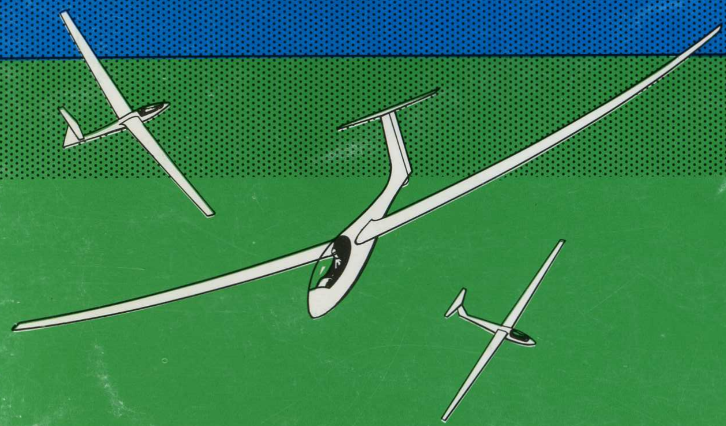
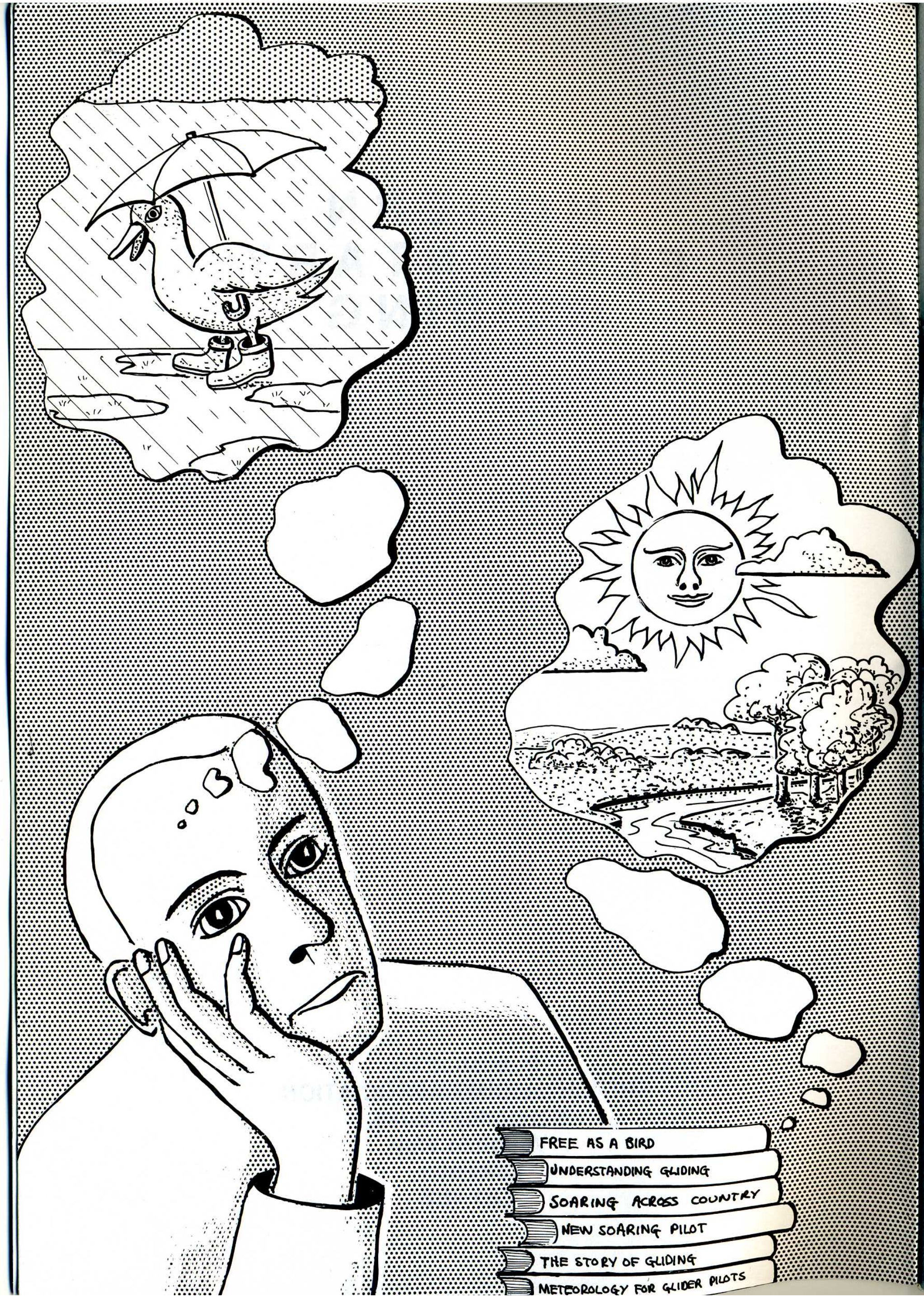
MODERN ELEMENTARY GLIDING



British Gliding Association


FREE AS A BIRD
UNDERSTANDING GLIDING
SOARING ACROSS COUNTRY
NEW SOARING PILOT
THE STORY OF GLIDING
METEOROLOGY FOR GLIDER PILOTS

CONTENTS

INTRODUCTION.

This manual is designed to be a source of basic information to which you, the student learning to glide, can refer in order to refresh your memory on the flying instruction you receive.

The first part contains a simple account of the fundamental principles concerned with the flight of a glider. In order to be able to fly you need not a have detailed knowledge of aerodynamics, but it may help you become an efficient pilot if you have some idea of the forces you are trying to control.

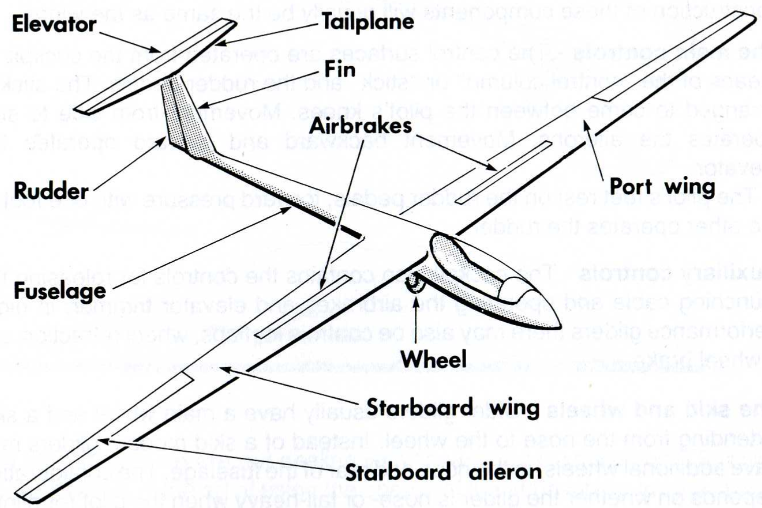
The later chapters are concerned with the various flying exercises that you will be taught during early training. This does not in any way replace the instruction you will receive on the field or in the air, or necessarily indicate the order in which the instruction will be given. Here we outline the fundamental basis; the actual technique can only be acquired by constant practice under skilled supervision.

We shall deal mainly with the exercises you will perform in the air. The manoeuvres involved in gliding and soaring are based on these principles, and some consideration of them will be repaid by increased mastery of the glider.

A few points of interest to the more advanced pilot have been included in the Appendix, in which graphs have been drawn and figures given appropriate to a typical glider currently in club use or as a first privately owned aircraft in which a moderately experienced pilot might complete a 300 kilometre task on a good day. There is a considerable range of new gliders and many now out of production which will give service for many more years to come. The list includes Schleicher's ASK8, ASK6, ASK19 and ASK23, the Slingsby Vega, Glsser Dirks (DG) 100 and 300, Schempp Hirth's Standard Cirrus and many others.

ELEMENTARY PRINCIPLES.

1. THE GLIDER AND ITS COMPONENTS.



As shown above, a glider consists of the following principal components:

The fuselage - This is built as one unit: it may be either a wooden framework covered with plywood and fabric, a steel-tube framework covered with fabric and fibreglass fairings or made almost entirely of metal or glass-reinforced plastic (GRP). It includes the cockpit where the pilot sits. Two launching hooks may be fitted, one at the front end of the fuselage (the nose) for aerotowing and a second aft hook fitted under the fuselage, usually beneath the pilot seat, for winch launch or autotow.

The wings - Each wing (port and starboard) is detachable from the fuselage for convenience in transporting. The wings are of "cantilever" construction, that is without any external struts; old gliders will have struts to brace them. The structure consists of one or two "spars" and a framework of "ribs", covered with plywood and fabric or metal. The wing of the modern glider will be made of GRP. The part of the wing joining the fuselage is known as the "root" and the extreme end as the "tip". The aileron control surfaces are built into the rear or "trailing" edge of the wings near the tips. The wings may also contain airbrakes or spoilers and, possibly, flaps; these are subsidiary controls which will be referred to later.

The tail unit - This consists of the tailplane, elevator, the fin and rudder. The fin is normally built into the fuselage, and the rudder is hinged to it. The tailplane (the fixed horizontal surface) and the elevator hinged to it is mounted either at the base or the top of the fin and is detachable. The material used in the construction of these components will usually be the same as the wings.

The main controls - The control surfaces are operated from the cockpit by means of the "control column" or "stick" and the rudder pedals. The stick is arranged to come between the pilot's knees. Movement from side to side operates the ailerons. Movement backward and forward operates the elevator.

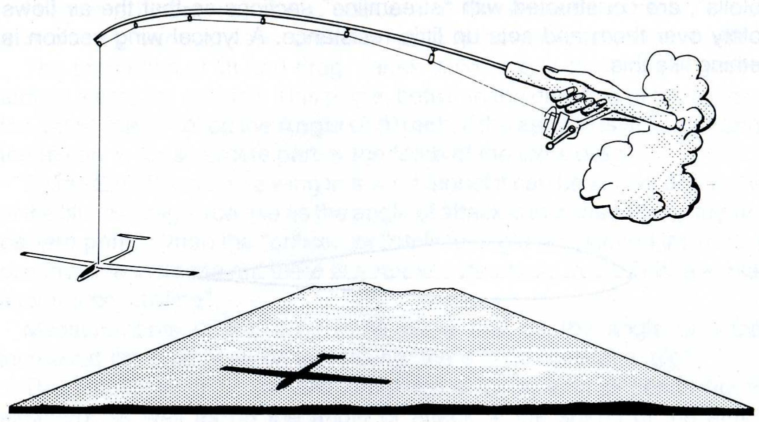
The pilot's feet rest on the rudder pedals; forward pressure with one foot or the other operates the rudder.

Auxiliary controls - The cockpit also contains the controls for releasing the launching cable and operating the airbrakes and elevator trimmer; in high-performance gliders there may also be controls for flaps, wheel retraction and a wheel brake.

The skid and wheels - Older gliders usually have a main wheel and a skid extending from the nose to the wheel. Instead of a skid modern gliders may have additional wheels, in the nose and rear of the fuselage. The configuration depends on whether the glider is nose- or tail-heavy when the pilot (or pilots) are sitting in it.

The instruments - A brief description of the instruments usually carried in a glider is given in the Appendix. It may be mentioned here that the Air Speed Indicator (ASI) indicates knots, and the altimeter gives the height in feet. Variometers may be found calibrated in feet per second, metres per second, hundreds of feet per minute, or knots. A knot is one nautical mile per hour, and one sea mile is approximately 6,000 feet; thus 100 feet per minute is 1 Knot which is equivalent to 1.15 statute miles per hour.

2. WHAT MAKES A GLIDER FLY?



In this chapter we are not dealing with "soaring" or "staying up". Soaring properly called, is the art of using the energy of the atmosphere in such a way that the glider will remain airborne, climb, and travel across country as required. We are only concerned here with the manner in which you can control the various aerodynamic forces to make the aircraft behave in the way you wish. The same principles apply whether the glider is soaring or descending in non-rising air. Soaring is made possible by the fact that the air around the glider is moving upwards.

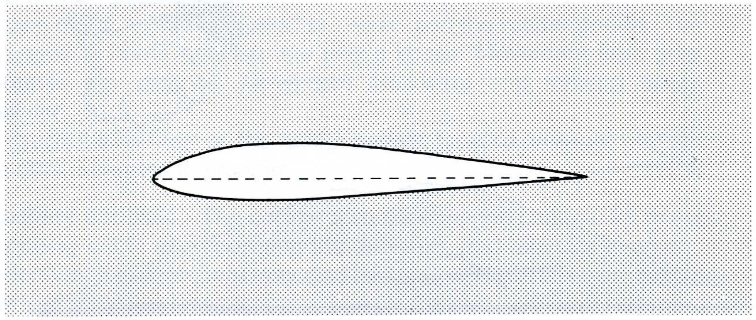
Airspeed

In later paragraphs it will be seen how the movement of a glider through the air produces the forces which keep it up and enable it to manoeuvre. The behaviour of the aircraft is determined by its rate of movement through the mass of air in which it is travelling, i.e., by its "air speed". If a wind is blowing, this mass of air will itself be moving over the ground but the only effect this has on the aircraft (as long as the wind is steady) is to alter its position with respect to the ground. The airspeed, which causes the airflow, which you would feel on your face in an open cockpit, depends only on the manner in which the controls are manipulated, and is not influenced by the wind.

For navigational purposes we may think in terms of the "ground speed" and take the wind into account. Here, we are concerned with controlling and manoeuvring the aircraft and need only consider the airspeed. However, the wind will be relevant later when we deal with judgement considerations.

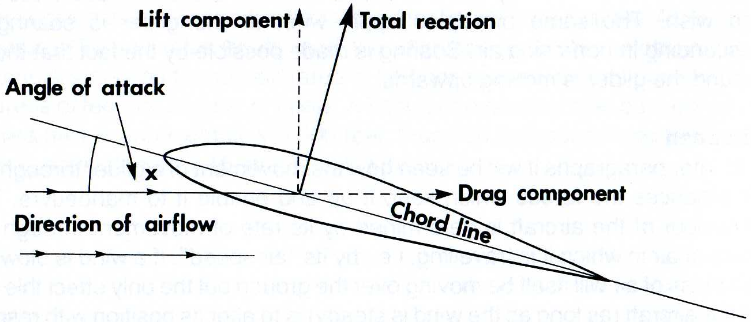
Aerofoils

The wings, tailplane, elevator, fin and rudder, which are known as "aerofoils", are constructed with "streamline" sections so that the air flows smoothly over them and sets up little resistance. A typical wing section is something like this:



Lift and Drag

If a wing is placed in a wind tunnel at a slight angle to a moving stream of air, as shown below, the reaction due to the air acts upwards and backwards. This total reaction can be represented by two components at right angles:



In the diagram here we represent each force by a line in the direction in which the force is working. The length of the line represents the strength of the force involved.

