is enough to give it the extra speed it needs near the edge. This force is not enough in the water, which behaves much like the air on the rotating Earth. In fact, near the ground, owing to friction, the wind does blow more towards the centre of the LOW, but higher up it blows anti-clockwise almost along the isobars, with the low pressure on its left.

Anticyclones and depressions

The fronts to be seen on the weather map and their movements are connected with the high- and low-pressure areas marked out by the isobars.

Highs, or 'anticyclones', tend to be large areas of not very strong winds, and fairly settled weather. They do not move very quickly across the map, but may gradually intensify or die away. As the air above is very slowly sinking, they tend to be areas comparatively free from cloud. A strong inversion may be formed, damping out thermals in summer, and forming stable layers of cloud in winter.

Round the edge of an anticyclone the isobars may sometimes be seen very close together, with consequent quite high winds. Remember that these blow round the High in the opposite direction to those in a Low. Swinging to the right all the time, they blow round in a clockwise direction.

Although calm anticyclonic conditions may not be good for easy soaring, an anticyclone to the north of Britain will bring north-east winds across the country in its circulation. This air will be continental polar, i.e. unstable and dry, and is popular with Londoners who hope to fly gliders across country to Cornwall!

Lows or depressions behave in a very different manner. They are formed out in the north Atlantic, often in families of four or five, and usually travel rapidly eastwards across Britain, bringing changeable and 'unsettled' weather.

Although a vigorous depression brings some non-gliding weather, it is likely to bring some gliding weather as well. To understand how it does this, let us follow the complete life history of a depression.

The starting point is an unstable wave on the polar front between the cold north-easterly flow from the polar regions and the warmer south-westerly air.

A picture of an unstable wave on the water-air surface of the sea may help. If, as a wave of any kind gets bigger, the wave-making forces also increase, then it will go on getting bigger until it collapses. Waves like this can be seen any day on the seashore.

In Fig. 11 the line shows the boundary between the water (beneath) and the air (above). To the character standing in the water the surface AB might be described as a 'wet front', and the surface AC as a 'dry front'.

The waves in which we are interested first appear on the weather map as a bend in the polar front perhaps 100 miles or so in length.

At the first little bend in the front, a tongue of warm air has begun to flow up above the cold air. As it goes up, it cools. It forms cloud, which releases heat, it goes up farther, and more air follows it. As air goes up in the centre, more air still moves in, and a cyclonic rotation is set up.

The centre moves in a west to east direction as a deepening disturbance, with distinct warm and cold fronts.

As the cold front catches up the warm front, the warm air is gradually lifted off the ground, and the depression is said to be

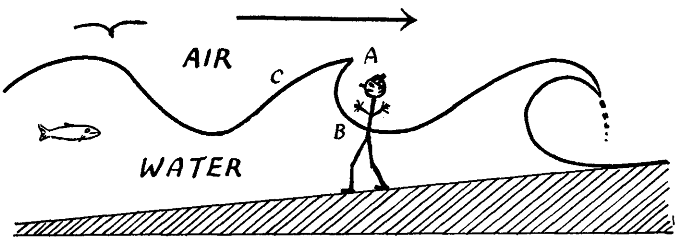


FIG. 11. An unstable wave in the sea

occluded. The ordinary weather map shows only conditions on the ground, a cross-section of a vast whirlpool in three dimensions.

Eventually the air is so mixed up that there are no longer large enough temperature differences to keep the thing going, the depression gradually 'fills', and in the end disappears from the map.

Fig. 12 shows four stages in the development of a depression. The dotted lines are the isobars, and the intervals between the stages are about 12 hours each.

Most of the depressions which pass over us in Britain have reached the occluded stage. If the air behind the occluded front is colder than the air ahead of it, it is called a *cold occlusion.* If it is warmer, it is a *warm occlusion.*

Many of the fronts we experience are of the cold occlusion type. This is more like a cold front than the other, and usually has a shorter period of rain.

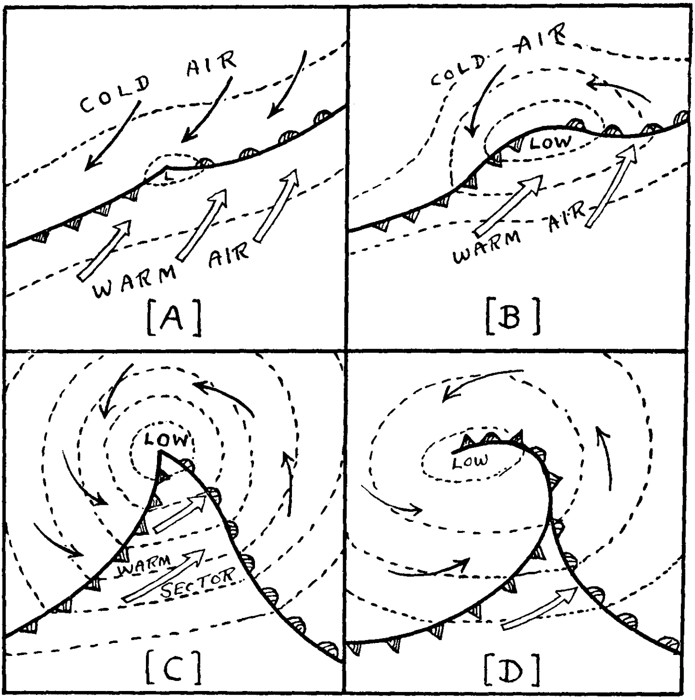


FIG. 12. Formation of a depression on the polar front (12-hour intervals)

A *secondary depression* sometimes forms. This has the features of a normal depression in miniature, very often in a more marked form. It may form at the point of an occlusion, or as a wave in the cold front of the depression.

Jet streams are narrow areas of strong winds at great heights (30,000 to 40,000 feet). They often blow along the fronts, and the *polar-front jet stream* can usually be traced for considerable distances. I have marked its position (J) in the warm and cold front diagrams (Fig. 10). The direction is out of the paper; its position is sometimes marked by extremely rapid movement of the edge of a line of cirrus cloud.

Wind speed table

Beaufort notation	*Speed in knots*	*Description in weather forecasts*	*Suitable activity at gliding club*
0	0	Calm	First landings. (But may only get poor launches)
Force 1, 2, 3	1–10	Light	First solos. Out-and-return flights
Force 4	11–16	Moderate	Pleasant for all
Force 5	17–21	Fresh	Good hill-soaring
Force 6, 7	22–33	Strong	Care when approaching!
Force 8	34–40	Gale	Experts only
Force 9	40–47	Severe Gale	Six people to hold each glider on ground
Force 10 +	over 47	Storm	Indoor games recommended

Forecasting

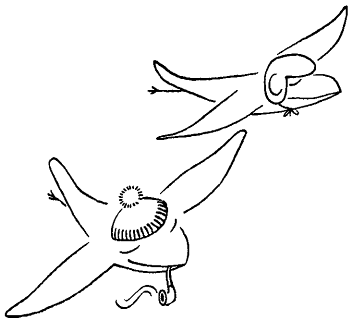
The professional forecaster has all the information available from weather maps and from his experience, and then has to give a general forecast. The more you understand about the weather the better use you can make of the forecast.

To give the simplest example, you will understand that the difference between 'rain and drizzle' and 'showers and bright intervals' is the difference between dull, warm front, non-gliding weather, and interesting unstable polar air conditions.

Until special gliding forecasts are published daily, the weather-conscious glider pilot should be able to gather much from the kind of weather map which appears in *The Times* and *The Guardian*. These maps are based on the information available from the Air Ministry at 6 p.m. the previous evening and include a forecast chart for the following midday. It is interesting to try to follow what is going on by watching the state of the sky, and checking with a barograph trace. The timing of fronts is still unreliable, and by doing this you may be able to revise the timing and improve the accuracy of a forecast.

In London you can telephone WEA 2211 for a forecast, and in other parts of the country there are local weather services which are well worth using. Information can be found in the front part of the local telephone directories.

The ideal will always be to discuss the situation with a professional forecaster over the weather map which he has just drawn. This is a thing that most of us are not often in a position to do, but the TV weather forecasts are a good substitute. Those who can read a weather map have a daily opportunity to develop one of the subsidiary gliding skills. There are some days for all of us when we have to work in order to earn money to spend on gliding. Even on these days (except for those who work underground) it is possible to compare your own interpretation of the forecast with the day as it actually develops.



6. How to stay up

Climbing in a glider (soaring)

As we have seen (in Chapter 1), unless it is being towed, the glider must always be sliding downwards through the air, probably sinking at about 3 feet per second. The only way it can climb is by gliding down through air which is going upwards. If the glider sinks at 3 ft./sec., and can manage to stay in air rising at 5 ft./sec., then it will climb at 2 ft./sec. away from the ground.

The old analogy of running down the ascending escalator is a good one. I expect the more enterprising of my readers have at some time or other run down a moving staircase that was going up. Suppose you are halfway down an escalator, walking downstairs at 3 m.p.h. and the escalator itself is moving upwards at a steady 5 m.p.h. Although walking downwards all the time at 3 m.p.h., you will gradually be carried up to the top at 2 m.p.h.

Quite large areas in the sky are frequently going upwards at more than 3 ft./sec., and the whole art of soaring flight is to find these areas of rising air and to stay in them.

Gliding has been compared to a glorified game of 'Snakes and Ladders'. There certainly are 'Snakes' but you don't stay near them for long if you can help it. The art is, of course, to gain height by finding and using the 'Ladders'. Fig. 13 shows the three main types of 'lift' used in gliding.

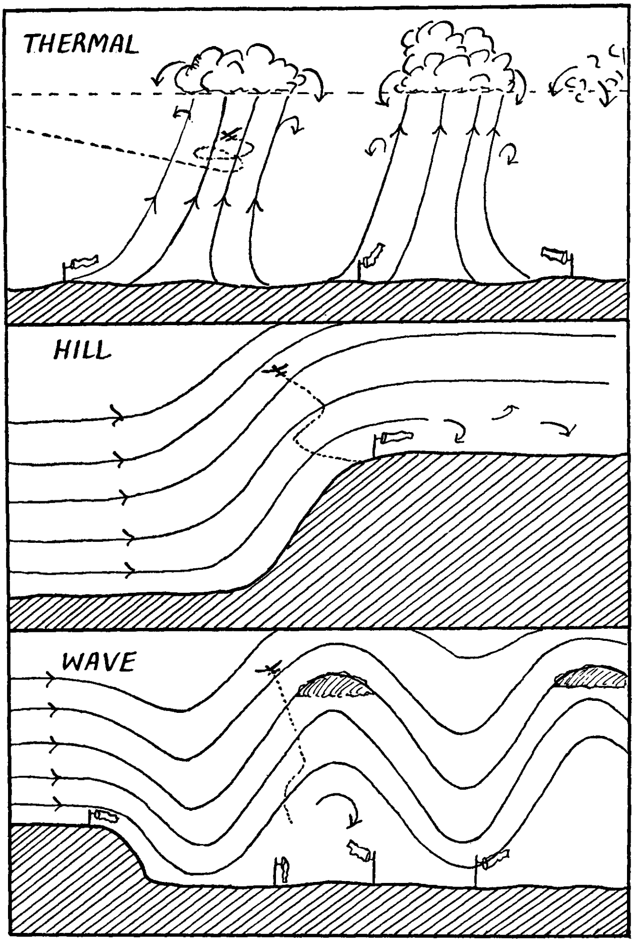


FIG. 13. Three types of lift

Hill-soaring

The first method of staying up in gliders was by the use of 'hill-lift'. The cause of the rising current of air is easy to understand. If the wind blows towards the side of a hill it cannot blow through it, nor even round it unless it is an isolated peak, so it goes up over it. In doing so, it acts as a hill over which the layers of air above must also climb.

You will have noticed sea-birds using this type of lift to soar along the cliffs near the sea. They float along, without flapping their wings, up to a hundred feet or so above the top. The birds don't need to go much higher than this, but a glider pilot using a similar kind of lift may find that he can climb up to about three times the height of the hill. So in the rising air above 250 ft. chalk downs you may be able to hold height at 700 feet. At the clubs in Britain which have soaring slopes as high as 700 feet, you may get to 2000 feet on a good day.

For good hill-soaring you need a wind of at least 10–15 knots, blowing nearly at right angles to the slope. The amount of lift obtained above any hill with any wind varies according to the weather and the time of day. On some hills, soaring conditions are not good early in the day, before the wind in the valley begins to move. Sometimes you may find that conditions improve in the evening, and you may continue to gain height when the wind on the ground has almost died away.

The strength of the lift and the height to which it extends generally increase as the wind gets stronger, but there is a limit to the wind strength which is really useful for hill-soaring. To gain height above a hill you normally fly at your minimum sinking speed, perhaps just below 40 knots. If the wind is more than 40 knots, it will be necessary to fly at least at this speed to avoid being blown backwards. At increased speeds the glider's sinking speed increases, so you may find the strong wind does not get you any higher.

Technique of hill-soaring

A hill-soaring flight will usually start either from a bungey- or a winch-launch. Let us consider a bungey-launch first.

After you pass the crew and the rope falls off, you should fly straight for a short distance out from the hill, with the ground dropping away beneath you. In a strong wind, when it is almost possible to hover, you can then move slowly forward, rapidly gaining height; but on a normal day it is necessary to fly accurately in the right place along the hill. This will mean turning right or left, in the direction of the best lift.

This turn must not be made too soon; it is dangerous to turn while still close to the hill. If you turn too close, you may find your outer wing in the strong lift, but the inner one will be close to the ground with less wind and weaker lift. Pilots have found themselves under these conditions unable to stop the turn and have hit the hillside. It is also possible to turn too late, but in this case the penalty is less severe. If you turn too far out from the hill, you will not be in the best lift, and may even fail to soar at all and have to land at the bottom.

A bungey-launch is cheaper, and pleasant for the pilot, but a winch-launch on the top has two advantages. It makes it possible to soar over a slope where bungeying is impossible owing to a sharp cliff-edge, or where there are hedges or other obstructions. Also, starting well above the top of the hill makes it easier to get settled in the lift; in fact, if no satisfactory lift has been found by the time the glider has sunk to 300 or 400 feet, it should be possible to land back at the starting point on the top.

If the launch is to be from a field at the bottom, provided it is fairly near the slope, it should be possible to arrive over the hill with plenty of height to spare. If the glider fails to soar, it should be easy to get back to the starting point. The London Gliding Club, which in the 1930s used to pull the gliders up to the top of Dunstable Downs and bungey-launch them there, has now for many years operated on this plan.

So, however you have been launched, you should be at a safe distance from the hill, flying along the line of the ridge, and gradually climbing as you go.

You will find that it is not just a question of pointing the nose of the glider along the ridge, but you will have to point the nose slightly away from the hill in order to avoid being blown back on to it. You will find yourself 'crabbing' along the ridge.

The actual 'right place to fly' along the hill is not easy to describe, and varies a certain amount from day to day and from hill to hill. In the lower stages you fly only two or three wing-spans from the hill, or even less if you know what you are doing. When you are only a few hundred feet above the hill you fly roughly above the steepest part of the slope. At greater heights this is a useful basis to work on; there is then room to experiment and to find the best places. It is not likely to be much good behind the crest of the slope, but at a thousand feet above a good hill there may be useful areas of lift extending half a mile or more upwind.

Direction of turns. When you reach the end of the ridge, you will need to turn and come back again towards the start. The one vital thing is that the turn should be made into wind, *away from the hill.* If you are not above the hill-top, this is obviously the only way to turn! If you are well above the hill, flying in a strong wind in good lift, it is equally important. Turning into wind, away from the hill, you have to make only a small turn from crabbing one way to crabbing back in the other direction. If you turn the wrong way, you will certainly have to turn through more than 180 degrees, and by the time you get round you will be several hundred yards downwind of the crest of the hill.

If the hill is not very long, the flight will be a series of figures of eight—round into wind, away from the hill at the end—back into the best lift—round into wind again at the other end of the hill. If the hill is long, then there will be a long straight beat in the middle of the 'eight'.

When hill-soaring in good lift, beginners tend to reverse direction by making a hurried steep turn to get round quickly. This often has the result that they go round too far, and get too far back over the hill. Even if not actually dangerous, this is an inefficient way to soar. The aim should be to make a slow, lazy, turn nearly all the way round, and complete the positioning over the slope by letting the glider crab sideways back to the place over the hill where it should be.

If the wind is not at right angles to the ridge, it may still be soarable, but more care is needed with the turns at the ends of the beats. The 'angle of crabbing' will be very different in the two directions. In the upwind beat the glider will be pointing almost along the hill, and moving forwards quite slowly. As soon as the turn is started at the upwind end, the glider will start swinging off rapidly downwind and care must be taken not to get too far round. As the ground speed on the downwind beat will be much faster, the turn at the downwind end must be started well before reaching the end, to avoid being blown too far along.

Beware of collisions!

Fig. 14 shows a slightly different path in the two directions along the ridge. If you had the hill to yourself, you would expect to use the centre of the lift in both directions. However, at a club on a busy day, there may be as many as a dozen gliders flying along a hill at the same time. It is to be hoped that they will mostly be at different heights, but occasions like this need very great care in keeping to the 'Rules of the Air'.

One rule is—'aircraft approaching head-on, alter course to the right', so when travelling from B to A you will expect to have the 'hillside' and when going from A to B the 'outside'.

In the turns at the ends, some anticipation and co-operation are needed. For instance, in the diagram, it would be foolish for pilot Y to try to get round in front of pilot X in order to pass him on the 'right' side.

Another important rule of the air in hill-soaring is the one about overtaking.

It is asking for trouble to overtake a glider on the side to which it is bound to turn sooner or later, and as it is standard practice when hill-soaring always to start turns into wind, another glider should never be overtaken on the windward side.

This rule is usually stated in the form: 'Overtake on the hill side.'

I have said that turns at the end of a beat should be made into wind, away from the hill, and this rule should be kept for all turns, for whatever purpose.

Even if the intention is to turn and fly downwind, it is better to start this turn the other way, away from the hill, and go right round. This will avoid a possible collision with someone just about to overtake you, and will enable you to cross the probable route of other gliders at right angles, when a good view can be obtained.

The turns do not, of course, have to be made exactly at the ends of the ridge. A pilot wishing to get as much height as possible above a hill will usually fly at least once right along the length of it. After that he will concentrate on using the best places only.

They may be 'best places' because the shape of the hill produces better lift at some special points. If this is so, then they will be found each time you come along the hill. The most likely cause of a sudden increase of lift at any point, however, is the presence of a thermal.

Thermal soaring

Thermals, short for 'thermal upcurrents', are the glider pilot's life-blood. With the discovery in 1928 that gliders could climb in thermals, gliding suddenly became a very much more worth-while sport. Previously some fine soaring performances had been made, but flights had been limited to the neighbourhood of hills and to 1000 feet or so above them. It now seemed possible, given suitable conditions, to fly a glider almost anywhere.

Thermals from the hill. The obvious advantage of trying to connect with thermals when hill-soaring is that if you fail to connect you don't have to land immediately.

On a good day with cumulus clouds, try to be underneath them as they pass above the hill. It generally gets fairly smooth at the

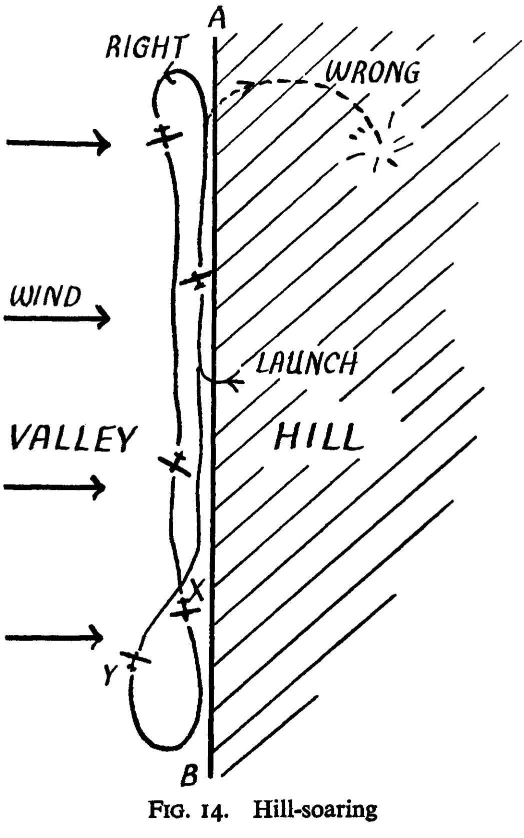


FIG. 14. Hill-soaring

upper limit of hill-lift, and as you fly along, the first sign of a thermal is a sudden rough patch. The variometer will register climb, perhaps quite smoothly after the initial rough area. After perhaps fifteen seconds or half a minute, there will be more roughness, and the variometer will begin to show 'down'.

These signs indicate a thermal, and you have flown right through it. You may gain considerable height by thus flying through it and out the other side; the obvious improvement is to turn in the up-current, just as you would in any increased patch of hill-lift. It is no good turning at once, or you may merely turn right out of it; it is necessary to wait at least 5 or 10 seconds to avoid doing this.

Fig. 15 (*a*) shows a thermal entered at the point (1) and the turn started at (2). Make your turn as usual, away from the hill, until you get to the point (3). At this point you have to make up your mind whether to go on round the circle or to fly back along the hill. If you are well above the hill, and the lift is showing no signs of reducing, continue the turn and make a 'thermal circle'.

A beginner should attempt this with care the first few times, as the glider will quickly drift back over the hill. It is important to fly in steady, uniformly banked circles, and it is difficult to do this with one eye on the horizon in front, one on the hill beneath, and the third (if available) on the variometer readings. The path over the ground in a strong wind will, of course, not be a series of circles, but a series of loops.

If by the time you get round to the point (3) you decide there wasn't a thermal there after all, you reverse the turn, crab onwards back to the hill, and fly back along the slope.

However, there is an intermediate plan possible from the point (3) onwards. This is simply to make 'S-turns' in the area of the best lift. Turn straight back to where you think the lift is, and if the thermal is large you may be able to make two or three figures of eight in it. If you let these turns gradually get you farther upwind from the hill, and the lift continues, then you will be a in very safe position to start experimenting with circles. (*See* Fig. 15 (*b*).)

Thermals from the winch. Connecting with thermals from a winch or car launch used to be rare, and considered a very skilled thing to do. Nowadays probably as many thermal flights are started by this means as any other. The trouble is that a descent from 1000 feet takes only about four minutes, and only the first two of these are really available for finding a thermal.

You are not likely to get a second chance in any one flight if you

11 Hill-soaring (clouds show a good cross-country sky)

12 Trailer and author's car

13 Rigging a Skylark 2

lose the first thermal you come across. It is therefore essential to make a search in the most likely places, and if any lift is found, to make sure that it is not lost.

Where to look for thermals

(1) *Marked Thermals.* An active cumulus cloud marks the top of a thermal. If the clouds are at 4000 or 5000 feet, their positions may not be of very much help in thermal hunting as low as 1000 feet, but it will be worth trying to get beneath the clouds, particularly if they seem to be forming in any sort of lines. You should remember that

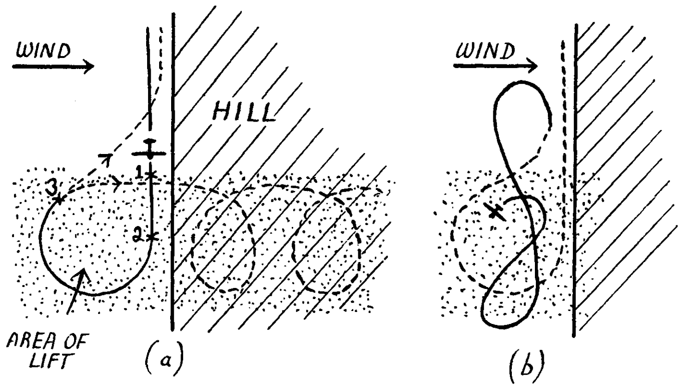


FIG. 15. Thermals from the hill

if the wind is much stronger towards cloud-base, the thermal will slope downwind, and when you are low down you should look for it after the cloud has passed.

Thermals near gliding clubs may often be marked by other gliders. The first person to find a thermal 'owns it'. Others joining him must circle the same way round. Two pilots circling in the same thermal can often be of some help to each other, but very many more are likely to get in each other's way. I have unpleasant memories of being the 13th to join a particular thermal in the 1957 National Championships. That thermal was certainly well marked. We all swam round and round like goldfish in a bowl, following the man in front and trying to make sure of avoiding each other.

Birds are often useful as markers of thermals, although they have the disadvantage that they are not easy to see at a distance; also they may be using thermals too small for a glider. Rooks sometimes soar in thermals in large groups, and the rookery at Lasham Aerodrome has often been of assistance. Other large birds I have often met soaring are buzzards and gulls, either alone or in groups of two or three. Swifts may be met, chasing insects carried up in a thermal, and I have occasionally met beetles, butterflies, and pieces of straw and newspaper.