The upward component, called **Lift,** is always considered as acting at right angle to the airflow; the backward component, called **Drag,** is parallel to the airflow. The combined effect of lift and drag is the **Total Reaction.**

In steady flight the total reaction is equal to the weight. Because of the shallow glide angle the lift is only a little less than the total reaction.

Drag is a hindrance, acting opposite to the direction of flight. It can be minimised in various ways, but some drag is inevitably associated with lift.

The proportion of lift and drag. varies according to the angle at which the airflow meets the aerofoil. This angle, between the direction of the airflow and the chord line, is called the **Angle of Attack**. If the aerofoil is at a large angle to the airflow a considerable part of the force of the air is drag.

By measurements on a wing in a wind tunnel it can be shown that the value of the lift and drag force rise as the angle of attack is increased **but only up to a certain point.** When the "critical" or "stalling angle" is reached the drag force continues to increase but there is a marked decrease in lift. This is explained later under "stalling".

Measurements of the drag force show that as the angle of attack is increased the drag goes on increasing; there is no "critical angle".

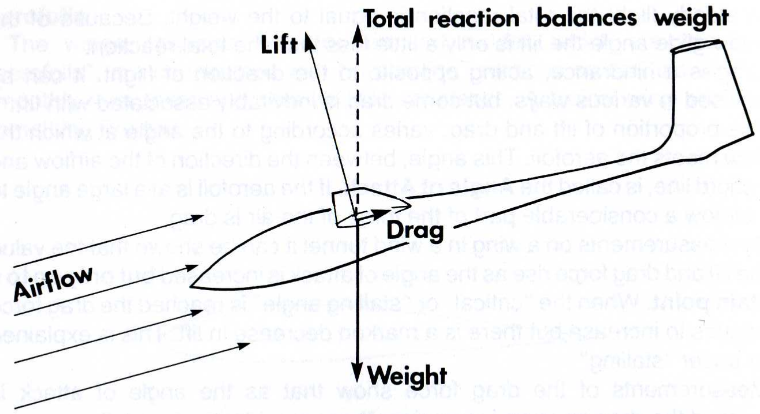
The actual value of lift (and drag) force for a wing depends upon the airspeed, as well as on the angle of attack. If the speed of the airflow is increased, both lift and drag are increased.

When a glider is in steady flight the values for airspeed and angle of attack are such that the lift force is always equal to the all up weight of the aircraft. If the speed is increased the aircraft is automatically flown at a smaller angle of attack so that the balance is maintained. If we wish to carry out a manoeuvre, such as a turn, in which extra lift is required, we may obtain this lift either by increasing the angle of attack (up to the critical angle) or by increasing the speed, or by doing both.

To get some idea of the magnitude of the quantities involved, let us take the case of typical glider. In normal flight this aircraft might be flying at about 45 knots (Kt.). At this speed the angle of attack is about 7 degrees, and this combination produces a lift force equal to weight (say 650 lb.). The drag force is about 20lb.

The forces on a glider

The movement of a glider through the air is derived from the pull of gravity, in that the weight of the aircraft acting downwards provides a forward component in the direction of motion. We have shown how the other forces, lift and drag, are produced. When a glider is in steady flight the three forces balance as shown overleaf. The force shown as **weight** represents the total weight of the aircraft. Although the weight is distributed over the entire structure and acts vertically downwards all along it there will be a point about which the aircraft, if placed on a pivot, would balance. This is the centre of gravity and the weight can be thought of as a single force, represented by a line, acting through that point.



Similarly the lift of the aerofoil is obtained from all over the wing, but the total effect can be represented as one force passing through the Centre of Pressure. The Centre of Pressure bears the same relationship to lift as the centre of gravity does to weight but while the Centre of Gravity remains fixed, the centre of pressure's position varies depending on the angle of attack and the distribution of lift over the wing.

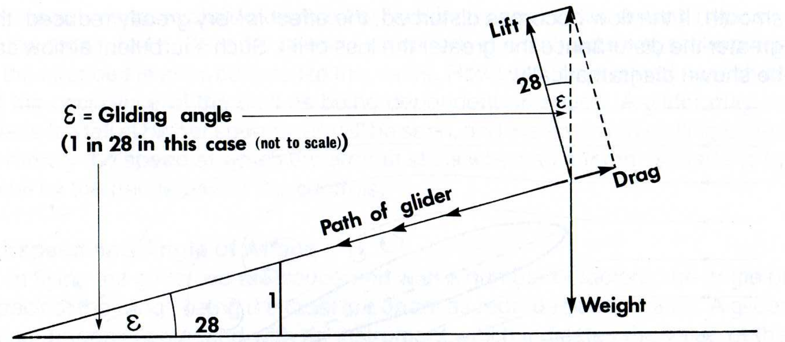
Similarly, drag is shown as one straight line which represents the resultant effect of all the drag.

Throughout this book we have stated that the lift is equal to the weight in steady flight. We now see from the disposition of the forces above that the weight of the aircraft is **actually** counter-balanced by the resultant of the lift and drag forces, i.e. by the total reaction. In practice, however, the lift is very nearly equal to the total reaction, since the component of drag is small for flat gliding angles, and the effect of drag in this connection can be ignored.

By the use of the controls the pilot may alter the equilibrium; it will be seen later that the use of the elevator alters the attitude of the glider with respect to the airflow, i.e., alters the angle of attack. If the angle of attack is decreased, for example, the values for lift and drag are altered and the forces no longer balance. As there is an unbalanced force a change occurs, and this continues until a new equilibrium is set up.

If we draw out the forces in relation to the path of the glider we see that the "gliding angle" (height lost/horizontal distance covered) is equal to the ratio of drag force divide by lift force. Thus the angle of glide is flattest when the ratio L/D is a maximum.

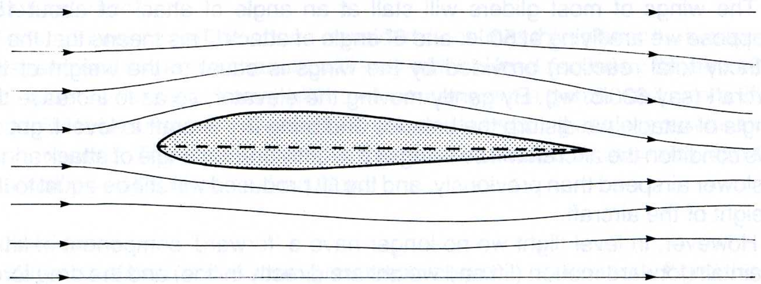
This maximum corresponds to a definite angle of attack (see Appendix). Therefore in order to cover the largest amount of ground, in still air, we must fly at this angle of attack (about 7 degrees for most gliders). In practice the pilot



selects a speed not an angle of attack. The gliding angle is usually expressed as a ratio, e.g., 1 in 30. It should be noted that in the example above the angles are exaggerated for the sake of clarity (and, therefore the ratio of the forces is not representative).

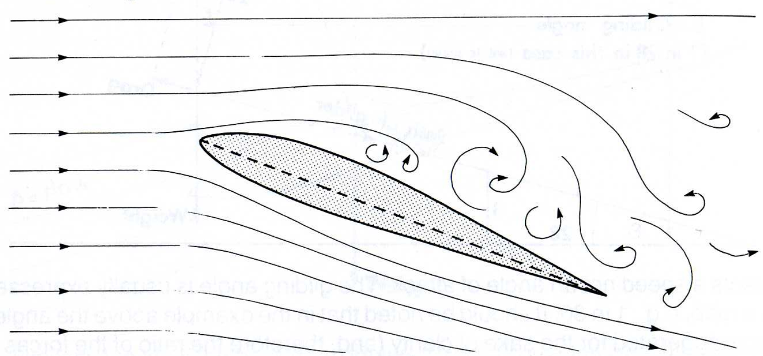
Stalling

It was mentioned earlier that if the angle of attack is increased beyond a certain point, the value of the lift rapidly decreases; the wing is then said to be "stalled". In order to explain this fact we must consider what happens to the airflow passing over the wing. Normally the flow is smooth like this:



The result is that the air passing under the aerofoil increases in pressure and exerts an upward force on it, while the pressure of air passing over the top of the aerofoil is reduced and this exerts an upwards 'sucking' effect. These changes in pressure are actually quite small but both the air passing over and the air passing under have a lifting action.

In fact the amount of lift provided by the sucking effect is greater than that provided by the pressure on the under surface. The upward, sucking effect is only maintained so long as the airflow over the top of the aerofoil remains smooth. If the flow becomes disturbed, the effect is very greatly reduced, the greater the disturbance the greater the loss of lift. Such a turbulent airflow can be shown diagramatically:



It is when the air over the aerofoil is in this turbulent state that the aerofoil is said to be stalled. Stalling occurs when the angle of attack is increased beyond the "stalling angle". The value of this angle depends on the design of the particular aerofoil. Stalling always occurs when the angle of the aerofoil relative to the airflow is increased beyond this value, and it cannot occur unless the angle is reached. Let us consider a set of circumstances in which the aircraft is stalled.

The wings of most gliders will stall at an angle of attack of about 15°. Suppose we are flying at 50 kt. and 6° angle of attack. This means that the lift (strictly total reaction) provided by the wings is equal to the weight of the aircraft (say 630lb. wt). By gently moving the elevator, so as to increase the angle of attack, we disturb the balance and bring the aircraft to level flight. In this condition the aircraft will be flying at a slightly greater angle of attack and at a slower airspeed than previously, and the lift produced will still be equal to the weight of the aircraft.

However, in level flight we no longer have a 'forward' component of lift to maintain forward motion (lift and weight are directly in line) and the drag force causes the speed to reduce. This also means a steady loss of lift, and the state of level flight can only be maintained by increasing the angle of attack still further so as to keep the lift constant. Again drag is also increased by this procedure, so that the speed falls off more rapidly, and finally in an attempt to maintain adequate lift the angle of attack is brought to the stalling point (15°). At this point the wings lose a large part of their lift and the nose usually drops; the aircraft loses height rapidly and is not under the normal control of the pilot until recovery has been made.

When a stall is performed gently as described above, the speed at the stall

will be at a certain value known as the "stalling speed" of the aircraft (typically in the order of 34 or 35 kt. for the modern glider). The stall will always take place if the airspeed is allowed to fall to this value. However, it is misleading to think of the occurence of the stall as being dependent on speed. A glider may be made to stall at higher speeds, as will be seen, and the so-called stalling speed is merely the speed at which the aircraft stalls when an attempt is made to fly level by the gentle use of the controls.

Airspeed and Angle of Attack

In flying the glider we are concerned with a number of factors, the angle of attack of the wings being the most important as regards performance. A glider is not normally equipped with an instrument which indicates the value of the angle of attack, so that you are taught to interpret, from the value of the airspeed and the behaviour of the aircraft, when the angle of attack is approaching that of the stall. You are able, by using the airspeed as a guide, to adjust the angle of attack to the most favourable value for a particular circumstance. It is important, however, that you should realise that this relationship is not precisely fixed, and we shall now go into this in a little more detail.

Consider once more the gentle stall described; by increasing the angle of attack as the airspeed fell off we kept the lift equal to the weight until the stalling angle of attack was reached. It follows that the Stalling Speed is that speed required to make the lift equal to the weight when the angle of attack is the "stalling angle".

It is apparent from the above considerations that the relation between the airspeed and the angle of attack will vary with the load carried by the aircraft. If our glider is carries a heavy pilot and we carry out a gentle stall, more lift is required to balance the increased weight, and the stalling angle is reached at a higher speed. The stalling speed is therefore increased by the extra load but the stalling angle remains the same.

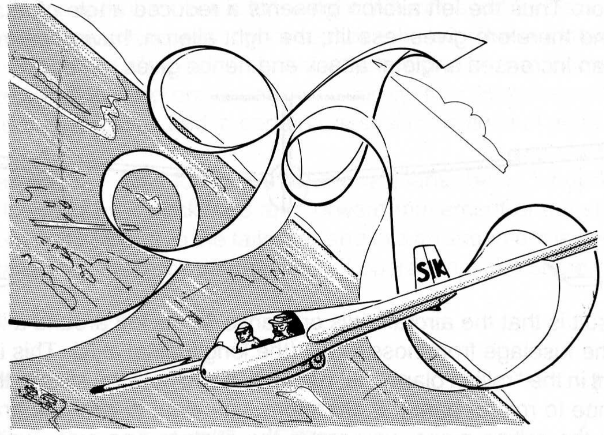
Load Factor

When an aircraft is performing manoeuvres (i.e. is not in steady flight) the lift which the wings are required to produce varies. For instance, during a turn part of the lift is used to cause the aircraft to turn (to provide the necessary inward force in the direction of the turn), and as the weight still has to be supported, this means that the total lifting force provided by the wings must be increased. This state of affairs is equivalent to a temporary increase in the weight of the aircraft and contents, and it is expressed by the **load factor,** which is the ratio between the apparent weight of the aircraft during the manoeuvre and its normal weight under gravity. A pilot may speak of carrying out a steep turn, for example, with a "load" or "load factor" of "2g", which means that the aircraft and contents including the pilot, apparently weigh twice as much as they do under gravity alone (1'g'), and the lift produced by the wings is equal to twice the ordinary weight. To the pilot, therefore, the parts of his body and anything that he tries to pick up appear to have doubled in weight.

Such an increased loading occurs to some extent in all manoeuvres involving change of direction, such as looping, pulling out of dive, turning and so on. It is caused as a result of manipulation of the controls by the pilot.

The increased lift required by the increased load factor can be obtained either by increasing the angle of attack (up to the angle of maximum lift) or by increasing the airspeed, or by a combination of both. If the airspeed is kept at some constant figure, the angle of attack must be increased; it is therefore brought closer to the stalling angle, and in this way the aircraft may actually be stalled in a manoeuvre although the airspeed is well above the usual "stalling speed". You must bear in mind, therefore, that **increased loading means increased stalling speed.**

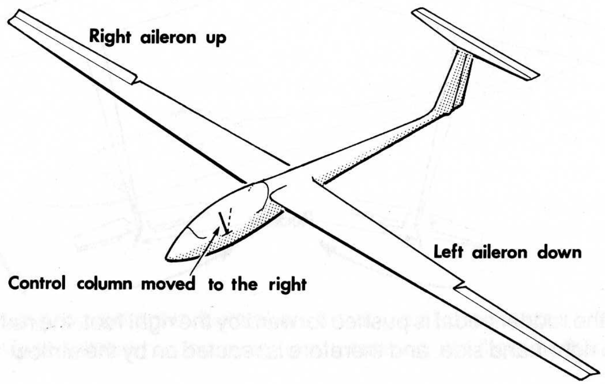
3. THE EFFECTS OF THE CONTROLS



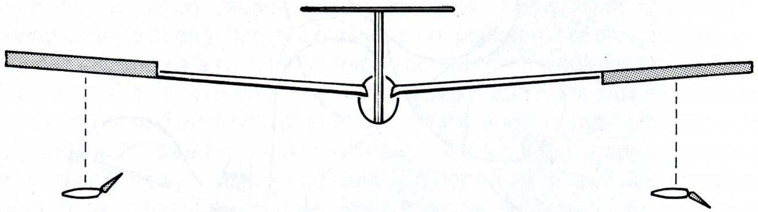
Before we go on to consider the effect of the controls is it essential to note this point: we will describe the action of the controls on the aircraft without any reference to the horizon, or any point on the earth. The controls always have the same primary effect relative to the aircraft (unless it is stalled) no matter what its position may be relative to the earth.

Primary Effects

1. **The ailerons** - These are parts of the wings and are connected as shown below. They are moved up and down by moving the control column (stick) from side to side, and are linked together so that one aileron moves down when the other moves up:



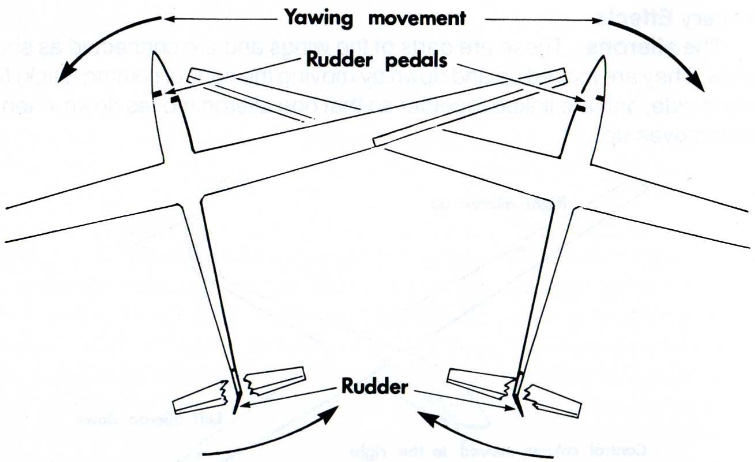
Movement of the stick to the left raises the left aileron and depresses the right aileron. Thus the left aileron presents a reduced angle of attack to the airflow, and therefore gives less lift; the right aileron, having been lowered, presents an increased angle of attack and hence gives more lift.



The result is that the aircraft rolls or 'banks' to the left around a line drawn through the fuselage from nose to tail (the longitudinal axis). This is called a movement in the "rolling plane", ie, banking. If you hold the stick to the left you will continue to roll (or bank). If, therefore, you want to alter the angle of the aircraft in the rolling plane, you move the stick to one side, wait until the required attitude is reached, and then centralise the stick to maintain the attitude.

It will be seen later how bank in the appropriate direction enables the aircraft to turn.

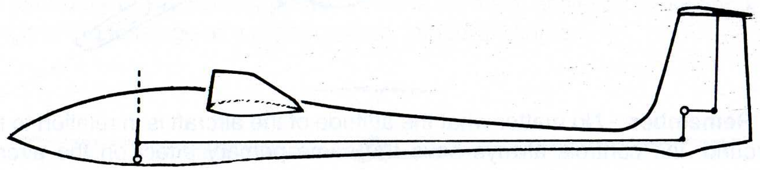
2. **The rudder** - This is hinged to the trailing edge of the fin. It can move to the right or the left, and is controlled by the rudder pedals:



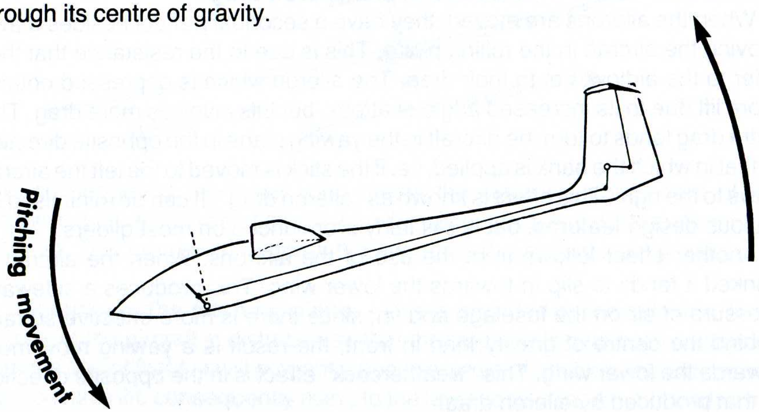
When the rudder pedal is pushed forward by the right foot, the rudder moves out to the right-hand side, and therefore is reacted on by the airflow. As a result

the tail of the aircraft moves round to the left, the aircraft pivoting on the centre of gravity; the nose thus moves in to the right. When the rudder pedal is pushed to the left the reverse happens, the nose moves to left. These movements are in the "yawing plane". The rudder is normally regarded as a secondary control; it is used to assist the ailerons to perform a correct turn. However, use is made of the rudder in sideslips and in certain unusual conditions of flight.

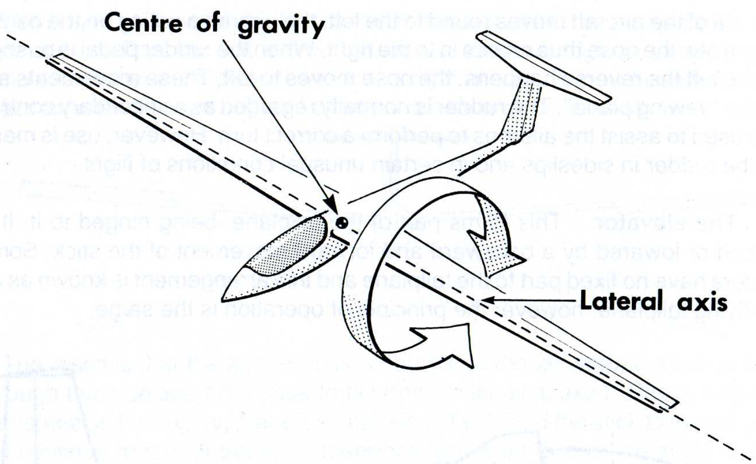
3. **The elevator.** - This forms part of the tailplane, being hinged to it. It is raised or lowered by a backward and forward movement of the stick. Some gliders have no fixed part to the tailplane and this arrangement is known as an all-flying tailplane; however the principle of operation is the same.



When the stick is moved backwards, the elevator rises and the airflow past them applies a downward force to it. This results in the tail of the aircraft falling in relation to the nose, or as it is usually thought of and seen by the pilot, in the nose rising in relation to the tail. Similarly when the stick is moved forward the elevator is depressed and the nose goes down. The elevator thus causes a movement in the "pitching plane", the aircraft pivoting about a lateral axis through its centre of gravity.



This pitching movement in flight alters the angle of attack of the wings to the airflow, and the balance of forces is upset, causing the flight path to change.



Remember. - No matter what the attitude of the aircraft is in relation to the ground, the controls always have the same primary effect on the aircraft (unless it is stalled). The ailerons give control in the rolling plane, the elevator in the pitching plane and the rudder in the yawing plane. These planes are referred to the aircraft and not to the earth.

The effect of a given control deflection depends upon the speed of the airflow over the control surfaces. At low speeds, larger control movements are necessary in order to produce the same effect on the aircraft.

The further effect of the controls, and aileron drag

When the ailerons are moved, they have a secondary effect besides that of moving the aircraft in the rolling plane. This is due to the resistance that they offer to the airflow, i.e. to their drag. The aileron which is depressed obtains more lift due to its increased angle of attack, but this involves more drag. This extra drag tends to turn the aircraft in the yawing plane in the opposite direction to that in which the bank is applied, i.e. if the stick is moved to the left the aircraft yaws to the right. This effect is known as "aileron drag". It can be minimised by various design features, but is still fairly pronounced on most gliders.

Another effect follows from the use of the ailerons. When the aircraft is banked it tends to slip in towards the lower wing. This produces a sideways pressure of air on the fuselage and fin; since there is more effective surface behind the centre of gravity than in front, the result is a yawing movement towards the lower wing. This "weathercock" effect is in the opposite direction to that produced by aileron drag.

The rudder also has a secondary effect. When an aircraft is yawed by using rudder, the outer wing moves faster than the inner wing. The greater speed of

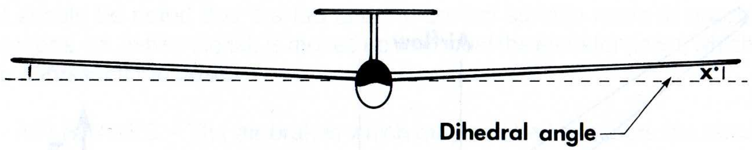
the airflow past the outer wing gives it more lift, so that it rises, causing a movement in the rolling plane, i.e. banking. When the rudder is applied by itself, the outward skid also contributes to this effect, owing to the lateral stability of the aircraft.

The elevator has no secondary effects.

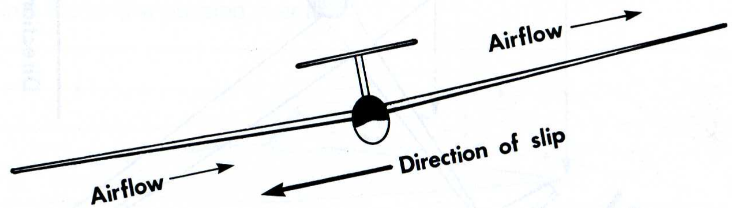
Stability

A glider is designed to be moderately stable in flight; this means that it should tend to keep the same attitude as that in which it is set, and to return to it if it is displaced by small air disturbances. This saves the pilot much effort, and tends to make the aircraft "fly itself".

1. **Stability in the rolling plane.** - This is normally achieved by setting the wings to the fuselage at a slight upward "dihedral" angle:

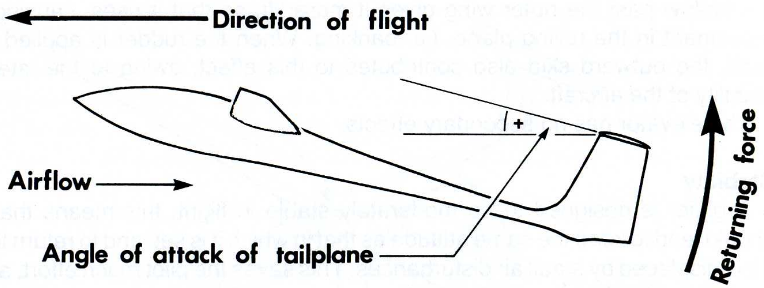


Should the aircraft, by reason of some air disturbance, become banked while flying straight, it will begin to slip towards the lower wing, like this:

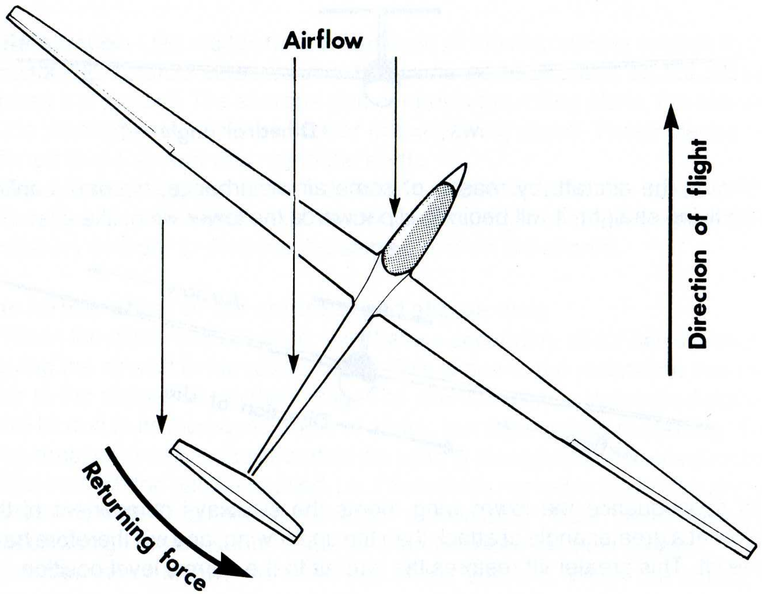


In consequence the lower wing meets the sideways component of the airflow at a greater angle of attack than the upper wing, and will therefore have more lift. This greater lift restores the aircraft to the normal level position.

2. **Stability in the pitching plane.** - This is provided by the tailplane. If the attitude of the aircraft is disturbed so that the tailplane is displaced downward from the line of flight, it will present a positive angle of attack to the airflow and have positive lift, consequently rising to the level position again. Similarly if is it displaced upwards it will have negative lift, and again be restored to the level position.

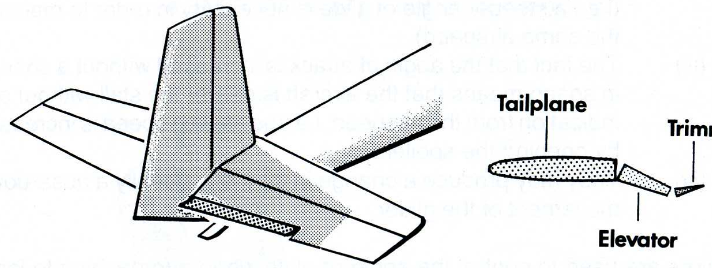


3 **Stability in the yawing plane.** - This is provided by the fin and the sides of the fuselage. As the greater part of these surfaces is behind the centre of gravity, the aircraft possesses directional stability, and if it is displaced in the yawing plane will tend to "weathercock" back again.



Subsidiary controls.