Although birds are hard to see at a distance, they can be a help in finding the strongest parts of a thermal. They are very skilful at doing this—in fact few of us are likely to meet any bird who has fewer flying hours' experience than ourselves.

Smoke from a fire on the ground is another useful marker, and it is worth studying the forms this takes, even if you are not flying above it in a glider. If you watch smoke from a large fire, such as one from burning straw in a field, you will see that it blows along the ground for a few minutes, and then suddenly a great mass of it may billow upwards. This is a thermal starting up. I have watched this happening in a heath fire about three miles distant, and have actually been able to time the thermal, from its release from the ground to the formation of its cumulus cloud at 5000 feet, about ten minutes later.

Some people find polaroid spectacles a help in 'seeing' thermals. Polaroid makes part of the sky look darker, especially when you are looking at right angles to the position of the sun. This has the effect of showing more clearly small clouds beginning to form, and may outline more clearly a very dusty thermal.

(2) *Features on the ground.* If no thermal is clearly marked, then some places are better than others for the search. It is certainly worth flying over a group of houses, or other objects likely to be hotter than their surroundings—the car park at Whipsnade Zoo, for example, is a favourite of London Club members.

Slopes of hills facing the sun are good sources of thermals. If a sunny slope faces downwind, it will be partly sheltered from the wind, giving a good chance for hot air to gather, and the production of a 'wind shadow thermal'.

The pattern of cloud shadows on the ground in turn affects the thermals which make the clouds which make these shadows! On a day with comparatively few clouds and a gentle wind, the cold air creeping along in the shadow of a cloud may well loose off thermals, so it is worth trying in front of this shadow.

With a stronger wind, and greater cloud amounts, the cumulus clouds may arrange themselves in 'streets' along the direction of the wind. There are usually strong downcurrents between these lines of cloud, and the lift is often strongest along one edge of the line.

If there is almost complete cloud cover, then any small patches of sunshine on the ground are worth investigating.

All these possible thermal sources are important, but none of them produces thermals continuously all day. The best sources start a thermal perhaps every ten or fifteen minutes. An indication as to which source to try can be got from the direction of the windsock and perhaps from small smoke trails. If the air is going up somewhere, then the windsock will show a deflection towards the thermal. Even on a day with some wind, this effect may be quite noticeable, and at least will give a suggestion as to which way to turn from the top of the launch. On a 'windless' or 'light and variable' day the effect is very marked, and will often give indications of the whereabouts of thermals.

On these calm days, thermals can often be detected on the ground by a sudden increase of wind springing up and lasting for two or three minutes. As the bubble is released from the ground, it draws in air towards it, and more and more follows it upwards. Sometimes this is quite a long and almost continuous process. You can sometimes circle in the same thermal for half an hour on end, and see the appearance of a continuous series of clouds over a point.

Use of instruments to detect thermals

Various methods have been suggested and many tried for detecting thermals from a glider. So far none has detected them from a distance. Such methods will indicate the strength of a thermal only when the glider is actually in it.

The most obvious device seems to be the use of a thermometer to indicate the hot air. However, this has not turned out to be a useful method; other causes swamp the small temperature differences due to the thermal, for instance sunshine and shadow.

There is an electric potential gradient across a thermal (a rate of change of voltage with distance), but so far no practical instrument has been made to utilize this in a glider.

Any glider you fly is likely to have a rate of climb indicator (variometer) which is worked by the reduction of air pressure as you climb.

A good variometer is essential for thermal soaring. A very experienced pilot can fly a certain amount by 'feel' in thermals, probably by sensing the different kinds of turbulence inside and outside a thermal and at its boundaries. The kind of 'feel' you have in the seat of your pants is not reliable. This shows only when you start or stop going up or down. In fact, starting to go up feels exactly the same as stopping going down, as you can prove any day in a lift. Going up steadily feels exactly the same as going down steadily; you cannot tell the difference in a lift with your eyes shut, and you cannot easily tell in a glider whether you are climbing unless you are very low down and can see the ground dropping away.

Centring in thermals

The form of thermals is a fascinating subject for argument among glider pilots and meteorologists, and much still has to be found out. Are they shaped like doughnuts (American style) or smoke rings? Or jellyfish? Can they be in the shape of a figure eight? Do they rotate? (If so, which way?) And so on.

I shall begin by assuming that a thermal is of circular cross-section, and that it drifts at the same speed as the wind. Then it is clear that all you have to do (after having found it!) is to set the glider circling round and round inside it, and you will be carried rapidly upwards. (*See* Fig. 16.)

In practice it is not always as simple as this. The title for Fig. 16 might well be 'Beginner's Luck'.

Remember that you cannot see the thermal beforehand. In fact, each thermal has to be mapped out afresh. The only way of doing this, unless it is solid with smoke, birds, or gliders, is by building up a picture of the thermal as a whole from the bits you have flown through.

To be able to do this, the first essential is to be able to fly *good regular circles.* I can't over-emphasize how important this ability is. Accurate circling in the rough air at the boundaries of thermals is difficult, but is the absolute basis of getting into thermals and staying in them.

To return to the 'lucky beginner' in Fig. 16. If he cannot fly regular circles, he will gradually get over to one side and, eventually, the effect of circling half in and half out of the thermal will be to tip him out altogether. He will then come down and land, complaining to his friends that 'the thermal died at 1500 feet'.

How lucky was he? Suppose he had turned right instead of left? (*See* Fig. 17.) He would then have soon found sink. Now this is where the ability to fly regular circles comes in. If he moons vaguely off the right (*a*), he is not likely to find the lift again. If he tightens up the circle to get back to the lift quickly, he will probably manage to miss it altogether (*b*). If, however, he can continue a firm, regular circle, he is bound to come back into the lift again (*c*). He should be able to fly round and round this circle, half in and half out of lift.

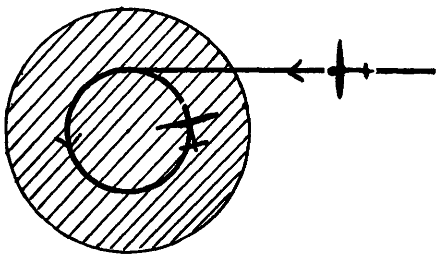


FIG. 16. A circle in a thermal

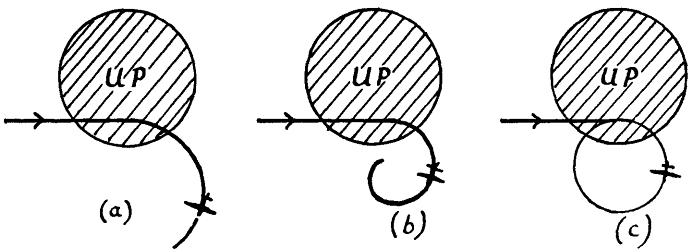


FIG. 17. Finding the lift again

From this position there are many ways used by experts of centring in the lift; most of these have become automatic and they might find it hard to explain how they know when to shift the circles. A good way for the beginner to try is this: as soon as you feel the lift again and it begins to show on the variometer, straighten out momentarily. Only do this for an instant, and then bank over into the circle again.

Don't overdo this! The complete circle will take about 20 seconds to go round. If you could straighten out immediately, fly straight for 5 seconds, and then go immediately again into the circle, you would have flown straight for about three-quarters of a circle-diameter. It may take you 5 seconds merely to straighten out and to go back into the turn. In this manœuvre you will have shifted the circle about one radius sideways.

Fig. 18 shows this in action, (i) with the circle shifted just over one radius, and (ii) almost complete centring after three circles.

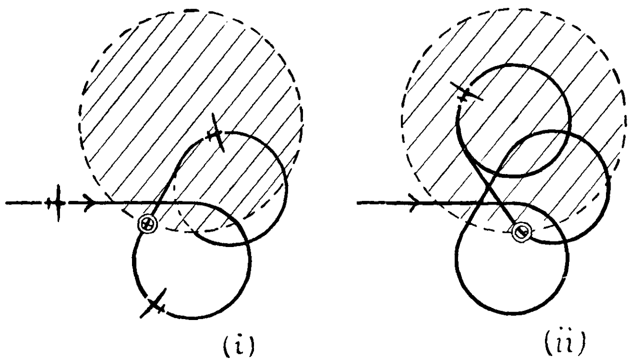


FIG. 18. Centring in a thermal
(i) First shift (ii) Second shift

Which way to turn?

It is of course clear that the glider in Fig. 17 was turned the wrong way at the start. It is sometimes, but by no means always, possible to feel which way to turn when entering the thermal. It may be possible to feel the lift under one wing only, showing on which side the thermal lies. This effect varies enormously; sometimes it cannot be felt at all, and at others it may be so strong that it is impossible at first to turn the glider at all in the right direction.

If the thermal seems to be straight ahead, it is best to fly straight for a few seconds, before turning. (Count seconds by saying aloud: 'Skylark 1, Skylark 2, Skylark 3, Skylark 4, Skylark 5, . . . 4 Skylarks are usually enough!) If you are sure the thermal lies to one side, *turn that way at once.*

The above scheme can be almost automatic, and will also work when flying in cloud.

Landmark Centring

When soaring in clear air, many people find it helpful to build up the picture of the thermal relative to features on the ground, using perhaps the wind direction, and some easily recognized features. The direction of the sun is particularly useful for maintaining a sense of direction when thermalling.

For example, you may make your first exploratory circle, and find that the lift is best soon after facing the sun on the gas-works side of the circle. Next time you come round, soon after passing the sun, you straighten out a little and edge your circle over a little towards the gas-works. Things should now be better, and if they are not yet perfect, a further shift can be made the next time round.

So far I have simplified things by dividing the air into two areas only—lift and sink. In practice, the areas of lift in any one thermal may not be uniform. There is often a stronger core of lift in the centre.

The plans outlined above for getting from sink to lift can be put into action in exactly the same way for getting from weak lift to strong lift.

The 'standard circle' can usefully be made bigger or smaller. A big circle in areas of varied lift will sample more parts of the thermal, and a very small circle will be needed to stay in a strong core of lift.

In a thermal with a strong core, the circle will be straightened out a little on coming into increasing lift and the glider should then be wound round tightly in the very centre. A very tight circle may be needed, but is only worth while in very strong lift, as the rate of sink increases considerably at anything much over 40 degrees angle of bank.

I find it one of the most delightful sensations in gliding to tighten up successfully in a strong core of lift. As I push the lower wing of my glider down and we surge upwards, I feel as if I am levering myself upwards on my lower elbow.

Wave-soaring

The regular use of 'standing waves' for soaring is much more recent than the use of thermals.

The world's first soaring flights in wave lift were made in 1935 near the Moatzagotl cloud in Germany, where aero-tows were used to contact the lift, and climbs made to over 10,000 feet. I was lucky enough, in 1937, to make the first wave-soaring flight in Britain to be recognized as such. I used the wave to climb 7000 feet, climbing above clouds from a catapult launch on the Long Mynd.

In 1939 the British altitude record was raised to 10,000 feet in a carefully planned flight by Noel McLean from a winch launch into the 'lee-wave' from the Pennines at Hartside.

As the form of thermals *may* be shown by cumulus clouds at their tops, so the form of wave-upcurrents may be shown by lenticular (lens-shaped) clouds. These clouds are especially noticeable in mountainous country, but my example in Plate 15 was photographed at Cambridge!

If you watch one of these clouds (or better still look at a speeded-up ciné film) you will see that it stays in the same place, although there may be quite a strong wind blowing. It is continually forming at its upwind edge, and dissolving at its downwind boundary.

It doesn't have to rush upwind in order to do this any more than a waterfall has to rush upstream: they both stay in a fixed place for the same sort of reason! The cloud is there, at a fixed place, because as soon as any little bit of air gets there it finds itself rising and cooled to condensation temperature. Farther on the air goes down, is warmed, and the cloud dissolves again. The waterfall is there at a fixed place for the very obvious reason that as soon as any water gets there it finds itself falling—farther on it goes along level again.

Stationary clouds of this sort are quite common and can often be seen if you look out for them. They occur at almost any height from the ground to 100,000 feet.

Before we leave my waterfall illustration, a further picture may help. Beyond the bottom of the fall, if the flow is right, and the depth is correct, quite large stationary waves may be seen, with three or four crests farther downstream, staying at a fixed place with the water rushing through them. A similar picture may be seen in the wake of a ship; this often has rows of parallel waves which follow the ship and remain stationary relative to it.