1 **The trimmer.** - Most gliders are fitted with a subsidary control on the elevators known as the "trimming tab" or "trimmer" which can be operated by the pilot. This may be a spring device in the control circuit, or an aerodynamic trimmer as shown; it is operated by a small lever which works in the same sense as the stick:

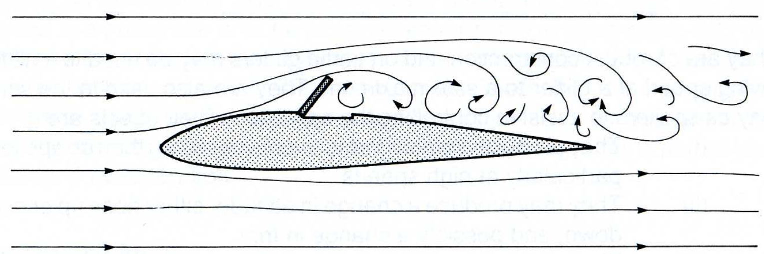


The trimmer is used to relieve the pilot of work in maintaining the required attitude in pitch. If, for instance, the pilot wishes to fly faster, he moves the stick to effect the necessary change of attitude and then, once the speed is steady, adjusts the trim until the aircraft maintains that attitude without any need for pressure on the stick.

It should be noted that the tab and the control surface move in opposite directions, i.e., when the tab is moved up it will hold the elevator down, which in turn depresses the nose.

2. AIR BRAKES. - The air brakes which may be fitted to gliders are either
   (a) Spoilers. or usually
   (b) Dive brakes.

(a) Spoilers are lightly constructed surfaces which can be projected from the wing into the airflow passing over it:



They have the following effects:-

(i) They reduce the lift over a part of the wing : this means that the angle of attack must be increased in order to provide the lift needed to balance the weight. The increased angle of attack involves increased drag, and the angle of glide is again steepened.

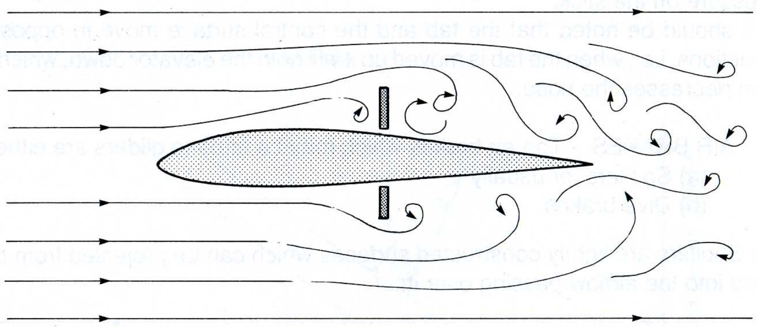
(ii) They increase the drag, and hence steepen the angle of glide (i.e., a steeper angle of glide is necessary in order to maintain the same airspeed).

(iii) The fact that the angle of attack is increased without a change in speed means that the aircraft is nearer the stall without any indication from the airspeed, i.e. the stalling speed is increased by opening the spoilers.

(iv) They may produce a change in trim, e.g, usually a nose-down movement of the glider.

Spoilers are used to control the angle of glide when approaching to land, thus making it easier to land safely in small spaces.

(b) **Airbrakes** normally consist of surfaces which may be protruded both above and below the wing but often only above:



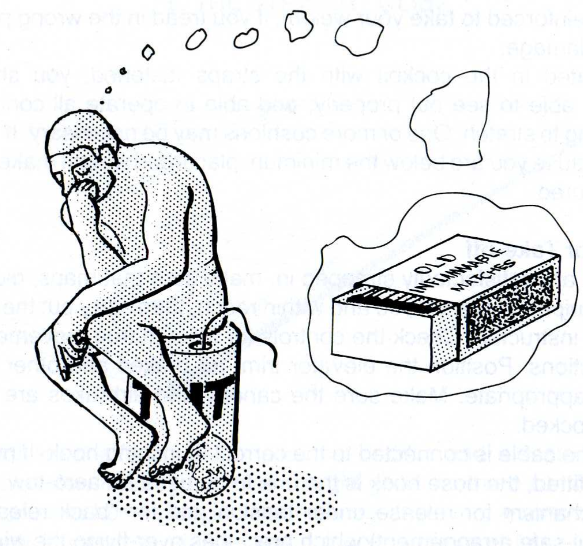
They are of robust construction and on some gliders may be used to limit the diving speed of a glider to a safe maximum. They are also used in the same way as spoilers to assist in controlling the approach. Their effects are:

(i) They produce a much greater increase in drag than do spoilers, particularly at high speeds.

(ii) They may produce a change in attitude, either nose up or nose down, and possibly a change in trim.

(iii) They reduce the lift over a part of the wing, necessitating an increased angle of attack and consequently both greater drag and higher stalling speed.

4. BEFORE YOU LEAVE THE GROUND



Preparation of the Aircraft

Make quite sure that the aircraft you are about to fly has been inspected and passed as serviceable and that the Daily Inspection (DI) book has been signed. If a parachute is to be worn, make sure it is in good order, and that cushions as necessary are available. Check the placard in the cockpit to ensure that you are within the weight limits. Check that the barograph, if carried, is switched on, and that it and any other items of equipment are properly stowed. All these aspects will be explained to you as a part of your training, **if not then ask.**

The Launch Point

The launch will normally take place from the downwind end of the airfield. Observe that the intended take-off path is free from obstructions.

While waiting for a launch, your aircraft should be parked in such a place that it does not constitute a hazard to other aircraft coming in to land. It should normally be parked with one wing-tip pointed into wind and weighted down, and with the brakes open (if any). When the aircraft is turned into wind there should be someone in the cockpit or stationed by the nose; a gust of wind can blow over a pilotless glider.

Getting in

Be careful where you put your hands and feet when you climb in. Parts of the cockpit are reinforced to take your weight; if you tread in the wrong place you may cause damage.

When seated in the cockpit with the straps fastened, you should be comfortable, able to see out properly, and able to operate all controls fully without having to stretch. One or more cushions may be necessary. If ballast is required because you are below the minimum placarded weight make sure it is properly secured.

Preparing for Take-off

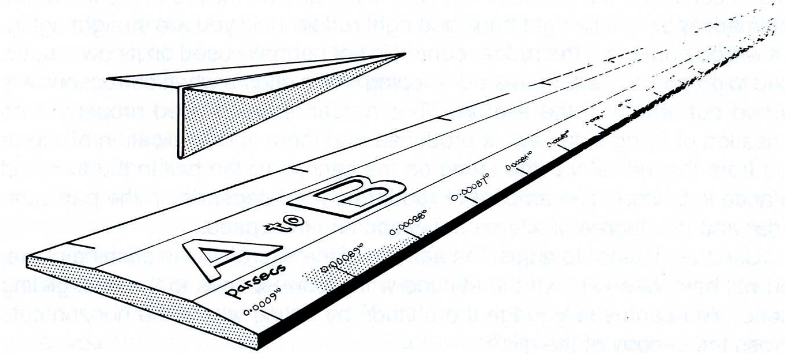
When you are satisfactorily strapped in, make sure that maps, gloves and any other equipment are stowed and within reach, then carry out the pre-take off check as instructed. Check the controls for full and free movement in the correct directions. Position the elevator trim, air brakes and other ancillary controls as appropriate. Make sure the canopy and airbrakes are properly closed and locked.

See that the cable is connected to the correct launching hook. If more than one hook is fitted, the nose hook is the one to be used for aero-tow. Test the release mechanism for release under tension and for "back release" (the automatic fail-safe arrangement) which precludes over-flying the winch.

Never be rushed into taking off before you are ready.

MANOEUVRES

5. THE STRAIGHT GLIDE



The individual effects of the ailerons, rudder and elevator have been described earlier. In carrying out a straight glide the three controls are used together so as to keep straight with the wings level and a constant airspeed. The aircraft is naturally stable, and if properly trimmed tends to remain in steady flight unless it is displaced by some air disturbance or by a movement of the controls.

In carrying out a straight glide, as in any other manoeuvre, the pilot observes the attitude of the aircraft with respect to the horizon, **glances** at the airspeed occasionally, decides what correction, if any, is needed, and then applies this correction with the controls. It should be remembered that the ailerons cause a roll, the rudder a yaw and the elevator a pitch whatever the attitude of the aircraft with respect to the ground.

How to Glide Straight

1. Choose a point ahead to act as a reference. This can be some point on the horizon, a cloud, or some distinctive feature on the ground as far ahead as possible.
2. Level the wings with the ailerons; you can check that they are level by observing the position of each wing-tip with respect to the horizon, but you should become accustomed to the symmetrical appearance of the nose against the horizon when the wings are level. If the left wing-tip should drop, move the stick to the right and at the same time apply a little right rudder. When the aircraft is level again, let the stick come back to the central position and centralise the rudder. Should the right wing-tip drop, the process is reversed.
3. Keep the nose pointing towards the landmark that you have chosen. If the

aircraft swings round to the right (for example) it is probably because you have permitted the right wing to drop; correct this by applying a little left bank and left rudder until you are almost on the correct heading once more. Then straighten up and centralise the controls. Similarly if the aircraft moves to the left of the landmark apply a little right bank and right rudder until you are straight again.

It will be noted that the rudder control is not normally used on its own, but is used to prevent the excessive sideslipping which occurs when corrections are carried out only with the ailerons. The rudder is being used properly if no sensation of flying sideways is produced and there is no indication of slip or skid from the indicators (the string on the canopy or the ball in the turn and balance indicator). The amount of rudder needed depends on the particular glider and the degree of aileron deflection and the speed.

4. Use the elevator to adjust the attitude of the aircraft in the pitching plane; you will have been shown the attitude which corresponds to the best gliding speed. You can usually judge the attitude by noting where the horizon cuts across the canopy of the glider.

If an elevator trim is fitted, adjust it so that no pressure on the stick is required to hold the attitude.

Wait and see what happens. If the nose of the aircraft starts to move up or down on the horizon, prevent this movement by use of the elevator, check the airspeed and then alter the trim.

When the attitude remains steady, check the airspeed again but avoid trying to control the airspeed by watching the ASI. In conditions of poor visibility the true horizon may be obscured, and the speed may be more difficult to control quite so accurately. The tendency will be to place more reliance on the ASI but try and avoid this. Realise the extent to which a glider, once correctly trimmed, will largely fly itself.

5. You will quite quickly get into the habit of controlling the movement of the aircraft in its three planes. You will find it easier to let the aircraft do as much for you as possible through its own stability. Try to relax in the seat, do not brace yourself against the rudder pedals, hold the stick lightly and keep looking around you.

Gliding Speed

You will remember that in steady flight, by adjusting the airspeed to a certain figure we are in fact selecting a certain angle of attack. In the early stages of training you will be shown a safe speed at which to fly. In the Appendix we shall explain how you use your speed range to best advantage in varying circumstances, varying your angle of attack according to the conditions.

Here we shall only emphasise one point which is of great importance. In order to cover the maximum amount of ground in still air, you must fly at the

"best gliding speed" of the aircraft (corresponding to the angle of attack of best L/D ratio).

Wind

If you fly a straight course across a wind of moderate strength it will probably be apparent that you are not moving over the ground in the direction in which you are pointing. This is to be expected. You are "drifting" due to the wind. Resist any temptation to correct for it by use of the rudder; the rudder should be central in straight glide.

Remember that you are flying your straight course in a block of air. Since there is a wind, the block of air itself is moving, and your movement over the ground is the resultant of the two motions. You will drift when you fly across the wind; when flying into the wind your speed over the ground will be reduced by an amount equal to the wind strength; when flying downwind it will be increased by the same amount. Do not be put off by this. In controlling the glider you are only concerned with the **airspeed** which you can judge from the attitude of the aircraft and the ASI reading.

Note in particular that you cannot "feel" the wind when you are airborne; you are in fact part of the wind. The influence of the wind on you is purely navigational **except when it is changing rapidly.** This exception is of considerable importance when flying close to the ground; it will be dealt with later under the headings "gusts" and "wind gradient".

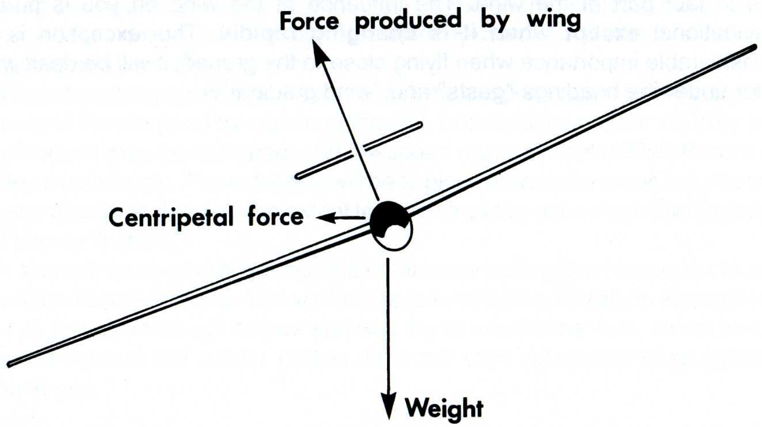
6. TURNS

The Forces in a Turn

Consider what happens when you are in a car going round a corner at speed. You find yourself pressed against the side of the car which is on the outside of the turn. This is due to the natural tendency of any moving body - in this case yourself - to continue to move in a straight line unless an external force is applied to it. The framework and the seat of the car produce a force on you which carries you round the corner. The car itself has also a tendency to go straight on, but the necessary force to cause it to go round the corner is provided by the steering and the friction of the tyres on the road.

The force acting towards the centre of the turn which is required to keep a body moving in a circle is known as the "centripetal force".

When an aircraft turns, the centripetal force is provided by part of the lift of the wings. This is done by banking the aircraft in the direction of the turn, so that the lift is able to provide a component towards the centre of the turn. The magnitude of the centripetal force required varies with the rate of turn and with the airspeed.



The weight of the aircraft still has to be supported during the turn; in order to do this as well as provide the necessary centripetal force, the total lift must be increased. As explained earlier, the "load factor" is now greater than one.

When a gentle turn is carried out with no alteration of airspeed, the increased lift is provided by the increased angle of attack. This means that the angle of attack is nearer the stalling angle, and if a greater rate of turn is attempted, ie, more bank, the critical angle of attack may be reached in trying to provide the necessary lift. This will result in a stall at a comparatively high

airspeed, as mentioned previously. For example, a glider with a "stalling speed" of 30 kt. will stall at 42 kt. in a turn at 60° bank.

When carrying out steeper turns, the risk of an accidental stall should be reduced by increasing the airspeed before beginning the turn.
Hence an increase in speed can be used to provide the extra lift needed.
The main principles of turning are summarised as follows:

1. At a fixed airspeed the rate of turn and the size of the turning circle depend upon the angle of bank. This angle of bank determines the proportion of the total lift providing the centripetal force. For a certain rate of turn at a given airspeed there is only one angle of bank.
2. As the angle of bank is increased the wing loading becomes greater. This involves an increased stalling speed and an increased rate of sink.

The use of the controls in the turn

In carrying out a correct turn we must use the controls so that the lift component providing the centripetal force always points in the direction we wish to turn. The aircraft must therefore be banked to the amount appropriate for the desired rate of turn.

The amounts of pitch and yaw are regulated so as to produce the required flight path. The relative amounts needed vary with the steepness of the turn. In a well designed glider a large part of the yawing movement required is provided by the weathercock stability.

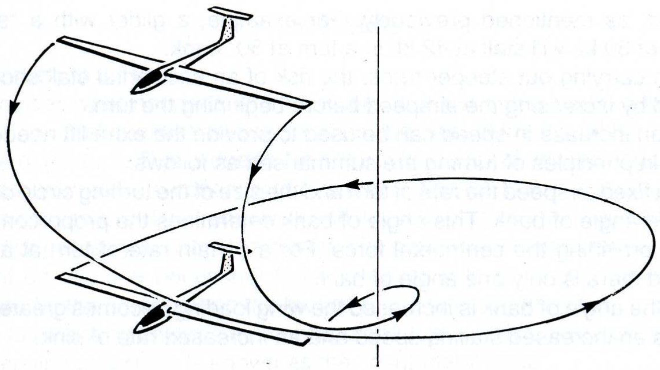
The use of the ailerons. - In a turn the ailerons are used to keep the bank constant at the amount appropriate for the required rate of turn (e.g. 20° - 30° of bank for a medium turn).

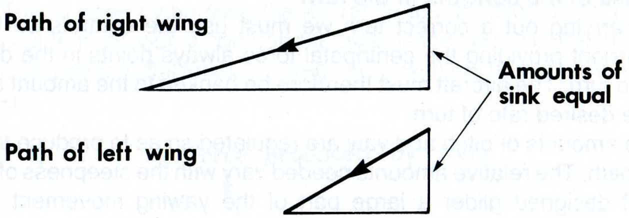
There are two effects which tend to alter the angle of bank during a turn. these are:

1. The outer wing in a turn is travelling faster than the inner wing, as it is further away from the centre of the circle. This results in greater lift on the outer wing, which tends to increase the angle of bank.
2. Relative to the air, a glider descends as it turns; after the turn both wings have descended the same amount, but the outer wing, as mentioned above, travels further than the inner wing during the descent. It has therefore followed a flatter path than the inner wing.

Diagrammatically, the paths followed by the two wings are shown below. (The spiral paths have been straightened out for comparison). It is apparent that the inner wing, making the steeper descent, presents a greater angle of attack to the airflow than does the outer. The inner wing therefore generates more lift and the effect is to reduce the angle of bank.

In a glider, these two effects more or less cancel each other out, so that once the bank has been adjusted, the ailerons are kept roughly in the neutral





position. However, it is not necessary to think of the position of the stick; merely use the ailerons as necessary to keep the bank constant.

The use of the elevator. - In a turn, as in level flight, the elevator is regarded as controlling the position of the nose above and below the horizon, and hence keeping the airspeed at the proper figure. By doing this, the extra lift and the required pitching movement are provided. For gentle turns a very slight backward pressure on the stick is necessary. For steep turns rather more pressure is needed and care should be taken to avoid the nose dropping on entering the turn. Once a **steep** turn is established a backward movement of the stick will tighten up the spiral without reducing the airspeed, and in order to raise the nose it is necessary **first to reduce the bank;** the speed can then be reduced and the turn steepened again, making sure that the nose does not drop to its previous position.

The use of the rudder. - The rudder is best thought of as a secondary control used to correct slip or skid. In a correct turn the aircraft should always be flying straight into the airflow rather than sideways. If you carry out a turn with too much rudder (i.e. a "flat" turn) you cause the aircraft to "skid" outwards. This results in a sensation of being pressed towards the outside of the turn. The aircraft is in fact being made to travel broadside through the air. This is an inefficient condition which will cause unnecessary loss of height and will not

get you round the turn easily. On the other hand, if you attempt a turn without using any rudder, the aircraft will "SLip" inwards when it is banked over. You will then feel a tendency to slide inwards on your seat.

This slipping and skidding is thus due to the incorrect co-ordination of the rudder movement with the movement of the ailerons. You can correct a skid either by using less rudder or more bank. However, you will find it easier to use the ailerons to keep the bank constant and the elevator to keep the speed correct. If you are skidding outwards, you applied too much rudder; if you are slipping inwards, you have not enough.

How to carry out a turn

The actual manoeuvres involved in a turn should be carried out in three parts, namely, going in, staying in and coming out. Before starting any turn **always have a good look around. You may be turning across the path of another aircraft. Indeed, you should always be keeping a good lookout for other aircraft.**

1. **Going in: look around, especially in the direction of the turn.** Then, to go into turn to the left, move the stick gently to the left to start banking the glider. At the same time as you apply the bank, apply sufficient left rudder to start the nose yawing to the left (thus counteracting the adverse yaw). When you have the required angle of bank centralise the stick and reduce the amount of rudder. As the aircraft banks apply a gradual backward pressure on the stick to keep the airspeed correct by keeping the nose in its proper position relative to the horizon.
2. **Staying in:** continue to look around. Keep the angle of bank constant by use of the ailerons, and remember to use the rudder in the same sense if you have to adjust the angle of bank. If the turn is balanced (i.e., no slip or skid) and the speed is steady the nose will keep moving smoothly round the horizon. If the nose rises or falls, correct with the elevator (but remember to take off bank before trying to raise the nose in a steep turn). If you find yourself slipping or skidding, correct with the rudder; less rudder is needed once the turn is established. **Look around frequently.**
3. **Coming out:** move the stick in the direction opposite to that of the bank, with some rudder in the same sense, until the wings are level. At the same time as you apply the opposite bank, apply a little opposite rudder to prevent skidding. When the aircraft straightens up on the new course, centralise the stick and rudder. Relax the backward pressure on the stick as the bank reduces to keep the airspeed correct; otherwise there is a tendency for the nose to rise on coming out of a turn (particularly a steep one).

Airspeed in a turn

You will remember that the stalling speed of the aircraft is increased during a turn. You will probably be taught to fly at a normal cruising speed which provides an adequate margin for gentle turns, in which case no alteration of speed is necessary. For steeper turns (above 30° of bank) it is advisable to fly a little faster than usual; the nose must then be kept in a lower position on the horizon by the appropriate use of the elevator.

Faults in a turn

The faults occurring in turns may take the following forms:

1. Failure to keep the bank constant.
2. Movement of the nose up or down with respect to the horizon.
3. Skidding or slipping.

A fault can be caused in more than one way. For instance, if you are slipping in during a turn, it may be due to too much bank or too little rudder. However, if each control is considered as having its own function, as outlined above, any fault can easily be corrected. In this case, if the angle of bank and the position of the nose is correct, you must correct any slip by applying more rudder. The application of rudder on its own will cause the bank to increase (secondary effect of rudder) and the nose to drop (the yaw axis is now tilted in relation to the ground). You will need to stop the bank and speed increasing by appropriate movement of the stick. For a smooth turn all three controls must be moved in close harmony. This appears to be a formidable procedure when set down on paper, but co-ordination is soon achieved by practice.

To summarise

For an accurate turn:

1. Keep the bank correct with the ailerons.
2. Keep the airspeed correct with the elevator, by holding the nose in the right position.
3. Counteract slipping or skidding with the rudder. If you are skidding, use less rudder; if you are slipping, use more.

7. STALLING.

In an earlier chapter we explained the meaning of the term "stalling," and outlined one set of circumstances in which an aircraft might be stalled.

A glider is often being flown at speeds which are within 5 to 10 kt. of the stalling speed. It is therefore important for you to be able to recognise the approach of a stall, and if you should stall inadvertently to recover with the minimum loss of height.

It will be remembered that an aircraft stalls when the angle of attack of its wing is brought past the stalling angle. This happens in steady flight at the "stalling speed"; under increased loading it occurs at some higher speed. Thus an aircraft may be accidently stalled:

(a) If the speed is allowed to drop to the "stalling speed" in straight flight.

(b) If the loading is increased (e.g., a turn is commenced) when flying only slightly above the stalling speed.

(c) As the result of a harsh manoeuvre (e.g., an over-enthusiastic pull out from a dive can cause a high-speed stall).

A stall is only a hazard if it occurs at a low altitude, or if it is allowed to develop into a spin.

How to detect the approach of the stall

If a stall is performed, some, but not necessarily all, of the following symptoms may be evident:

1. Slightly higher position of the nose.
2. Reduction of noise (due to the slow airspeed).
3. Less effective or ineffective controls, particularly the ailerons.
4. Increased rate of descent (this may show on the variometer).
5. The control column will be in an unusual position, maybe to the limit of its aft movement in the elevator sense (and, possibly, the aileron sense).
6. On some gliders a slight shudder or " buffeting " of the tail may be noticed.

When the aircraft is properly stalled, height may be lost quite quickly and the nose usually drops.

Recovery

To some extent the recovery from the stall is automatic, if the angle of attack of the wings is reduced by the dropping of the nose. However, unless the stick is moved forward the glider will stall again. Therefore the recovery action is to ease the stick forward, regain flying speed and then return to the normal gliding attitude. If the stick is moved forward too far during the recovery, an unnecessarily steep dive results, and considerable height may be lost. Since the aim is to **recover with the minimum loss of height** learning the right amount of forward movement for a particular stall is very important.

If one of the wings should drop when you are carrying out a stall, no attempt should be made to pick it up with aileron. As already pointed out, the ailerons are ineffective in a stall, and use of them will make things worse. The correct procedure is to carry out the recovery from the stall in the normal manner. Only after flying speed has been regained can the wings be levelled in the normal way.

A consideration of the mode of action of the ailerons will show why they cannot be used at the stall. The lowered aileron normally lifts a wing because it is presenting an increased angle of attack to the airflow. If however, the wing is already at the point of stall, lowering the aileron will merely stall it more.

In addition, the effect of aileron drag will be to cause a yaw in the direction of bank, and this ocurring at the stall may give rise to a spin (see later). You must therefore resist the instinctive tendency to use the ailerons under such circumstances.

How to carry out a practice stall and recovery

It is good practice to carry out a thorough check before exercises such as stall, spinning or aerobatics. A mnemonic, HASLL, will help to remind you of the things to check:

H Height is adequate for the exercise. Bear in mind the distance from the airfield.

A Airframe: you should know the limiting speeds, especially for any critical configuration such as flaps extended.

S Security: make sure there are no loose articles in the cockpit and that the straps are tight.

L Location: it is preferred to be over open countryside and not over the airfield or local villages and towns.

L Lookout: make "clearing turns" to the left and right to make sure there is no other aircraft below you. (If you circle other gliders may think that you are in rising air and come to join you.)

If a succession of stalls are being carried out then repeat the clearing turns regularly.

1. At an adequate height carry out the HASLL checks.
2. Level the wings, and then raise the nose slightly above the horizon. Hold it in this position by a steady backward movement of the stick as the airspeed falls off. Note how quiet everything seems, and how movements of the controls have very little effect.

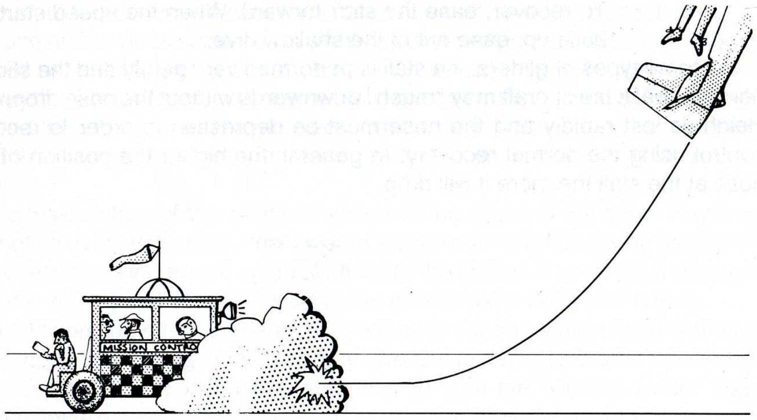
When the stalling angle of attack is reached, the nose drops although the

stick is being held right back. If a wing should drop, still use the standard recovery.

3. To recover, ease the stick forward. When the speed starts to build up, ease out of the shallow dive.

On some types of gliders, if a stall is performed very gently and the stick is held fully back the aircraft may "mush" downwards without the nose dropping. Height is lost rapidly and the nose must be depressed in order to recover control using the normal recovery. In general, the higher the position of the nose at the stall the more it will drop.

8. THE WINCH LAUNCH.



Refer to page 25 for notes on preparation for flight.

The launch is normally made into wind. This ensures that the aircraft reaches flying speed with the lowest possible ground speed and shortest take-off run. Let us consider the launch of a typical club glider which has a stalling speed of about 30 kt. At any speed greater than 30 kt. this glider is capable of developing an amount of lift equal to its weight, and can therefore become airborne. Assuming that the surface wind speed is 10 kt. the aircraft, if it is launched into wind, only has to reach a speed of 20 kt. over the ground in order to take off; thus the winch can be run comparatively slowly and the length of ground run is a minimum. If the aircraft was launched downwind under these conditions, a ground speed of 40 kt. would be required before flying speed was reached; this would involve a long run at high speed on the ground, and any unevenness in the surface would impose considerable stress on the aircraft.

During a launch there is always the possibility of a cable break or winch failure. This means that the early part of the climb (up to about 100 ft.) must be performed gently so that the aircraft can be put into the normal gliding attitude without delay. (See later on Cable breaks.) However, in order to gain the maximum height possible, the aircraft should be climbed fairly steeply from 100 ft. upwards, provided that the glider has adequate speed throughout the launch.