In the air something similar happens, but on a very much larger and grander scale. After the air has blown down a steep hill- or mountainside it may quite possibly rebound up again a few miles downwind to a height greater than the original hill. It may rebound a second or a third time or more, perhaps producing ten or more lee-waves reaching a height ten times the original hill. The distance

14 Cumulonimbus

15 Wave-clouds

16 Olympia circling in a thermal

from the crest of one wave to the next varies a good deal, but is of the order of five miles.

Already in this country climbs to 20,000 feet have been achieved in waves, and cross-country flights made of over 100 miles, on wave after wave.

Conditions for waves to occur

When a long ridge lies across the wind direction some kind of hill-lift will always be formed, but lee-waves will only be formed if the airstream is suitable. The most important requirement is an increase in wind strength with height, but direction should not vary much.

The wave length may vary during the day; it may increase as a result of heating from the sun. As the lengths vary, the hill-lift and waves produced by other hills may go in and out of phase. When the hills are in the 'right' position, the lift may be enormously reinforced. Waves may disappear in the middle of the day; and many of the earlier wave flights were made in the morning and evening. Waves are not necessarily prevented by convection in a comparatively shallow layer near the ground, but the air must not be stirred up at greater heights by convection.

The existence of an inversion layer is not a necessary feature, but it may be a help as it is likely to be associated with a cloud layer. This may make the position of the waves visible, either as clouds at the crest of the waves, or clear gaps between the waves in the troughs.

Technique of wave-soaring

If a stationary wave cloud is seen, and if you can get your glider just in the right part of the wave, then the technique is similar to that used in hill-soaring. In fact the first wave over the hill is no different in nature from 'hill-lift'.

The wind is very likely to be strong, and if it is nearly up to the slowest speed of your glider you will almost be able to hover above a fixed point. It is worth fixing a point on the ground over which the best lift has been spotted, and noting which way the nose is pointing and a landmark under one of the wing-tips. By *very small* changes in the direction of the nose of the glider you can make yourself shift slowly up- or downwind into the area of best lift. Unless the wind is very light, which is unlikely, circling is not advisable and is a likely way to lose the lift.

Although the plan is very similar to that used in hill-soaring, it may often be above an invisible 'hill'. It is easier if the 'hill' is made visible by stationary clouds forming at the crests of the waves, with clear areas in the troughs. Although this clear strip may be quite narrow, it may be possible to climb up above the clouds through the gap. When you are floating up along the front of a wave cloud, it is awe-inspiring to see the great mass of cloud in the down-wave in front of you pouring down and dissolving before it reaches you. The gap below may suddenly close, and it is necessary to keep an eye on this and be sure you can cope with the situation of being cut off from a view of the ground. With a strong wind, a small error in direction will make it very difficult or impossible to get back to the club from which you started.

Smoothness

Strong turbulence may be found while trying to connect, but one very distinctive feature about flying in waves is the quite extraordinary smoothness even in the strongest parts of the lift. When the glider has been placed in the right position it is sometimes possible to fly for minutes on end without any movements of the controls. It feels exactly like sitting in the glider on the ground.

Waves are much more likely to be set up by a straight mountain range than by isolated peaks, and up to now the most thorough investigation that has been made has been near Bishop, California. Waves here have been explored to over 40,000 feet in gliders, and only left at that height owing to the absence of a pressure cabin. Cross-countries of over 300 miles have been made, at heights between 15,000 and 20,000 feet, and research is still going on.

New Zealand is known in the Maori language as Ao-tea-roa, the Land of the Long White Cloud. This is a stationary wave cloud of enormous size and height, and an out-and-return flight of 200 miles has been made using it. The altitude record of 1954 was made in New Zealand by Philip Wills, who climbed to 30,000 ft, flying in the lee-waves from Mount Cook.

Wave clouds formed by the mountains in Norway have been estimated to be at 100,000 feet, and it has been suggested that, with a suitable design of glider, the world's altitude record for aeroplanes might be raised there.

Over Japan there are strong disturbances in the 'jet stream'. These, it has been suggested, are due to gigantic lee-waves set up by the winds blowing down off the Tibetan plateau and the Himalayas.

There is no need to leave Britain, however, for wave-soaring to suit all tastes, from that of the club pilot who wants some fun on a short flight, to that of the serious record-breaker.

The Welsh Mountains, the Lake District, the Pennines, the Cairngorms, and other large (by British standards!) ranges are all known to produce soarable waves. Many of these have already been used to make cross-country flights.

There are two methods in which a wave system can be used to make a distance flight. If a wave is long enough, you can cruise straight along it, for as long as the lift extends. This may enable you to make long distances across wind, and to return the same way. This was done in the 200-mile flight in New Zealand.

Waves can also be used to make cross-country flights straight downwind. Although a few enterprising pilots had succeeded in doing this before, the possibilities became much more obvious in the 1951 National Championships, when a dozen pilots made flights using waves from Camphill, near Sheffield, towards the Yorkshire coast. Some pilots used up to seven waves, and climbed alongside lenticular clouds at about 7000 feet.

If the waves are there, a flight in almost any direction can be made by suitable proportions of cruising along a wave and moving to the next one, either up- or down-wind.

A very notable flight of this type was made by Mick Kaye in October 1957, when he flew, from Camphill, 145 miles to a point beyond Newcastle. A great deal of this was done flying north along the wave, and he also moved downwind, using three waves. He was able to fly for 90 miles above 12,000 feet.

Much remains to be found out about the use of waves, in particular about the use of aero-tows to contact wave-lift.

Other types of lift

Sea-breeze front provides another type of lift, which glider pilots are now able to use more frequently. On sunny days, during the morning, the land becomes hotter than the sea, and when the wind is either calm or fairly light the general ascent of air over the land causes a flow in from the sea. During the day, this air-mass penetrates inland by fits and starts, often with a clearly marked 'front' and a narrow line of upcurrents.

At the Southdown Club, near Firle Beacon, about five miles inland, this flow of air often reaches the club ground by about midday. I have seen the sea-breeze front here usually marked by a line of heavy cumulus and have found it possible to connect with the lift caused by this front, from winch-launches to about 600 feet.

At Lasham Aerodrome, 30 miles inland, the effect of the sea-breeze is often felt at about 4 p.m., with a change of wind direction, and lift along a line of cumulus with a much lower base than the former clouds. The effect has been known for some time, and was first used by Philip Wills on a flight to Cornwall before the war, when he reached the coast near Lyme Regis and was able to soar straight along the coast for many miles in the line of lift formed there.

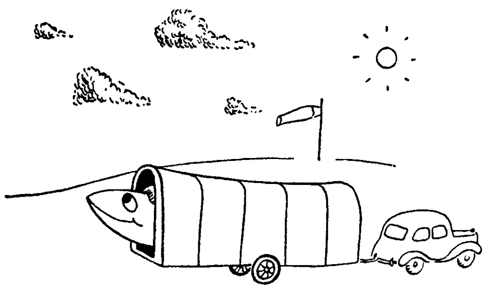
It also seems likely that a coastline can produce lee-waves out to sea, owing to the wind's blowing over the mass of sea-breeze air.

Dynamic soaring over the sea—the albatross and many smaller birds can fly for hours without flapping their wings, using the variation in wind speed at different heights above the waves. They can also be seen 'hill-soaring' around ships.

The soaring done by the albatross appears to be 'wind-gradient soaring'. I have explained why a glider coming down facing into wind through a wind gradient will rapidly lose height. The converse applies during climbs up away from the ground into a wind gradient: the glider's speed will increase and it will be able to rise more rapidly. The albatross directs its flight so that it climbs away from the water upwind in the wind gradient; it can then use its excess speed to fly in any direction it likes. Next, instead of descending into wind as we do, it has only to turn and dive downwind, when the wind gradient will work the other way, and actually increase its airspeed again! The process is completed with an exhilarating steep turn close to the water, with the lower tip just skimming above the waves.

I have heard it said that men will never be able to do this, but I wouldn't be too sure. Many years ago it was firmly stated by 'experts' that upcurrents under cumulus clouds could not be used by gliders. There is at least scope for experiment in soaring at sea. The argument that 11 feet must be the maximum span for dynamic soaring, otherwise the albatross would have grown larger, is open to doubt. Vultures aren't any bigger either, although they spend most of their lives in thermals which can easily be used in 50 ft. span gliders.

Perhaps, at first, experiments could be made with small radio-controlled models, to learn how to use the lift. The prizes are considerable, and might include flights above the ocean right round the world.



7. First Cross-country Flights

Local soaring

By 'local soaring' I mean soaring flights in which you keep within gliding distance from your landing field, not relying on finding lift to gain enough height to get back again.

The problem of how far you can go from the field turns up for the first time as soon as you start circling in a thermal and find yourself drifting away downwind from the landing area. Clearly, in a strong wind, the lift must be strong if you expect to get back again. On a day with no wind at all, you can circle happily in 'zero-sink'.

If you are drifting fast downwind, make sure that you are not making a gross mistake, and climbing at a flatter angle to the ground than you can expect to achieve during your return. For example, flying a T.21 in a wind of 15–20 knots, you may expect to return to the field at about the same ground speed as you drift away. This means that the rate of climb must be more than the rate of sink expected on the way back. This is at least 4 ft. per sec., so you certainly ought not to hang on to your thermal unless the variometer is showing 6 or more most of the time. (*See* 'fumble factor' later on.)

You get a large safety margin if you can start to circle at 1000 feet or more, upwind of the aerodrome.

Judgment on how far to go, and when to discard lift, can only come by practice, but bear in mind, when experimenting, the difference between making a mistake on the high side and on the low side.

Getting back 'too high' brings you back to a favourable position for finding another thermal.

Getting back 'too low' has been one of the most common causes of completely destroying a glider. There seems to be a feeling that perhaps it will be possible to reach the aerodrome after all, so instead of making a careful landing in a field outside (if there is one!) the glider ends up in the hedge or is damaged in a hopeless last-minute attempt at a landing outside.

A glider pilot can get a lot of entertainment from local soaring, carrying a map and getting to know the local countryside, as far out as 5 or 10 miles upwind from his local aerodrome. Ten miles sounds a long way away, but such a distance is within reach of home—provided you are at about 4000 feet, upwind of it.

Draw circles on the map, centred on the club, of radius 4, 8, 12 miles, marked 2000, 3000, 4000 feet. These will help to give you confidence in venturing farther away from the field, still making reasonably certain that you can get back again without relying on finding lift.

Judging how far you will have to glide to reach the next cloud needs practice. As it is hard to judge exactly its size, it is hard to judge its distance. The trick here is to estimate the distance of its shadow on the ground, which can be done quite accurately.

Silver distance

When you are proficient in local soaring, and are used to staying up in thermals within reach of the field, you may begin to think about cross-country flying. Making a cross-country flight, in which you turn your back on your home aerodrome and finish up 50, 100 or more miles away, is an altogether different order of flying from merely floating round your local field.

The Silver C Certificate (Silver Badge) has, as one of its tests, a cross-country flight of more than 50 kilometres (32 miles), and most clubs now provide facilities for its keener members to attempt this. So your first cross-country flight is likely to be an attempt on 'Silver C distance', sent off in a club aircraft under the supervision of an instructor.

Preparation for flight

You need a good settled day, with similar soaring conditions extending for some distance away. On a good day, cumulus should not start much before 10.30 or 11 a.m., or there may be a chance of 'over-convection'. A perfectly calm day with no wind at all is not suitable: you will get along too slowly and, more important than that, you will not have the help of a wind to steepen your angle to the ground in a forced landing. Obviously a howling gale is unsuitable—thermals are hard to use, and landings are tricky.

One of the rules of the test is that the loss in height between the starting point and the landing point must not exceed 1 per cent of the distance covered. This means that for a 50 kilometre (32 mile) flight, the loss in height must not exceed 500 metres (1600 feet). As the starting point may be a release from winch at 1000 feet or from aero-tow at 2000 feet, this 1 per cent rule must not be neglected.

To take just one example, a quite probable one, of a release at 2000 feet above the airfield and a landing at a place 500 feet lower. Two thousand five hundred feet is 0·47 miles and as by the 1 per cent rule you need to go 100 times this height, you must go 47 miles.

So I recommend you to choose a goal about 50 miles distant. This should be approximately downwind. It is best to choose an aerodrome, but make sure that it is one which welcomes strange gliders dropping in. A flight to another gliding club is worth considering; if the members are operating you can be sure of a welcome there.