The angle of the climb possible depends on the condition. In rough air the climb should be made a little flatter to avoid breaking the cable. At steeper angles the loads on the aircraft (and the winch) are greater. However, it should be recognised that the glider cannot be over-loaded if the correct weak link is included in the winch cable and the winch launch limiting speed is not exceeded.

If the launch is too fast, easing the stick slightly forward will slow the aircraft down somewhat, as well as easing the force on the wings; this is because the glider is made to travel on a shorter arc. However, unless the winch driver reduces power the speed may increase again. It is standard practice to yaw the glider from side to side (after lowering the nose slightly) to indicate that the speed is too high **before** it reaches the limiting value.

If the launch is too slow the glider cannot be climbed safely and the launch should be abandoned. It is not possible to increase the speed by climbing at a steeper angle; this only causes the aircraft to " mush," which puts more load on the winch and leaves the glider in an awkward position if the winch should fail completely.

More often than not a pitching oscillation ("bucking") may be noticed towards the top of the launch, particularly if the launching speed is rather fast. The situation is caused by the nose of the glider being pulled down by the cable towards the top of the launch and the bucking can usually be stopped by easing the stick slightly forward.

The cable is normally released when no more height is being gained. This will occur shortly before the glider arrives over the winch although the position depends on the strength of the wind. As the winch cannot easily be seen during the launch, the pilot must decide when to release from other indications such as a prominent feature to one side of the winch. The rate of climb is determined by the attitude, the position of the nose in relation to the horizon. The climbing attitude may be checked by glancing to one side to compare the angle the wing makes with the horizon. Lowering the nose of the aircraft prior to release will assist releasing by reducing the load on the hook and cable.

Remember that if at any time during the launch the speed should rise above the specified safe launching speed, the cable should be released without delay to avoid straining the aircraft, and subsequent action carried out as in the case of a cable break (see later).

If any launch takes place too fast or too slowly, the pilot should report this on landing to the instructor and the winch driver.

How to Take-off and Climb

1. Carry out the preparation for flight on page 26.
2. Make sure that the take-off path is clear, and that no one is standing in front of any part of the aircraft; then tell the signaller that you are ready to be launched. The signaller should check that there are no aircraft approaching to land at the time.
3. Give the verbal commands "take up slack" and, as the cable tightens, "all out".

4. During the ground run, keep the wings level with the ailerons and keep straight with the rudder; coarse use of the controls is necessary initially because of the low speed. Use the elevator to keep the glider running forward in a level attitude (balanced on the wheel), with neither the nose nor the tail on the ground.
5. The glider will take itself off when sufficient speed is reached. Keep the initial climb gently by appropriate use of the elevator, (the actual amount and direction of the control movement required depends upon the particular glider, the position of the hook and the speed of the launch), but in most gliders, in the first phase of the launch, a forward pressure on the stick is necessary to stop the nose from rising too quickly. Keep the wings level with the ailerons.
6. At a safe height (100-ft. or so) progressively steepen the climb to the optimum angle. This steepening should be done gently to avoid breaking the weak link or cable.
7. Glance at the ground to see how the launch is progressing. When just short of the winch lower the nose slightly to reduce the tension on the cable, release by pulling the knob (pull it twice to make sure).

Occasionally it is necessary to launch slightly across wind. This means that if the wings are kept level the glider will drift during the launch until it is downwind of the winch. This will give maximum possible height of launch under such conditions, but may involve dropping the cable in an inconvenient place. If so, it is necessary to sacrifice some height and maintain the original path by using slight bank into wind once the glider is airborne.

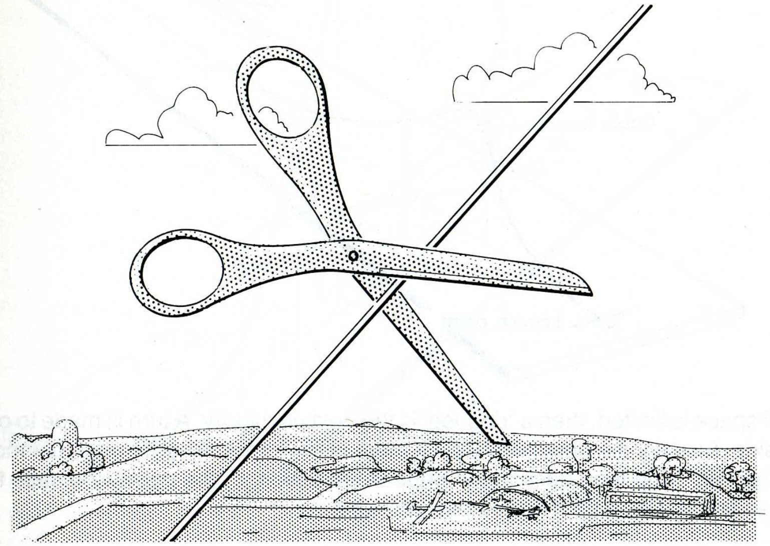
Other Methods of Launching

The winch launch has been described in some detail as it is by far the most commonly used method. On aerodrome sites, however, motor- or auto-towing may be used. This method is very similar to winch launching except that the initial acceleration is less; also with less power available the climb angle of the glider may, of necessity, be shallower.

Many clubs also use aerotow in which the glider is towed to 2000 ft. or more by a light aircraft. This has the advantage of more time in the air on each flight and also enables lift (rising air) to be contacted more readily.

One other possible way of getting airborne is the self-launching motor glider. This is a glider with an engine which is stopped once the aircraft has been climbed to the height required; it provides a convenient method of launching since no assistance is required.

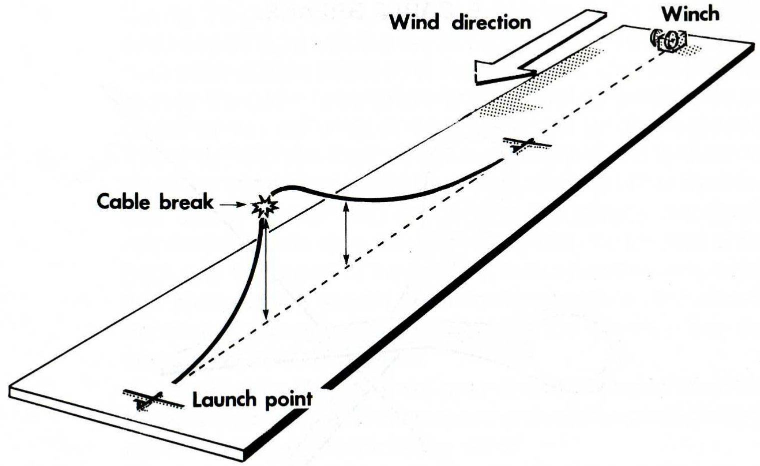
9. CABLE BREAKS.



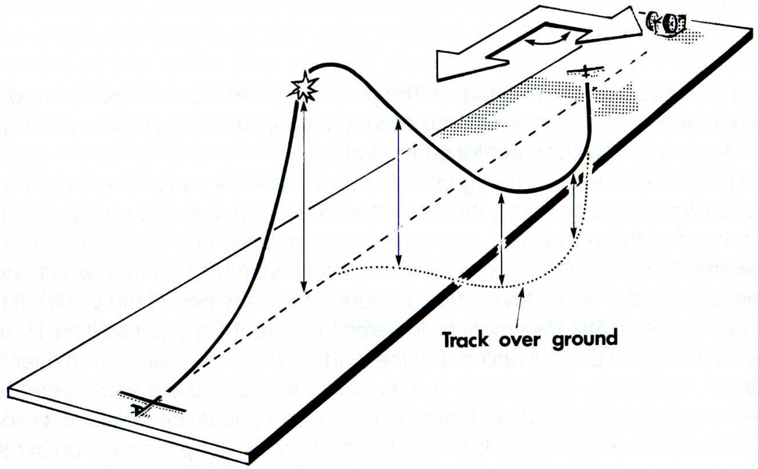
At all times during every launch the pilot should anticipate a cable break so as not taken by suprise when one occurs. If cable breaks are infrequent, you will be given simulated breaks during training.

A cable break is easily recognised except in the early part of the climb. There is usually a snapping noise, the aircraft jerks and the airspeed starts to fall off. The nose of the glider may also tend to rise and the first consideration is to maintain flying speed. In order to do this, the nose must be put down at once; unless the glider is in a level attitude (during the early part of the climb). If the glider is nose up the nose must be lowered to prevent the glider stalling. Hence the necessity for prompt action and the inadvisability of a steep climb near the ground. When the aircraft is in a nose down attitude, and a safe speed has been established, any cable attached to the glider should be released as soon as possible. In order to facilitate this, the pilot should keep his hand on or near the release knob during the launch.

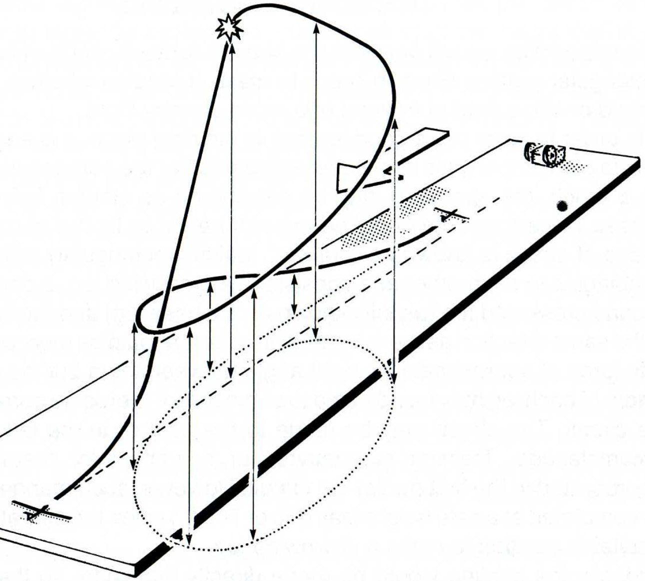
The action to be taken after the glider has been put in the normal approach attitude, the speed checked and the cable released, will depend on the height available and the size and shape of the airfield. If possible a landing should be made straight ahead:



If space is limited, then a 'dog-leg' is the next possibility. A turn is made to one side, (usually the downwind side if there is any cross wind) through not more than 90°, and then back in the opposite direction. In the crosswind case the landing will then be more or less into wind.



A circuit should only be attempted if the pilot is quite sure that he has ample height. If the straight-ahead or dog-leg options are not possible the likelyhood is that there is sufficient height for a circle or circuit, although any circuit is likely to be smaller than a normal circuit (see 44).



The most important consideration is completing the final turn at a safe height. Ideally the height by which the final turn will be completed is 250 ft. but, in some circumstances it may have to be a little lower.

Action to be taken when the Cable Breaks

1. Get the nose well down.
2. Check the airspeed.
3. Release the cable.
4. Size up the situation. If you can comfortably land straight ahead, do so. If you think you will overshoot, turn to one side first and, if space permits, land into wind (dog-leg).

If you are quite sure that you have **plenty** of height, carry out a circle or circuit.

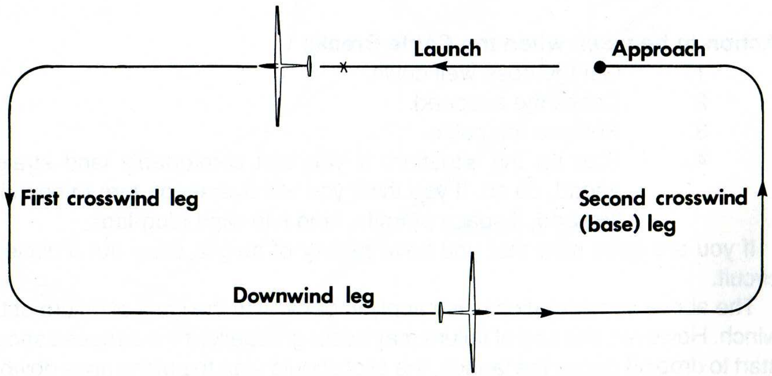
The above considerations also apply in general to the case of failure of the winch. However, this sort of failure may occur gradually; if the airspeed should start to drop off during the launch, the pilot should start to put the nose down at an early stage. If complete failure then occurs, he is in a more favourable position to recover. If the launch is slow due to a winch engine fault or winch driving error the glider cannot climb; **make an early decision to abandon it while there is sufficient space to land ahead.**

10. CIRCUIT AND LANDING.

In this section we will deal with the straight-forward circuit which is the basic rectangular pattern flown in order to make a landing whether at your base airfield or into a field at the end of a cross-country flight.

In order to carry out a good landing in the right place, it is essential for the pilot to plan properly his circuit and approach. For the purpose of early training on a winch, the approach may be considered as starting from the point of release since there may only be enough height to fly the circuit. The usual shape of circuit is known as "square" (strictly rectangular) with the 'legs' at rightangles to each other and consists of a crosswind leg, a downwind leg, a second crosswind leg (usually known as the base leg) and the final approach in the same direction as the take off. These legs should be more or less straight with turns of approximately a right angle between them but the direction and length of each leg may be adjusted to some extent in order to correct the size of the circuit. The circuit may be made to the right or to the left according to circumstances. Training manoeuvres or searching for thermals may be incorporated in the first part of the circuit. However, such manoeuvres should be completed at a safe height (say 600 or 700 ft.) when the aircraft should be in a suitable position to make a downwind leg.

Ideally the landing would be made directly into wind, so that the ground speed on touch-down is a minimum, and the landing run is as short as possible. However, on airfields the take-off and landing directions are usually the same and limited space or some other constraint may mean both are more or less crosswind.



During the whole of the circuit, the pilot should be considering his position relative to the landing point, and making such adjustments to his direction of flight as he considers necessary. In the early stages of training, the landing point chosen should be some distance into the field to allow a margin for error.

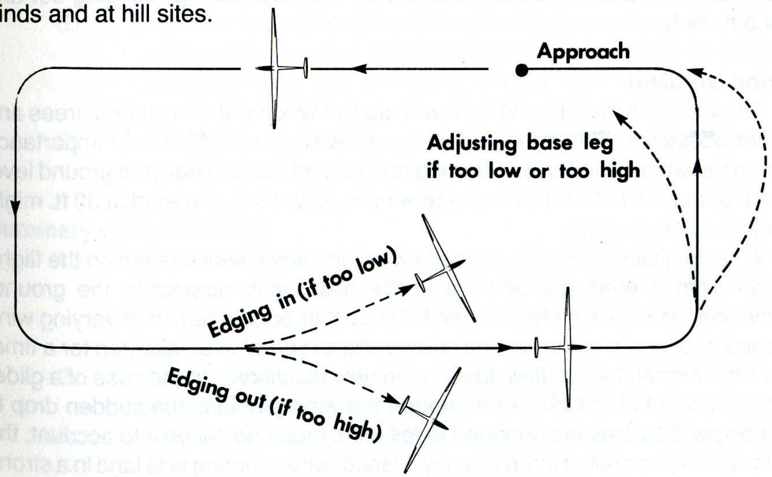
The downwind leg is used to make major adjustments, the circuit being made smaller or larger by edging in or out according to the height available.

The second turn across wind on to the base leg will normally be made a short distance downwind of the landing point. This distance will vary according to the height available, the strength of the wind and terrain considerations. The glider should at all times be kept within safe gliding distance of the field; practice at the circuit will develop your judgement of this.

Whenever the glider is down to final turn height, typically 250 ft. but often much higher in windy conditions and at hill sites, the glider must be in a position to land. For example, if the aircraft is very low on the downwind leg, the turn must be made early, before reaching the downwind boundary. This will involve landing some distance into the field, but it is better to do this than to risk having to carry out the final turn at a very low altitude.

The second crosswind turn puts the glider onto the base leg which should be at right angles to the landing direction. The pilot must continue to consider his position in relation to the landing area. The direction of the base leg can be adjusted so that the glider moves nearer to the boundary of the field, or further away, or directly across wind, according to the height available and the strength of the wind.

In a moderate or strong wind, allowance will have to be made for drift on this leg by heading somewhat into wind. The amount of drift experienced is a good guide to the strength of the wind. The steepness of the flight path on the final leg (into wind) will depend on the strength of the wind, and this must be allowed for in judging the approach. During the approach, the pilot should ensure that he has adequate air speed; for most club gliders the speed will be in the order of 50 kt. if there is no wind, 55 kt. in moderate winds and higher still in strong winds and at hill sites.



In a perfect circuit, the final turn into wind is made as the glider approaches the line of the landing run; however, the pilot can turn in and land at any time on the crosswind leg if he thinks that he is low. If the circuit has been made too high, height may be lost by the use of the airbrakes for a time on the base leg.

The Landing

The final turn into wind should be completed at a good height (250 ft. or more). The remainder of the approach should be made steadily at the correct speed towards an unobstructed part of the landing area. As the glider gets close to the ground, the glide path is gently flattened out so that the aircraft is flying just above the ground and parallel to it. In this condition the airspeed will steadily decrease; in order to prevent the aircraft from hitting the ground too early, the angle of attack is increased by a steady backward movement of the stick at such a rate that the loss of lift due to the reduction of airspeed is balanced by the increased lift due to the higher angle of attack. This brings the tail of the aircraft nearer the ground, and when the aircraft reaches the correct attitude for landing it should be allowed to sink on to the ground, touching main wheel and tail skid together. After landing, the glider is kept straight and level by progessively coarse use of the controls until it has come to rest. In windy conditions the pilot should stay in the cockpit until help arrives.

Faults

If the stick is moved back too slowly, the aircraft will touch down too fast in a nose-down attitude, and may bounce. If it is moved back too quickly the aircraft may climb and subsequently stall well above the ground. If the last part of the approach is made too slowly, the aircraft may stall during rounding-out and land heavily.

Wind Gradient

The wind near the ground is slowed up by friction with the ground, trees and other obstacles. This effect is known as "wind gradient"; it is of importance when the wind is moderate or strong and is most marked from the ground level up to about 30 ft. When the surface wind is, say, 15 kt, the wind at 30 ft. might well be 20 kt or more.

When a glider is flying in a steady wind, the wind has no effect on the flight, apart from altering the position of the glider with respect to the ground. However, when the glider is flown RAPIDLY through a region of varying wind speed, the inertia of the aircraft causes the airspeed to be affected for a time, until the aircraft has settled down in the new conditions. In the case of a glider approaching to land into wind through the wind gradient, the sudden drop in wind speed causes the airspeed to fall off. If this is not taken into account, the aircraft may be stalled inadvertently. Hence, when coming in to land in a strong

wind, the pilot should maintain speed until the final stage of the approach. Some speed will be lost in the wind gradient but this is allowed for by having an adequate margin of speed. In any case, the approach in a strong wind should be made at a higher speed than usual in order to provide adequate control in turbulent air.

If an aircraft is turning into wind steeply banked as it approaches the ground under conditions of pronounced wind gradient, the lower wing will be affected by the gradient before the upper, and consequently lose some of its lift. This may make it difficult to recover from the turn, and is one of the reasons for avoiding turns close to the ground.

Summary of Manoeuvres in the Circuit

1. After release, settle down to a glide at normal speed, and then turn across wind to clear the area for any subsequent launch.
2. If you think you are low, turn downwind immediately; if you have plenty of height, continue across wind before making the turn.
3. On the downwind leg, keep looking at the landing area. If you are low, edge in towards it; if you have plenty of height, edge out a bit.
4. Turn across wind (on a normal circuit) a little way downwind of the landing area. Ensure you have adequate speed. If you have plenty of height, continue across wind until you are in the right position for the final turn. Judge the strength of the wind from the amount of drift. Keep a good look-out for other aircraft. If you have approached too high, lose excess height by using the airbrakes.
5. After the final turn, make sure speed is correct, and aim for an unobstructed part of the landing area. If the glider is drifting sideways, you are not flying directly into wind. Make the necessary correction.
6. If there is a moderate or strong wind, counteract the effect of wind gradient by putting the nose down as you get lower.

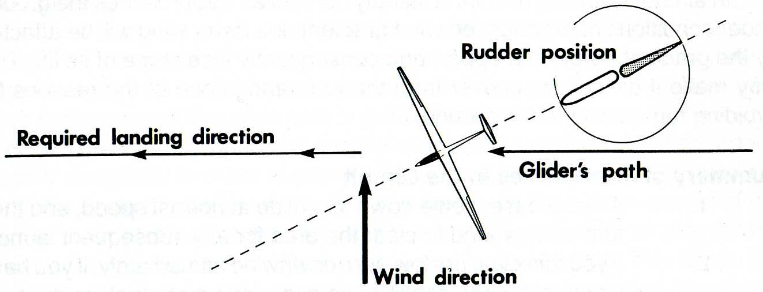
Summary of the Landing

1. Look well ahead during the landing. As the glider approaches the ground, gradually level out so that you fly along just above the ground. Keep the aircraft from touching down until it is in the right attitude for landing.
2. After touching down, keep wings level and keep straight by progressively coarse use of the ailerons and rudder.
3. When you have come to rest, stay in the aircraft until someone arrives.

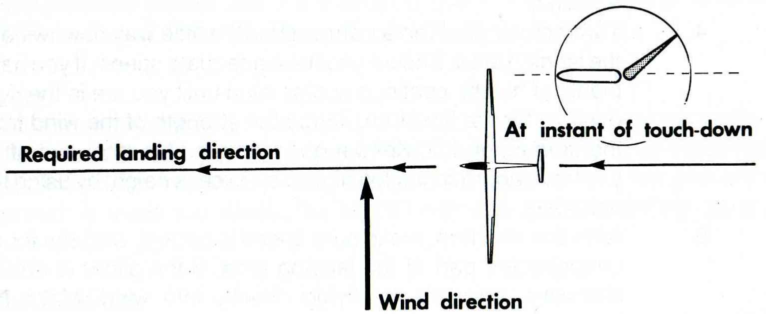
Landing across Wind

On occasion it may be necessary to carry out a landing across the direction of the wind. In light winds this is not difficult.

The glider should be turned slightly into wind sufficiently to produce the required track :

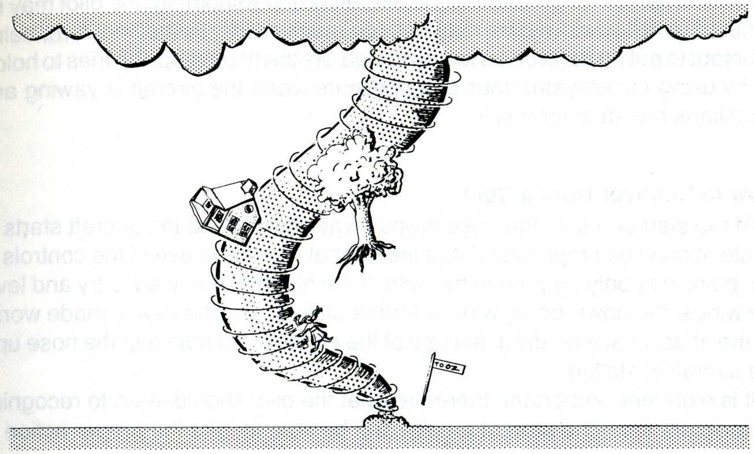


just before touching down, rudder should be applied in the direction of drift:-



This counteracts any strain the touch-down might cause the undercarriage, by swinging the aircraft in line with the direction of motion; if this is done at the correct moment, the aircraft will touch down before the flight path has altered.

11. SPINNING.



A spin is a condition of stalled flight in which the aircraft makes a spiral descent, losing height rapidly. During a spin the aircraft is moving simultaneously in the rolling, yawing and pitching planes, and it cannot be controlled in the ordinary way until recovery has been made.

Most gliders may be made to spin under the right circumstances, but the form of spin varies. Some may be held in a continous spin, but others come out of their own accord. Many gliders will come out of a spin if the controls are centralised, but recovery may be slow. The position of the centre of gravity affects the spinning characteristics of a particular aircraft; the further back the C. of G., ie, the lighter the pilot, the easier it is to cause and hold a spin, and the slower may be the recovery.

How a Spin Occurs

An aircraft may spin if it is allowed to stall when it is moving in the yawing plane, or conditions are such that the stall itself will lead to a yawing movement.

If the aircraft is moving in the yawing plane when a stall occurs, the outer wing is moving faster than the inner wing. Consequently the inner wing will be more stalled, and will drop. As it drops, it meets the airflow at a still greater angle of attack, and this aggravates the stall.

The aircraft thus continues to move in the rolling plane; the inner wing produces more drag than the outer, because it is at a higher angle of attack, causing the yawing movement to continue. This state of affairs ("autorotation") may be quite stable.

Lack of care on the part of a pilot may bring the aircraft to a condition when an accidental spin is possible. If the aircraft is undershooting, the pilot may be tempted to fly too slowly; he may use too much rudder in the final turn, being reluctant to put on bank close to the ground. As the nose drops he tries to hold it up by using the elevator; thus a stall occurs when the aircraft is yawing and conditions are ideal for a spin.

How to Recover from a Spin

At the start of a spin the nose drops away sharply and the aircraft starts to rotate. It must be emphasised that the normal instinctive use of the controls at this point may only aggravate the spin. If the ailerons are used to try and level the wings, the down-going wing is further stalled, and the yaw is made worse by the effect of aileron drag; the use of the elevator will not keep the nose up if the aircraft is stalled.

It is extremely important, therefore, that the pilot should learn to recognise an incipient spin (the start of a spin) and be able to take the proper action to prevent a full spin developing. To recover from a spin:

1. Apply full opposite rudder. This tends to check the rotation. Some force may be necessary.
2. After applying the rudder, move the stick forward steadily until the spinning stops. This unstalls the wings and allows the speed to build up.
3. When the spinning stops, centralise the rudder and ease out of the resultant dive, levelling the wings with ailerons as the speed builds up.

Note: - If the rudder is kept applied after the rotation stops, a spin in the other direction may result.

Do not move the stick further forward than is necessary, or an excessively steep dive will result.

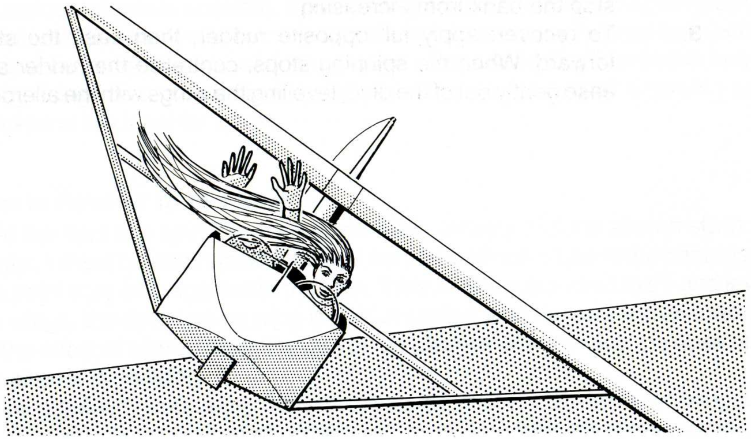
The ailerons should be kept central until the aircraft is unstalled and is gathering speed.

Practice Spins

As mentioned above, it is important that you should be able to recognise the start of a spin and take the appropriate corrective action. This involves practice recoveries from spins and incipient spins. These may be performed dual quite safely if adequate height is available.

1. Complete the HASLL checks.
2. Commence a spin, e.g. by performing a slow turn with too much rudder, holding the nose high and using opposite aileron to stop the bank from increasing.
3. To recover: apply full opposite rudder, then ease the stick forward. When the spinning stops, centralise the rudder and ease gently out of the dive, levelling the wings with the ailerons.

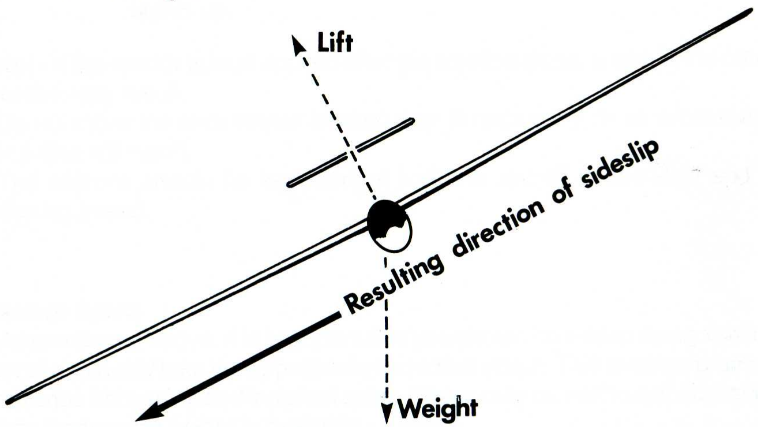
12. SIDESLIPPING.