When you have chosen your goal, draw a line to it on your map. Measure the distance, and measure the direction of this line—your proposed 'track'. Measure this angle in the same way that your compass reads, e.g. if you are going south-east, the track is 135 degrees. Add the magnetic variation of 9 degrees, giving 144 degrees, which is therefore the direction you will need on your compass to point the glider along this line. Look at the line you have drawn and see if it passes through any places where there are restrictions on flying. (*See* 'Air Law' at the end of Chapter 4.) Remember that in control zones there may be numbers of airliners flying at speeds of 400 m.p.h. or more, and that the law says, although you may go into a control zone when the visibility is good, you must keep away from cloud.

Maps

As you must carry with you in the air a map with control zones marked, it is best to have a special 'aviation map'.

Two main scales are used—the 4 miles to the inch, and the scale 1 : 500,000, which is about 8 miles to the inch.

The '¼-inch map' is very similar in style to the popular Ordnance

Survey map used for cycling or motoring, but with flying information printed on it. This includes particulars of aerodromes, airways, obstructions, special landmarks, and so on.

The 'International ½-millionth' is completely different, as it was designed especially for flying, and shows only features of use for air navigation. At first sight it looks rather empty compared with the ¼-inch map, which has its space filled in with little minor roads and villages. However, a little use in the air will soon convince you how admirably it has been designed for the job. Aerodromes and general flying information are marked, and also clearly visible towns, railways, large woods, and main roads. Both styles of map show height contours, and spot heights.

It is hard to give a simple rule about which map to use, as this must depend on the conditions in which you are flying. The ¼-inch map is useful, when local soaring, in getting to recognize features a few miles from your club. It may also be useful on a day of bad visibility, but for a cross-country flight on a good clear day, with visibility almost 'unlimited', the half-millionth will be much less confusing.

A ¼-inch map (but not necessarily an aviation one) is useful in the landing area, to give details so that the retrieving crew can find you.

You may not be able to do complex measurements and calculations in the air, and your problems will be much simplified if you have marked on the map beforehand 10-mile stages on your line.

Also mark on the line points 4 miles and 8 miles from your goal, and label them 2000 feet and 3000 feet. When you reach these points at or above these marked heights, you can consider yourself 'home'. This means that you can glide in to your goal without having to find any more lift. With more experience, you can work to much finer limits than these, allowing 4 miles per 1000 feet, and 1000 feet to spare.

Arranging to get back

Before leaving, you will have to make arrangements for the retrieve. Make sure that there is a car and trailer in order, and that someone is willing to fetch you.

When retrieving from long cross-countries and in competition flying, it is usual for the trailer to leave the aerodrome at about the same time as the glider. Private arrangements may be made for getting the information back to the crew about the landing. These usually avoid expensive telephone calls right back to base.

To avoid possible confusion in a journey which will probably take only a couple of hours, it will probably be best to arrange for the crew to wait at the club until you land and telephone the news. . . .

Final preparations

A sealed barograph must be carried to record the flight. This has to be sealed and signed before the flight by an official observer. It is opened by him afterwards, when you return and ask him to certify your flight.

It is your responsibility to see that the barograph has been turned on and you can hear it ticking. It is annoying enough if a barograph goes wrong during a flight and fails to record, but it is maddening when it fails to record because you have forgotten to turn it on!

Other equipment needed includes some convenient food and drink. I usually carry glucose sweets or chocolate and a small bottle of orange juice. Put them where you can get at them!

You will also need some change for telephoning.

At last you will actually be sitting in the glider, ready to go. Set the altimeter to the height of the aerodrome above sea level.

On the way

Assuming you find a thermal, climb as high as you can in it, and start to get an idea of the sort of day it is. For example, if you find the cloud-base is below 3000 feet it is not going to be much of a day for a beginner.

As you are not in a race, and have plenty of time to do your 50 miles, a good plan is to try to work a second thermal still within reach of the aerodrome, as you have previously done during local soaring.

If you cannot find this second thermal, it is more satisfactory to land back on the aerodrome than to struggle on for perhaps only ten miles. If, however, you have found your second thermal with ease and climbed up well in it, you can set off with much more confidence in the conditions of the day.

The moment of decision to turn your back on the home aerodrome and set off across country is always an exciting one—especially so the very first time you do it.

For the next hour or two you can look forward to moments of agony, when you may be praying for a last-minute thermal to save you. There may also be moments of delight that I can hardly begin to convey on paper. Some of these on which I still look back with a stirring of the pulse include a 10-mile dash along a cloud-street at 70 knots; and a last-minute save at 500 feet in a 20 ft./sec. thermal—getting the first glimpse of the goal ahead, with the line of the sea-coast beyond.

On your first cross-country flight, keeping a good supply of height will be your chief occupation, but you should also expect to do some navigation.

Pointing in the right direction!

Your first glide away from the home aerodrome should be towards the most promising cloud nearest the line on your map. Before you start, you should have a fairly clear idea of the direction of this line from the airfield across some local landmark, such as a town or a hill.

The compass, which is vital for flying in clouds and in very poor visibility, may not be as important as you might think on a cross-country flight, as you can very rarely settle for long on any definite compass course. If you are flying across wind, you may have to make a big allowance for drift. This angle can be estimated beforehand and checked and corrected in the air on the first straight glide.

The direction of the sun is a great help in rapidly straightening out in about the right direction. (Remember as the day goes on, the sun moves round through the south towards the west!)

If there is any wind, it can be a help in fixing your direction. Drift is easy to detect, and the movement of the cloud shadows can also be seen. But beware of wind changes on a long flight, especially near the sea-coast.

Finding your way

Map-reading in the air takes some practice. It is surprising how unrecognizable even one's own home-town may appear when seen for the first time from this unfamiliar angle. Quite different features stand out in importance when it is seen from above. Look down and see if you can spot the railway station and junctions in the right place, also the river and the gas-works and the cathedral (if they exist!).

If you cannot make these features fit into the right places on the map, then perhaps you have made a mistake, and it is not the town you thought after all. If it doesn't really fit, be prepared to look for another town on the map with the right features. On a cross-country once I had a town appear in front which I expected to be Andover, a place with a good selection of railway junctions. I must confess to a feeling of annoyance with the town for apparently having a large cathedral in the centre and a big by-pass road. At last I had to admit to myself that it must actually be Winchester, 15 miles to the south.

Railways are useful features for navigation, and are clearly marked on maps with a symbol showing the number of tracks. Main roads may not always be good landmarks, and they tend to disappear in towns. However, on Saturdays and Sundays the main routes can be spotted by the sun glinting on the rows of cars stuck on them.

Don't worry about knowing the name of every little village you pass over. Unless you have made a big mistake in the direction you have been taking between thermals, you will eventually come across a railway line or a larger town which will give you a positive fix.

There may be a feeling of being lost, if the next landmark doesn't turn up when expected. This feeling can be much reduced by trying to get an idea of the speed you are making over the ground. Sometimes you get a feeling of having been flying for hours with no progress to show for it. Take stock at the end, say, of one hour after leaving the aerodrome. If the wind is 15 or 20 knots at 2000 feet, you can hardly have gone less than 25 miles downwind in that hour. At that rate, another hour should see you through your 50 miles.

Landing in fields

If you find yourself down to 2000 feet without lift, you must face the possibility of having to find somewhere to land. Don't fly farther forward along your course if the country in front is becoming more difficult for landing. Choose a good field for a possible landing and think of yourself as 'local soaring'—keeping this good field within reach as you would your local aerodrome. When you have got settled in a good thermal, then you can forget this field and go on your way.

A deplorable amount of prangery has been done by people who ought to have known better as a result of choosing their field too late. An advanced pilot flying in competitions will naturally work to a lower limit than a beginner on his first cross-country, but in both cases a decision to land must be made before it is too late.

It is not easy to pick a good field from the air, and it is not easy to land in a strange field if nearly all your previous landings have been on the same aerodrome. It is simply asking for trouble to break off what should be a carefully planned and executed approach looking for last-minute thermals.

If the worst happens, and you continue to sink without lift, then at 1000 feet above the ground you must firmly decide to give up the flight and land in your field.

Choosing the field

An aerodrome is, of course, ideal, and should present no problems in the actual landing, but it is wise to be sure beforehand what aerodrome it is.

You may perhaps claim to be allowed to land anywhere in a genuine case of 'aeronautical urgency'. However, no excuses can be made, for example, for having got yourself into a position when a landing at London Airport is the only way to avoid a prang. Even if no aerodrome is available, from 2000 feet you have a large selection of fields to chose from. (I am assuming you are not at 2000 feet on your first cross-country among mountains, nor over the centre of London.) There are usually a few obviously bigger fields, and you should start by considering the longest one available in the direction of the wind.

Next try to get an idea of the *slope* of the field, if any. This is probably the most important feature of all. If you try to land downhill, you may find it impossible to touch down at all, and may even fly out of the far end of the field. But if the field is slightly uphill, you need very much less length for a landing.

Detecting slope on the ground from 2000 feet is difficult. In fact, a slope which is easily seen from this height is probably a hill too steep to land up, with a danger of running backwards after coming to rest.

There are various ways in which you can deduce the presence of this all-important slope. To take one example, fields next to a river can hardly slope down away from it. They are either flat, or sloping up from it. Railways can also help. They rarely have gradients steeper than 1 in 100, so if you think of the line as level, the start of a cutting or embankment will give a clue to the lie of the land alongside.

Nature of the surface

Obviously when you first put your field on the list of possibles you had some idea of the kind of surface to be expected.

The best is, of course, grass, preferably mown and rolled! Playing fields fulfil these conditions, but they are rarely large enough and not often entirely free from obstructions both in the field and on the boundaries.

A large pasture field is usually fairly easily identified, by its uniform darkish green. A field with cows is to be avoided unless it is very much the largest available and the cows are obviously out of the way. It is not very likely that you will harm the cows, but they may easily harm the glider. It is well known that cows take an interest in a strange glider and this eventually leads to their trying to use it as a rubbing post. Also, they seem to like the noise (and possibly the taste) of crunching fabric and ply. You may have difficulty single-handed in keeping them off, but *never* leave a glider unattended in a field with cows.

If a field has a line visible across the middle, make sure in time that you know what this means. It may be just a footpath, but it may be an invisible wire fence. If there is a change in surface colour or texture at this point, then you can be sure there is some kind of wire. Barbed wire, especially, should be treated with more respect than a hedge.

Cornfields, especially of almost ripe wheat, should be avoided. It is impossible to land in one safely in a glider whose wing-tips or tail are low. The heavy heads of grain will catch the tip and pull the glider round, and tailplanes have been torn off altogether.

A stubble field, on the other hand, may be one of the best for landing. When the crop has been taken away, the surface will almost certainly be smooth.

A field soon after it has been ploughed, when the furrows are still very large, may be too rough for a landing. I have landed skidded gliders across the furrows, but in a wheeled glider it is better to land along them. Another reason for this is that the furrows will probably be running up and down the slope and not across it.

Obstructions on the boundary

A feature which will have a big effect on the ease of landing in a field is the kind of boundary over which you will have to approach. The best boundary you can reasonably expect is a low hedge, with no other obstructions. Perhaps a single tree may even help in height judgment on the approach, but tall trees lining the approach boundary are to be avoided. You will need to approach quite high above them to avoid possible downdraughts behind, and this will mean that the field will have to be very long indeed for a safe landing.

Tall trees can at least be seen, but another possible boundary obstruction is quite invisible—that is a line of telephone wires. Until you have done a bit of flying, it is hard to realize that telephone and power wires which look so obvious from the ground when seen against the sky are invisible from above until you are a few feet away.

Fortunately, telephone poles and power poles are usually visible, although they may be partly hidden by trees and houses.

The really big power lines are easier to spot, as the steel lattice towers show up fairly well, but beware of the lower voltage ones which have poles just like telephone poles. The wires may have long spans between poles, and they don't always stick to the boundaries.

The actual approach and landing

For four or five minutes now you have been looking for lift, flying within range of the good field you picked at 2000 feet. Now down to 1000 feet, you have made the disappointing decision to abandon the flight and to make a good safe job of your first genuine forced-landing in a field.

Decide whether you are going to make a right- or left-hand circuit. This will depend on which side is clearer of obstructions and whether there is a light cross-wind.

Fly upwind over the field (or slightly to one side as you will then be able to see it better), and if you feel you have plenty of height to spare, do a circle over it. This will give you a last clear view of any snags and get you in the familiar position of having been launched out of the field.

As you turn round on your circuit, remember that the field is probably much smaller than your club landing ground. If you have been used to flying on an enormous aerodrome, you may have been able to plan your whole circuit hardly going outside the boundary at all. So don't be tricked into doing your circuit too close in. If the fields are of average size then you will expect to fly downwind and start your cross-wind leg at least two fields away, possibly three. Don't crowd the field—approach high up and well out—use plenty of coarse brake on the final cross-wind leg, and finer adjustment as you come over the hedge.

Don't try to push the glider on to the ground, do your usual hold-off to touch down as slowly as possible. In an emergency, if you are obviously going to run into the far boundary, the glider can be forced on to the ground with stick forward and held there. However, on rough ground this is very likely to cause damage.

After landing

On two or three occasions I have landed in a field and no one has turned up for fifteen minutes; but usually people will begin to spring up all round the hedges in a few moments.

You have been accustomed to staying seated in your aircraft after landing at a club until help comes. If the wind is very strong you will of course have to stay in the cockpit and ask for help in turning the glider cross-wind. Otherwise you can get out and do this. It is a good idea to carry a couple of pegs and some rope for picketing down the tip, a much better plan than the one of using your parachute, either inside or outside its bag. It may get wet, and people may lift it off the tip to examine it.

The glider will have to be left while you go and telephone the retrieving crew. Make sure that there are no cows about, and none expected shortly. If possible get someone sensible to take charge for you while you are away.

You will of course give directions to the crew such as, 'Four miles north of X-town, on the B1066 road to Y, turn down lane on right opposite the Red Lion'. Experience has shown that it is also necessary to give a telephone number where you can be traced, and preferably a full postal address!

The next thing to be done is to get a landing certificate to show to the official observer who is to certify your Silver C application when you get back to the club. Two local witnesses should be asked to sign a paper saying that you landed your glider at the place you did, with the time and date.

Now comes the problem whether to derig or not. A modern glider is so easy to derig with a crew who understand what to do, that it is better to wait until your trained helpers arrive. Only a few minutes can be saved by derigging with local helpers, and unless you are very experienced at this it is quite easy to do serious damage. Also, the parts are more likely to get damaged if they are left lying about on the ground. A little time can be saved by removing control pins—replace them in their fittings at once.

One way in which spectators can safely help is to pull the glider to the side of the field close to the gate where the trailer may be expected. This is important, especially if there is a crop in the field which may be damaged by people coming in and wandering all over it.

Do not forget that you are an uninvited guest in someone's field. Nearly all farmers are friendly and helpful to uninvited glider pilots who sink into their fields. These visits can hardly be a help to the farmer in his work, and it is up to the pilot to make sure that he does not do any damage. If some unavoidable damage has been done, however small, it is essential for the good name of the Gliding Movement and consequent toleration of glider pilots' activities in the future, to see the farmer about it. You can appreciate the difference between finding some damage done on your property by someone who has just disappeared, and being approached by someone who apologizes for some damage accidentally done and offers to pay for it.

Lastly, as you leave, make sure there are no bits of glider left behind, and make sure the gates are shut.

International badges for gliding

1. *Silver Badge*

(*a*) Duration—A flight of at least 5 hours.

(*b*) Distance—A flight of at least 50 kilometres (32 miles) made in a straight line.

(*c*) Height—A gain in height of at least 1000 metres (3280 feet).

2. *Gold Badge*

(*a*) Duration—A flight of at least 5 hours.

(*b*) Distance—A flight of at least 300 kilometres (186 miles) made either:

(i) In a straight line, or

(ii) Around a triangular course of which the shortest side must measure at least 28 per cent of the total distance, and of which the turning points must be previously declared, or

(iii) In a broken line of not more than three legs of which none shall be less than 80 kilometres (50 miles). The turning points must be previously declared.

(*c*) Height—a gain in height of at least 3000 metres (9843 feet).

3. *Gold Badge with Diamonds*

The accomplishment of each of the following three performances gives to the holder of a gold badge the right to add one diamond to the badge:

(*a*) Distance—a distance flight of at least 500 kilometres (311 miles) made either:

(i) In a straight line, or

(ii) Around a triangular course of which the shortest side must measure at least 28 per cent of the total distance, and of which the turning points must be previously declared, or

(iii) In a broken line of not more than three legs of which none shall be less than 80 kilometres, and of which the turning points shall be previously declared.

(*b*) Goal—a goal flight of at least 300 kilometres, made either:

(i) In a straight line, or

(ii) Around a triangular course of which the shortest side must measure at least 28 per cent of the total distance, and of which the turning points must be previously declared, or

(iii) In a broken line of not more than three legs of which none shall be less than 80 kilometres. The turning points must be previously declared.

(*c*) Height—a gain in height of at least 5000 metres (16,404 feet).

8. More Advanced Flying

Aerobatics

Most glider pilots at some time or other want to perform aerobatics. If you see someone throwing his glider about the sky he may perhaps just have completed a difficult flight and be expressing his delight on the way down to the ground. Perhaps it may be an instructor who is fed up with flying straight and level with pupils all day.

Aerobatics are sometimes performed as a display for people on the ground to see, and they can be a fine sight if well done. Although at one time I got great satisfaction myself from polishing up my aerobatics in public displays, the most intensely exhilarating aerobatic flight I have ever done in a glider was by myself, above the clouds. For part of the time I had an audience of one—the pilot of the aeroplane who had towed me up there, and who joined me in some of the manœuvres.

Some clubs expect some simple aerobatics as a qualification for flying their more advanced machines. The reason for this is simple enough; if you are proficient at aerobatics, you will be used to having your glider in all sorts of unusual attitudes and to making a smooth, safe recovery from them. You will know much more about the capabilities of your aircraft.

Aerobatics can be divided into two main classes. The first kind should be possible in any type of 'semi-aerobatic' glider, and include the *loop*, *stalled turn*, and *spin*.

The second kind all involve putting an inverted loading on the glider; for example—*inverted flying*, *slow rolls*.

The loop

Everyone knows what a loop is, but although it is the simplest aerobatic, it is a very satisfying thing to do.

As in all aerobatics, you first look round to make sure that there are no other gliders near you. You then lower the nose and dive steeply to gain enough speed to do the loop. It is a help to choose a clearly marked line on the ground to dive along, such as a straight road or railway line. It is also easier if the loop is made straight up or downwind. The speed needed in a T.21 is about 80 knots (the maximum speed allowed is 90 knots). It will seem to take a long time to gain this speed, and you will have a marked feeling of standing on the rudder pedals. A T.21 begins to make a loud whining noise at this speed!

When you are sure you are going fast enough, all you have to do is to start the glider climbing steeply and go on climbing all the way round the circle until you are the right way up again. Ease back the stick firmly, but slowly, to start with, and you will feel a strong pressure from the seat on your bottom. The scenery in front disappears and there is nothing but sky ahead. As you go round, and the speed decreases, you need to move the stick farther and farther back to maintain the same pressure on your seat.

Look up for the far horizon of the earth to appear above your head. The stick should be right back by now, and the earth should come on round until it is in front of you. You will now start to gain speed again, and there should be no difficulty in regaining normal attitude from the dive.

The wings have to be kept level, but there is not much difficulty in doing this, as the whole loop is over very quickly. From the bottom of the dive, it will take only 4 or 5 seconds to go right round.

Nothing is likely to go very wrong with the first loop you attempt. You should have enough feeling for the aircraft not to pull the stick back roughly and put too much load on the wings in the pull-out from the dive. The other possible error is getting too slow on the top.

I have mentioned a loop as a manœuvre in which an inverted loading is not put on the wings. The glider certainly should be upside-down at the top of the loop, but you should have no feeling of being upside-down. The forces all the way round should be as in starting a steep climb; you will be pressed down on to the seat, the loads on the wings will be in the same direction as in normal flight, but rather increased.

If you do get too slow at the top it may be uncomfortable. Your feet will tend to come off the rudder pedals, and the loose bits of dust and rubbish which always seem to be in a glider cockpit will come up in your face. Provided that the earth has begun to appear again (i.e. that you have got well over on to your back), it is merely a question of waiting with the stick back, and you will fall onwards the right way up.

It is dangerous to get too slow with the glider's nose pointing steeply upwards, so that it starts to slide backwards. The danger is that the control surfaces may be violently forced to the end of their travel and damaged or even broken off. The only thing you can do in such a situation is to hold the controls very firmly, but even so it may not be possible to prevent damage in a violent tailslide.

The stalled turn

A full stalled turn is not a desirable manœuvre in a glider, and it is usually done in the reduced form known as the

Chandelle

Dive steeply, once more along a line for accuracy, to a speed similar to that for a loop. Pull up into a steep climb. In a powered aeroplane it is safe to climb some way vertically using the engine, and when on the point of the stall, tip over by means of rudder one way or the other.

In a glider you should gradually begin to turn one way, say to the left. As your speed drops off tip farther and farther over to the left. Soon you will get very slow indeed, and, in the 'deathly 'ush' which follows, you and the glider will continue to fall round until you are pointing nearly vertically downwards. If you have done it correctly, you will now be pointing back along the line in the opposite direction to your original dive.

The glider must be well on the way round the turn before the stall is reached to make sure there is no chance of a tailslide, with the dangers already described.

The spin

This has already been dealt with as a part of flying training. In training the emphasis will have been on recognizing the beginning of a spin and on applying correct control to stop it at once. In aerobatics you will want to go into it firmly and get out cleanly after a definite number of turns, pointing in a definite direction.

Not many people particularly enjoy the feeling of a spin, but it may make a very effective part of an aerobatic display.

Inverted flying

I shall say very little about this, as there are few gliders in this country safe for unrestricted inverted flying.

It is not a sensible thing to try to teach yourself inverted flying and slow rolls without considerable previous experience, which would probably have to be gained from power flying.

It is a good idea to fly with your hand on the brakes in aerobatics, in case of sudden need to limit the speed. However, the margin of error in recovering from the inverted position in a clean modern glider is so small that it is all too easy for your speed to exceed the maximum allowed before you can check it with brakes.

Height needed for aerobatics

In this account I have made no mention of distance from the ground. I have assumed it is so far below that you haven't got to worry about it at all. It is vital (in the strict sense of the word!) that this should be so.

Most clubs have local rules about aerobatics and you must find out what your club rules are. For your own safety at least, any new aerobatics should be tried out above 2000 feet (3000 feet is better); normally any aerobatics should be completed by the time you are down to 1000 feet.

The law demands that aerobatics be not done in certain places. In particular this applies to control zones and above towns.

Instrument flying

Cloud-base on a soaring day in Britain may be as low as 3000 feet and is rarely higher than 5000 feet. If you are restricted to flying only below cloud, then the height available for a glide to the next area of lift is much reduced. Also the strength of a thermal generally increases above condensation level; so being able to fly 'blind' in clouds enormously enlarges one's scope as a glider pilot.

The proper instruments are essential for flying in cloud, and it is necessary to learn how to use them and to keep in practice. You have to learn to interpret the readings of the instruments and to ignore your sensations. The balancing organs in the human ear work well enough for their normal purposes, but depend a great deal on checks from visual messages via the eyes.

In a rough cloud when you are circling continuously and also being pushed violently up and down, your balancing organs will completely mislead you. You know the sensation you have after spinning round a few times when standing upright. Try to keep upright afterwards with your eyes shut!

You must learn to fly on the primary instruments—the turn-and-slip and airspeed indicator. You also need, as minimum secondary instruments, variometer, compass, and altimeter. A clock with a large seconds hand is also useful. An artificial horizon makes instrument flying much easier, but you must be able to cope without it in case of failure.

A parachute should always be worn when cloud-flying, and oxygen available for climbs above 10,000 feet. Don't forget that you may not fly in cloud in airways and control zones.

Both fully equipped two-seaters and instructors experienced in teaching instrument flying are in short supply, but the ordinary club pilot who has reached cross-country standard should be able to cope on his own without undue difficulty, and certainly without danger.

Start by practising a few simple things in clear air. Switch on the turn-and-slip, doing rather larger circles than usual. The turn needle should be held at about rate 2; glider instruments are usually adjusted so that this represents a 25- or 30-second circle. You will not find it easy to stop the needle swinging around a bit, and it would be foolish to try to fly with the needle near the stop. As a steady turn depends chiefly on the angle of bank, the turn needle is controlled by the ailerons, together with the small amount of rudder which by now you automatically apply in the same direction every time you apply aileron.

It is not important to keep the ball precisely in the middle. As it moves to the side to which the glider is slipping, rudder is needed in that direction. Only a little, or the turn will also be affected.

The A.S.I. must be used to keep your attitude correct in pitch. Adjust the trim so that the glider flies hand-off at about 10 knots above stalling speed, and then practise keeping the speed in a safe speed-range, say 45 to 50 knots.

You have used your brakes many times to steepen an approach, but probably haven't often investigated their properties as speed-limiting brakes. It is instructive to get the glider into a variety of curious attitudes, steadily open the brakes fully and take your hand off the stick. You will be glad to see the slowing and steadying effect the brakes have.

Practising in the clear will not get you very far, as it is very hard not to 'cheat' out of the corner of your eye, and get some clues from what the world outside is doing.

It is best to start in cloud on a day when the cumulus can be seen to be small; start on instruments a few hundred feet below cloud-base, so that you are well settled by the time the ground disappears. Check in order, at perhaps 2- or 3-second intervals—Needle—Ball—A.S.I. One of the secrets of instrument flying is *Doing one thing at a time*.

(i) *Needle*—keep the needle where you want it by aileron, together with a little rudder.

(ii) *Ball*—use rudder sparingly to keep the ball central.

(iii) *A.S.I.*—if the speed increases a little, reduce bank slightly, ease stick back *a very little*. Do this step by step, with a pause between each movement to give the A.S.I. time to settle. Remember the A.S.I. reading corresponds to attitude only when it has been steady for several seconds.

If the speed continues to increase, or the turn seems to be getting out of control, *take off bank* before trying to slow down.

In your early attempts you may stall, and the sensations may be very disturbing as you try to ease out of the dive and perhaps stall a second time. It takes time to learn to believe the instruments instead of your sensations. Even if nothing goes wrong, every time you stop a turn it gives a violently misleading feeling of turning the other way.

In recovering from a dive, ease the stick back very gently. It is worth remembering that the aircraft is just about level at the instant when the speed starts to fall.

Don't be afraid to open the brakes fully as soon as you reach the speed limit previously decided on. A point to bear in mind, however, is that in serious cloud-flying you will pass through an icing layer, and as the brakes may possibly freeze in, you must eventually learn to manage without relying on their use.

The A.S.I. will also suffer from icing unless it is heated or fitted with a pot-pitot. If it does ice up, then it will be unserviceable until you are low enough for the ice to melt again. It should be possible to fly by the sound the glider makes, but this may be very difficult in a 'noisy' cloud with heavy rain or hail.

A *spin* is unlikely in cloud, as few gliders will continue in a spin unless held in one. The turn needle will be full over, but the speed is not very high. (In fact with a pot-pitot, the A.S.I. may give a negative reading!) In this case, rudder is needed to stop the turn until normal flying speed is gained. If the full spin recovery is needed, it consists of the control movements already described on p. 49.

A *spiral dive* is much more likely. It may look like a spin in the early stages, but will soon show as a dive by increasing airspeed. Recover by taking off the turn with ailerons, and ease very gently out of the dive. Once again—use the brakes!

Keeping in the lift

When you have learned to control your rate of turn, then, if you begin to fall out of the edge of the lift, centring technique can be applied just as described in Chapter 6.

Leaving the cloud

Assuming you have not fallen in a screaming dive out of the bottom of the cloud, you will want to make a planned exit from it in a definite direction. As you rise and reach the top of the lift you may perhaps see a patch of light getting brighter, and 'going past' each time round. This will turn out to be the sun, and if you can remember the direction it should be to your course, the straightening out should be easy. (Bees and ants fix their courses by this method.)

Clouds sometimes get very rough towards the top of the lift, and you should have made a note beforehand of the course to steer to get out as quickly as possible. With a Cook compass, it is possible to start to take off the turn 20 or 30 degrees before reaching the required course, and come out nearly correctly.

When you can fly with confidence on instruments, you have the power to climb thousands of feet in cloud, and to have the incomparable experience of emerging out of a wall of cloud a mile or two above its base. Flying on, above and between other cloud peaks, you may fly for half an hour or more before using any more lift, perhaps choosing another cloud which you have spotted 20 or 30 miles distant.

Cumulonimbus clouds

Flying on instruments in a well-developed cunim cloud is not to be undertaken lightly by a beginner. He may not come to any actual harm, but it is probable that he will at least frighten himself!

On the debit side, such clouds may contain hail, lightning, severe turbulence, and bad icing conditions.

On the credit side, they contain vast areas of 'green 'air. (Air is 'green' when it makes the green pellet of a variometer register on the UP scale.)

Fig. 19 shows a possible layout of a cunim cloud, which may consist of several cells of this general pattern.

The most active newly forming areas of lift are marked from outside by the usual firm cauliflower-like bulges. The downcurrent areas, near the rain or hail, are either ragged or, perhaps, bulging downwards (*Mamma* cloud). The very top part of the cloud

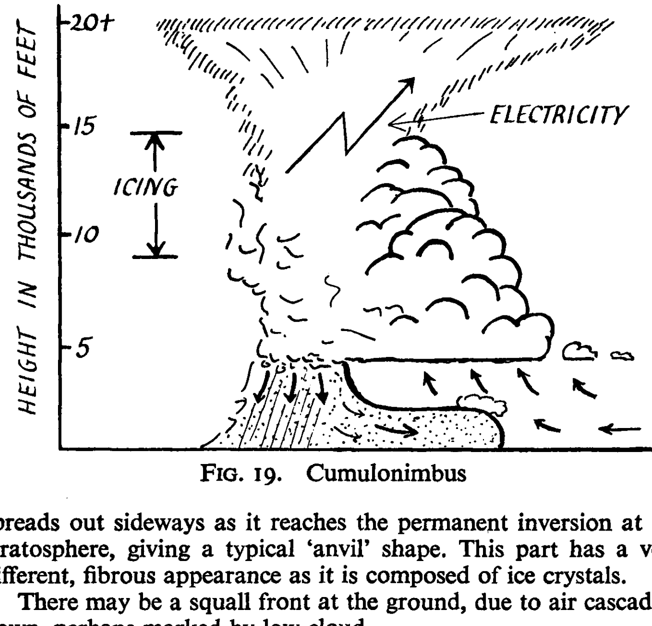


FIG. 19. Cumulonimbus

spreads out sideways as it reaches the permanent inversion at the stratosphere, giving a typical 'anvil' shape. This part has a very different, fibrous appearance as it is composed of ice crystals.

There may be a squall front at the ground, due to air cascading down, perhaps marked by low cloud.

It is quite likely that the air-flow is towards the cloud from some distance away. Areas of smooth lift are sometimes found in the clear in front of the active part of the storm.

Lightning

Lightning fortunately does not seem to be a severe hazard to a slow-moving wooden aircraft such as a glider. The flashes and the noise of the thunder can be quite awe-inspiring, and when you start getting electric shocks from the stick it is easy to imagine that the worst is about to happen.

I know of only one pilot who has actually been struck by lightning in a glider: Derek Piggott; and he says that it was 'rather alarming'.

Ice formation

Thirty-two degrees Fahrenheit is usually stated as the 'freezing point of water', perhaps it would be better to call it merely the 'melting point of ice'. Water can in fact be cooled well below 32°F without turning into ice at all, remaining as 'super-cooled' water drops. This may happen in the range down to about 10°F, below which temperature ice is almost certain to form. Dust particles, mechanical shock, and especially contact with crystals of ice will immediately cause super-cooled drops to turn to ice.

Ice formation on a glider will occur if it is flying through super-cooled water drops. These will freeze rapidly on to the nose and cabin, and especially on to the leading edge of the wings.

There may be some effect on performance, controls, and instruments. The effect on performance is due to the ice changing the shape of the wing section, and of course adding weight. The effect on the controls is not likely to be serious on ailerons and elevator, but may be serious on brakes. In some gliders the brakes freeze in and cannot be used, and in most the brakes will freeze out if opened for any length of time.

The effect on instruments is limited to the freezing up of the pitot tube, unless it is heated, or is of the 'pot' type in the nose.

What can you do about icing?

Some experts say, 'Look out of the window from time to time to observe the ice forming, as a change from concentrating too hard on the instruments.' Others say, 'All you can do about icing is to keep the window shut so that you don't frighten yourself by the horrid sight.'

The best advice I can give is to make sure you don't go on collecting ice for too long. The layer in which super-cooled drops occur extends for about five or six thousand feet, so, if you are climbing well, you should pass through the icing layer in 5 or 6 minutes. If the lift is not very good, don't hang around in the icing layer, but try to find a better area.

The average height at which icing may begin is between 6000 feet and 8000 feet in spring and autumn, perhaps as high as 10,000 feet in midsummer.

Gliding competitions

The biggest events in competitive gliding in Britain are the National Gliding Championships, which take place in alternate years. As many as 70 sailplanes have been entered, and their pilots spend just over a week meeting their friends and performing various flying tasks for which points are awarded.

Competitions no longer consist entirely of pure distance flying, as distances covered by gliders are now so great that they cannot all be got back in time to fly again the next day. Points are not awarded at all for height or for duration, but tasks are set, based on distance and speed, in the following four classes:

(i) *Free distance.* Marks awarded per mile flown, above a certain minimum limit.

(ii) *Distance along a line.* The line is announced at the briefing —for example, Dunstable to Land's End. Marks are awarded only for distance achieved along this line. 300 miles towards Edinburgh would not score anything!

(iii) *Pilot selected goal.* Similar to free distance, but if the pilot reaches the goal he selected before take-off, he receives a bonus on the score for distance flown.

(iv) *Speed flights.* These are races to another aerodrome, or races round a set course. The gliders do not all start together, but the time of each glider is taken between its crossing the starting and finishing lines. Part of the skill is in choosing just the right time of day to start.

Launches for all tasks are usually by aero-tow, and limited to three tows on any day.

Scoring. The marks are scaled so that the best performance on each day is awarded 100, and the others given points in proportion. In races 50 points are given to each glider which completes the course, and the winner for the day receives 50 speed-points to make up his 100. Speed-points are given in proportion to other gliders which finish the course; those which don't get round score points only for the distance flown.

I have mentioned points being awarded to gliders, rather than pilots, as it is usual for many of the gliders to be flown by a team of two or three pilots. There is a Team Championship and an Individual

Championship; the winner of the latter is the National Gliding Champion.

Flying in the Championships is an event much looked forward to by many pilots, and provides an exciting and memorable week. A Silver C is necessary for entry, but even if your standard is not much beyond that, it is a fine opportunity for gaining experience and comparing your own skill with that of others. To encourage pilots who are not of the top International Standard, a League II has recently been started, in which the tasks are not quite so difficult and include, when possible, chances of making qualifying flights for the Gold Badge.

Turning-point checks

In triangular and other out-and-return flights some kind of check has to be made that the pilot has really passed the turning points. This is not quite as simple as arranging for sailing boats to round a buoy.

In competitions the glider has to round the turning point below some definite height, such as 3000 feet, and should be identified by an observer on the ground. In case this fails, there is also a scheme for ground signs to be changed every half-hour or so. The pilot can state on his return the sign he saw at the turning point.

For qualifying flights for the Gold Badge and for record flights photographic evidence is allowed. The principle is first to take a photograph before the flight of a notice giving details of the proposed turning point. During the flight a picture is taken from the air over, or beyond, the turning point. On return another photo is taken of the notice board. The film is then taken out by the official observer under whose supervision all this has been done. The film when developed, but *uncut*, can be satisfactory evidence of having reached the turning points.

Crewing

Crewing in the Championships is a very worth-while job. Each glider has to have some reliable car-drivers for retrieving, and helpers for rigging and ground handling. Success of any pilot depends to a great extent on the efficiency of his crew.

How to go fast across country

Learning to go faster is not just for Competition Pilots, but for any-one who wants to make more successful cross-country flights. Going faster also means going farther, as the time when thermal conditions are good is limited. In any day there may only be an hour or two when soaring conditions are good, and six or seven hours is the limit.

Going fast depends on gaining height efficiently and also flying at the 'best speeds'.

You must choose the best cloud, and centre quickly in the lift. Proper centring can often double the rate of climb achieved. A lot of time can be wasted fiddling about in weak lift. On a day when you know there are good thermals, leave lift as soon as it begins to fall off, or if it doesn't come up to standard. This should be done at any stage when you are above some determined 'safety height'; below this height any lift must be carefully nurtured to keep you up at all costs.

Flying at the best speeds

The best exploitation of lift is more important for success than flying at precisely the right speeds. However, while the former is almost entirely a question of practice in the air, the latter provides a pleasantly endless subject for argument, discussion, and production of charts and tables—so here goes!

The 'best speed' depends on the stage you are at during a flight. You may be (i) circling in a thermal, (ii) gliding to the next thermal, (iii) on the final glide towards your goal.

(i) *Circling in a thermal*

You should fly at your speed for minimum sink, e.g. in Skylark 2, about 40 knots. This speed will need to be slightly increased when you are in rough air, circling very steeply, when flying on instruments. Use the same speed for hill-soaring or wave-soaring, and whenever you want to prolong a glide for as long a *time* as possible.

(ii) *Gliding to the next thermal*

If you want to glide to a distant cloud with the least loss of height, you must fly at the speed for best gliding angle. If you fly slower than this, at the speed for minimum sink, although you sink less feet per second, you will take so many more seconds arriving that you will arrive lower down!

From the graph (Fig. 5, p. 22), you will see that the speed for best gliding angle in a Skylark 2 is about 43 knots.

However, in a cross-country flight made in thermals, this is not the whole story. The flight consists of a series of glides and climbs;

so you want to keep the time of each combined unit of 'glide-plus-climb' as short as possible. When you are in a hurry and thermals are strong and plentiful, fly faster. Although you arrive lower down at the next thermal, you can nevertheless reduce the total time between leaving one thermal top and arriving at the next thermal top.

So the answer to this one is that the best cruising speed between thermals is faster than that for the best gliding angle, according to the strength of the thermals of the day.

It is quite simple to calculate the theoretical best speed to glide according to the climbs achieved. This best speed to fly is clearly quite independent of the wind speed, and of whether you are flying up- or downwind, as it gives an average speed achieved in the journey *through the air*.

For example, in a Skylark 2, achieving an average climb in thermals of 5 ft./sec., 60 knots is the best speed to fly between thermals (neglecting up- and downcurrents), and the average speed through the air is then about 33 knots.

'Fumble factor'

A term used by pilots to describe the efficiency with which a gliding activity is carried out. For example, most pilots find that the actual rate of climb achieved when checked by a stop-watch through a measured height is much less than they would guess from the readings the variometer seems to be showing. A 'fumble factor' of one half is quite good going. So, if the variometer seems to be showing 10 ft./sec. up most of the time, you may well find that you have actually made only 5 ft./sec.

Achieved rates of climb of over 5 ft./sec. are not very common, and we can summarize by saying that, on a very good day, one should cruise a Skylark 2 at about 60 knots between thermals; on an average day one should fly somewhere between 50 and 55 knots.

Flying through up- and downcurrents

The theoretical best speeds to fly in all cases can be calculated, but most pilots make a simple adjustment, increasing airspeed in downcurrents.

In upcurrents, the speed should be reduced a few knots, and in downcurrents it may pay to increase the speed quite considerably. Take the example I have given of a Skylark 2 on a '5 ft./sec. day', with basic cruising speed of 60 knots. If the variometer shows 10 ft./sec. down, the speed should be about 70 knots, and if it shows

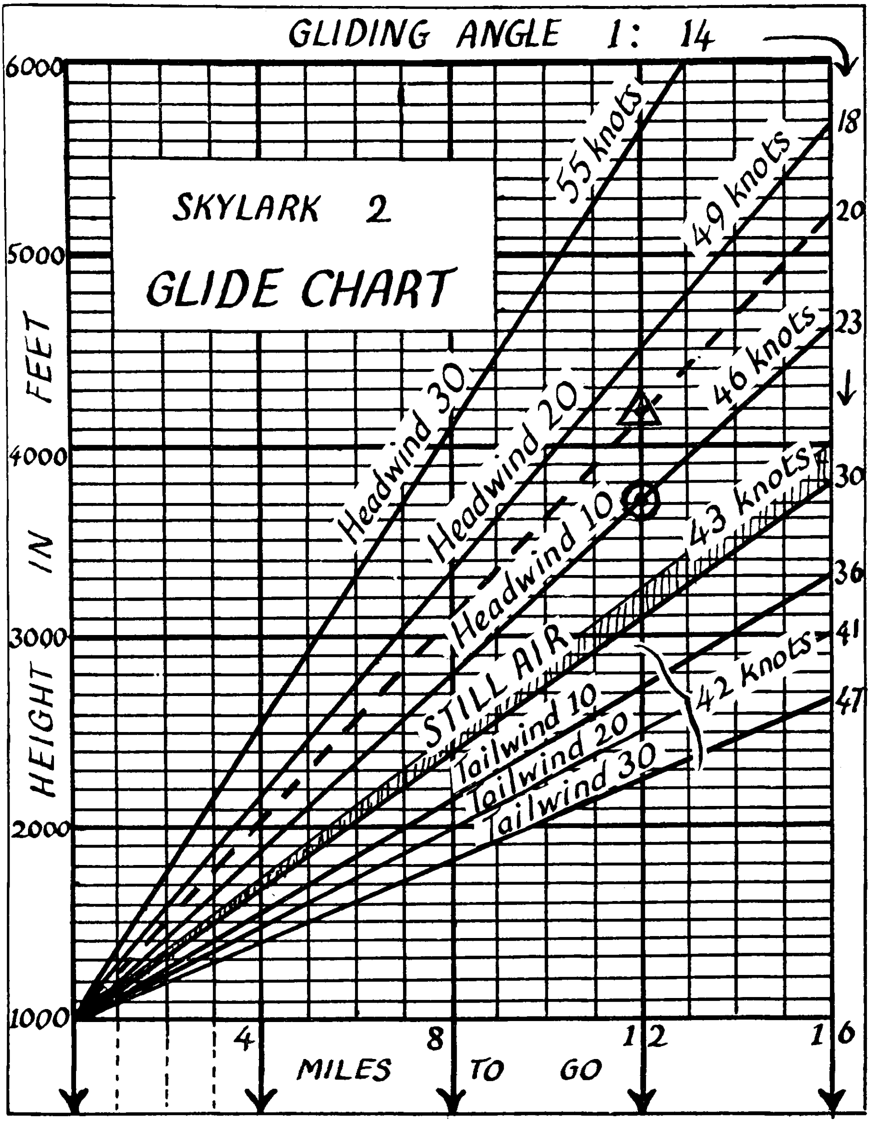


FIG. 20. Skylark 2, Glide Chart
Speeds to fly for maximum glide distance in various headwinds with gliding angles given. To fit a ¼″ map

15 ft./sec. (God forbid!) the speed should theoretically be about 80 knots. On a '2 ft./sec. day', with basic cruising speed of 53 knots, the corresponding speeds are 65 knots and 73 knots.

Pilots have constructed various types of computer to show them at once what speed to fly under any conditions. One of the neatest arrangements is a set of scales mounted on a hexagonal pencil exactly alongside a pellet-type variometer. The position of the pellet opposite the scale indicates the speed to fly.

I must repeat, though, that for beginners, correct use of lift is much more important than too many precision calculations based on uncertain information.

(iii) *Speed for final glide*

Practice in dealing with this can be started when doing local soaring round the aerodrome. You need to answer questions like—How far can I go from the aerodrome? What is the best speed to fly to get back?

This one certainly does depend on the strength of the wind. For example, to glide to a goal against a 40-knot headwind, a speed of over 40 knots is obviously necessary! In a following wind of the same strength, 40 knots would probably be the best.

I have already mentioned the plan of having 4-mile circles drawn on the map round the aerodrome, and 4-mile marks on the last dozen miles to your cross-country goal. You will probably find that, the first few times, you arrive with lots of height to spare, and the next stage is to make a chart like Fig. 20, which includes the estimated wind, and allows you to work to closer limits.

You will see that this chart shows the best speed to fly in various winds to cover the maximum distance, and allows a safety height of 1000 feet at the end. The distance scale is 4 miles to the inch, so you can copy it full size and use it on your ¼-inch map to measure how far you will be able to glide with the height you have. For example, if you are 3700 feet at a distance of 12 miles from the aerodrome (point marked ʘ), you should get there (downcurrents excepted!) against a headwind of 10 knots, flying at 46 knots airspeed. Your gliding angle for best distance in these conditions is 1 in 23, and this is the best gliding angle you can possibly make with a 10-knot headwind.

A racing finish to a goal

The speeds on the chart are not the best at which to glide to a goal when finishing a race.

The speed for the last glide is the cruising speed based on the strength of the last thermal. Knowing this speed, you can calculate the gliding angle at that speed relative to the ground in the estimated wind. Thus, if you have a chart of gliding angles, you can tell from the map at what point to leave the last thermal to start the final glide.

Check as the glide proceeds whether you are getting too low to reach your goal, or have height to spare. If you are getting too low you can save the situation to a certain extent by reducing speed to the speed for best gliding angle. If too high, you can afford to speed up a bit more, and burn off the excess height.

To take my previous example of a Skylark 2 on a '5 ft./sec. day', the cruising speed being 60 knots. At 60 knots in a 10-knot headwind you have a gliding angle of 1 in 20 (you need another table, or card, for this!). Suppose you are climbing in a thermal at a point 12 miles from your goal, the chart shows that you need not climb any higher than 4200 feet for a glide-in at 60 knots and hence an angle of 1 in 20. This point is marked with a triangle in Fig. 20.

On the glide, the variometer should show 4.2 ft./sec. sink, and as variations in this sink occur, you increase or decrease speed as is appropriate. As the glide goes on, check with points on the map as you pass over them. If you are falling below the 1 in 20 line, then you can reduce the speed as low as 46 knots, so improving the gliding angle to 1 in 23. On my chart you still have a safety height of 1000 feet; most experts will reduce this, cutting it down almost to zero as they near the goal.

Cruising steadily, looking towards your distant landing field, you may think it is incredibly far away and out of reach. Perhaps some other gliders are ahead of you or behind you.

There is an awful feeling that perhaps you have cut it too fine; then the final realization that you are now certain to make it. You dive in to the field, perhaps between the trees on the boundary, the hedge passes underneath, and you have made it!

You won't find anything in gliding more exciting than this.

Gliding Records (January 1961)

WORLD RECORDS

	Single-seaters	Two-seaters
Distance	Czech., 560 miles	U.S.S.R., 515·6 miles
Height Gain	Germany, 31,709′	U.S.A., 34,425′
Absolute Altitude	U.S.A., 42,000′	U.S.A., 44,255′
Goal Flight	France, 421 miles	U.S.S.R., 372 miles
Goal and Return	Poland, 331·7 miles	Poland, 311 miles
100 km. Triangle	U.S.S.R., 68 m.p.h.	U.S.A., 54·37 m.p.h.
200 km. Triangle	U.S.A., 66·98 m.p.h.	U.S.A., 50·64 m.p.h.
300 km. Triangle	U.S.A., 60·14 m.p.h.	U.S.A., 51·17 m.p.h.

UNITED KINGDOM RECORDS

	Single-seaters	Two-seaters
Distance	Nick Goodhart, 360 miles	L. Welch/F. G. Irving, 254 miles
Height Gain	G. J. Rondel, 29,100′	A. D. Piggott/B. Whately 15,240′
Absolute Altitude	G. J. Rondel, 30,580′	
Goal Flight	Nick Goodhart, 360 miles	W. A. H. Kahn/J. S. Williamson, 194 miles
Goal and Return	A. J. Stone, 222 miles	D. J. Corbett/H. Hilditch, 148 miles
100 km. Triangle	F. Foster, 46·3 m.p.h.	D. B. James/D. Marshall, 35 m.p.h.
200 km. Triangle	A. J. Stone, 40·5 m.p.h.	A. D. Piggott/P. G. Burgess, 22·32 m.p.h.
300 km. Triangle	Nick Goodhart, 41·2 m.p.h	
100 km. Goal	D. Goddard, 67·2 m.p.h.	D. B. James/K. O'Riley, 60 m.p.h.
200 km. Goal	Nick Goodhart, 58·8 m.p.h.	J. S. Williamson/D. C. Kerridge, 34·9 m.p.h.
300 km. Goal	E. A. Moore, 57·4 m.p.h.	W. A. H. Kahn/J. S. Williamson, 43 m.p.h.
500 km. Goal	Nick Goodhart, 56·4 m.p.h.	

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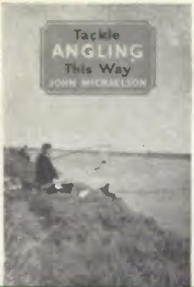

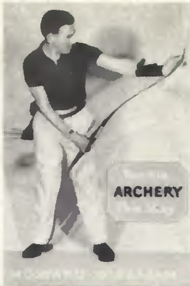

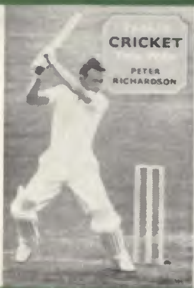

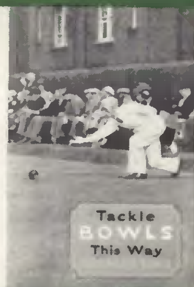

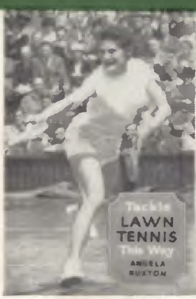

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