During a sideslip the aircraft is made to travel through the air partly broadside on, so that the line of flight is at an angle to the heading of the nose. This results in inefficient performance; the angle and rate of descent are increased without a corresponding increase in airspeed.

A sideslip may be used to correct for overshooting on the approach to land. It may be employed when in a straight flight or in a turn.

The force providing the sideways movement of the aircraft is derived from the lift and the weight.



The steeper the angle of bank, the greater will be the sideways component of the motion. However, the sideslip is an unnatural condition of flight, with both

the lateral stability and the weathercock stability trying to prevent it. The lateral stability tends to level the wings again, and the weathercock stability tends to convert the sideslip into a turn.

Therefore, in order to keep the aircraft in a straight sideslip, the aileron control must be used to maintain the bank and opposite rudder must be used to prevent a turn. The degree to which a glider can be sideslipped straight is limited by the rudder control available. On most gliders the rudder is comparatively weak and full rudder must be used at a small angle of bank. If the angle of sideslip is increased further, a turn cannot be prevented.

During a sideslip the position of the nose is rather higher than in normal flight at the same speed. When recovering from the sideslip, therefore, the nose must be put well down to avoid the airspeed falling off. Because of this effect, and also since the aileron control on some gliders is rather sluggish, the recovery from the sideslip must be carried out at a reasonable height.

Sideslipping in a Turn - A slipping turn is an effective method of losing height, particularly if a glider has comparatively poor rudder control. In this manoeuvre a turn is performed with excessive bank and opposite rudder, thus producing insufficient rate of turn for the angle of the bank. The glider may be sideslipped quite steeply; the yaw produced by the weathercock stability is only partly counteracted by the opposite rudder and the turn is allowed to take place.

How to carry out a Sideslip

The Straight Sideslip

1. Having made the final turn into wind bank the glider to the left or right and apply opposite rudder, swinging the nose round so that the resulting sideways path is in the direction of the landing area.
2. Keep the speed at the normal approach speed; the nose will be slightly higher than in a straight glide.
3. To obtain a greater rate of descent, increase the angle of bank. More opposite rudder will be needed to overcome the tendency to yaw. The limit is reached (for a straight sideslip) when full rudder has been applied.
4. Recover in good time: allow the nose to swing round to its original heading, level the wings and centralise the rudder. Put the nose well down to maintain the airspeed.

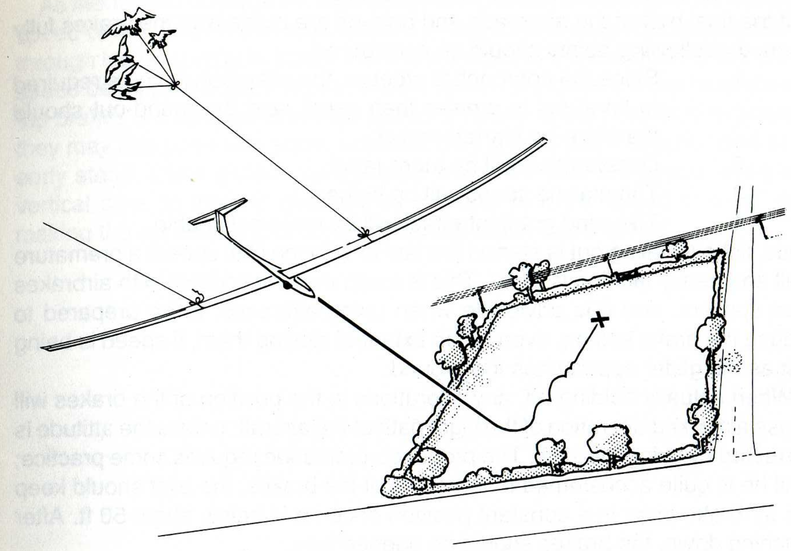
The Slipping Turn.

Start the final turn into wind rather higher and closer than usual. Increase the angle of bank, and put on opposite rudder to cause the slip.

Recover when facing into Wind

The slipping turn can be converted into a normal gliding turn at any time if sufficient height has been lost. If you are still too high at the end of the turn, carry on into a straight sideslip.

13. USE OF AIR BRAKES.



The air brakes fitted to gliders are of two alternative types, either spoilers or airbrakes. (Refer to page 23 for a description.) These are both used in the same way as an aid to landing, although the airbrakes are much more effective.

Use of Airbrakes on the Approach

By using the air brakes, the angle of glide can be progressively steepened to a considerable extent, and because of this a simple straight approach can be easily made without the complication of sideslipping. An approach is made which, if continued with the brakes closed, would result in an overshoot. The air brakes are then opened as required to make the necessary adjustments to the glide path. Airbrakes increase the stalling speed slightly and the approach will normally be made at a speed which allows for this and other effects, eg, wind gradient, turbulence, and the strength of the wind.

When flying with airbrakes or spoilers shut, the air loads on them are such that there is a tendency for them to open. To prevent this, spoilers are usually fitted with springs and airbrakes with some sort of lock. The springs on spoilers are normally strong enough to return them to the closed position if the pilot lets go of the control, but airbrakes will usually ride fully open once they have been unlocked. For this reason the pilot should have the habit of keeping his hand on the lever once the airbrakes or spoilers have been opened on the approach, until he has touched down and come to a stop.

If the final part of the approach and hold-off are made with the brakes fully open, the following points should be considered.

1. Since the approach is steeper, the alteration in angle required to level out is greater than usual, and the round-out should therefore be started earlier.
2. Deceleration will be more rapid.
3. The stalling speed will be higher.
4. The wind gradient effect will be more noticeable.

Thus, if the levelling out is started too late or with too little speed, a premature stall and heavy landing is likely. This is much more noticeable with airbrakes than spoilers, and it is advisable when using airbrakes, to be prepared to reduce the brake setting, even to the extent of closing them, if speed is being lost as the glider approaches the ground.

When actually holding off, any alterations in the position of the brakes will cause a marked alteration of the flight path of the aircraft, unless the attitude is corrected by using the stick. The proper co-ordination requires some practice; until he is quite accustomed to the effect of the brakes, the pilot should keep the air brake lever in a constant position once he is below about 50 ft. After touching down, the brakes should be opened fully.

The Approach with the Airbrakes

1. Make the final crosswind leg and position the final turn so that you would overshoot if you did not use the brakes and chose a reference point in the landing area.
2. When you are sure you are going to overshoot, open the brakes to steepen the angle of glide. Monitor the speed with occasional glances at the ASI.
3. Adjust the air brakes as necessary to control the approach (to keep the reference point stationary in the canopy), lowering the nose as you open them or raising it slightly as you close them to maintain the selected speed.
4. On an aircraft fitted with very effective airbrakes, until you are thoroughly familiar with them, avoid landing with full brake and do not alter the setting when close to the ground unless losing speed. With spoilers, it will not usually be necessary to close them but again they should be kept in a constant position during the last part of the approach.
5. When you are on the ground, open the brakes fully.

Use of Airbrakes in an Emergency

As mentioned on page 24, airbrakes (not spoilers) are designed to keep the speed of the glider within safe limits. If at any time through bad aerobatics or through losing control in cloud, there is a danger of the maximum permissible speed being exceeded, the pilot should open the brakes without hesitation. If the brakes are opened when the speed is nearly at the permitted maximum, they may ride open with some violence; they should preferably be used at an early stage. Older gliders have brakes which will limit the speed, even in a vertical dive. In modern gliders they will only limit the speed in a 45° dive making the consequences of losing control much more critical.

APPENDIX A

Instruments

The usual instruments carried in a sailplane are:

1. **The airspeed indicator:** This instrument records the speed of the airflow past the aircraft (owing to the effect of wind this is not the speed over the ground). It is operated by the pressure of the air on an open tube (the pitot tube) fixed on the aircraft and pointing forward. The scale of air speed is in Knots. (1 Knot = 100ft. per min, or 1 sea mile per hour). To convert knots to m.p.h. multiply by 1.15.
2. **The altimeter:** This instrument is operated by the fall in air pressure with increasing altitude, and is calibrated to record this directly as feet of height. It registers the height of the aircraft above sea level or aerodrome level, or any other zero according to the way the pilot has set the instrument. As the pressure in the cockpit does not always correspond with the actual external pressure, the altimeter is usually connected to an external static connection.
3. **The compass:** This instrument shows the heading of the aircraft with respect to the magnetic north. In the United Kingdom the magnetic north varies between 5° and 9° west of true north. The compass is subject to various errors when the aircraft turns or varies its speed.
4. **The turn and slip indicators:** These two instruments are usually included on the same dial face, but are operated independently.

The turn indicator uses an electrically driven gyro, the needle moves to the right or left according to the turning movement of the aircraft.

The slip indicator records slip and skid, it may take the form of a bubble or ball in a curved tube of liquid, like a spirit level.

5. **The variometer:** This instrument records the vertical movement of the aircraft with great sensitivity, and is the chief aid to thermal soaring. It is operated by the change of pressure accompanying a climb or descent. These changes cause air to flow into or out of an insulated container (the "capacity"); this movement of air is arranged to indicate "climb" or "sink" by a needle on a dial.

APPENDIX B

Thermals

A glider must always descend relative to the air through which it is flying. The glider pilot must find rising currents of air in order to remain airborne. Such rising currents are either "thermals", due to local heating when the atmosphere is "unstable", or hill "lift", where the ordinary horizontal wind is forced upwards by a hill. Other types of lift (frontal, wave, etc) also occur in special circumstances.

Thermals are fairly localised, and are usually accompanied by areas of descending air ("down draughts"). A pilot flying through an area where such small-scale air movements are occurring will feel these movements as "turbulence". The aircraft will be bumped about to some extent, sometimes in temporary defiance of the position of the controls.

In such "rough air", improved control will result if the speed is increased a little (say 3 - 5 knots) but it is not necessary to correct for every little deviation from the normal attitude. Small deviations will often cancel each other out; large deviations should be corrected by appropriate use of the controls, but avoid using excessive control movements. If the pilot succeeds in remaining in one particular portion of rising air, known as centring in the thermal, the turbulence will generally be less.

Gusts

Rough air at altitude does not constitute a hazard unless the glider is going too fast (when the structure may be strained). Near the ground thermal turbulence is not usually sufficiently marked to affect the handling of the aircraft; however, "gust turbulence" may be encountered at low level in conditions of strong wind, and this may be dangerous unless anticipated, by flying a little faster than usual. Gusts are small and violent vertical and horizontal air currents caused by the strong wind striking against obstacles on the ground. It is particularly marked when the ground is rough, in the lee of obstacles (buildings, trees etc.) and in the "curl over" on the lee side of hills. Such areas should be avoided as landing places; the approach in a strong wind should be made at a slightly higher speed than usual, and the final leg into wind should be started at a good height.

APPENDIX C

More about Lift and Drag

You have seen that the value of the lift and drag forces on a wing depend upon the angle of attack and the airspeed. The density of the air is also involved, and the full relationship is given by the formulae:

Lift = $C_L ½.p.V^2.S$

Drag = $C_D ½.p.V^2.S$

Where:

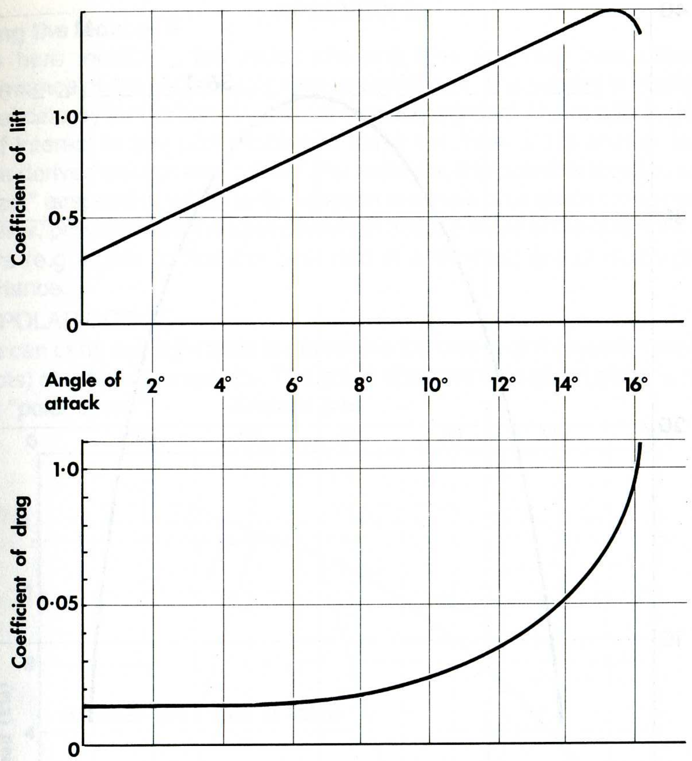
- C_L is the lift coefficient, which depends on the design of the aerofoil, and varies with the angle of attack.
- C_D is the drag coefficient which similarly depends on the shape of the aerofoil and the angle of attack.
- p is the density of the air.
- V is the velocity of the airflow
- S is the surface area of the wing.

It was mentioned earlier that when in a steady glide the values in the expression for lift are such that the lift force is equal to the all-up weight of the aircraft (for a typical glider this might be 750 lb.). If the speed is increased the aircraft is automatically flown at a smaller angle of attack (reducing the value of C_L) so that the balance is maintained. If we wish to carry out a manoeuvre such as a turn in which extra lift is required, we may obtain this lift either by increasing the angle of attack (up to the stalling angle) or by increasing the speed, or by a combination of both.

So far we have only considered specifically the drag caused by the wings (we defined this as the component of the total reaction which is parallel to the airflow). However the rest of the structure, fuselage, tail surfaces all tend to resist travelling through the air, and produce "Parasite" drag. The total drag of the aircraft is made up of the wing drag together with parasite drag. These two main types may be subdivided into induced drag, profile drag, skin friction, etc. To give an idea of the magnitude of the forces involved, the total drag force on a modern glider weighing 750 lb. with at its best glide angle of 1:35 is about 22lb. of which about 6 lb. is parasite drag.

Lift and Drag Coefficients

For the most purposes we are concerned with the lift and drag of the **whole glider,** i.e. we wish to take into account the fuselage drag and any other effects. We must therefore use the values of C_L and C_D appropriate to the whole aircraft. These can be found by wind-tunnel experiments on a model, or may be calculated from the results of flights tests. If the values found at various angles of attack are plotted, the curves are of the type shown:



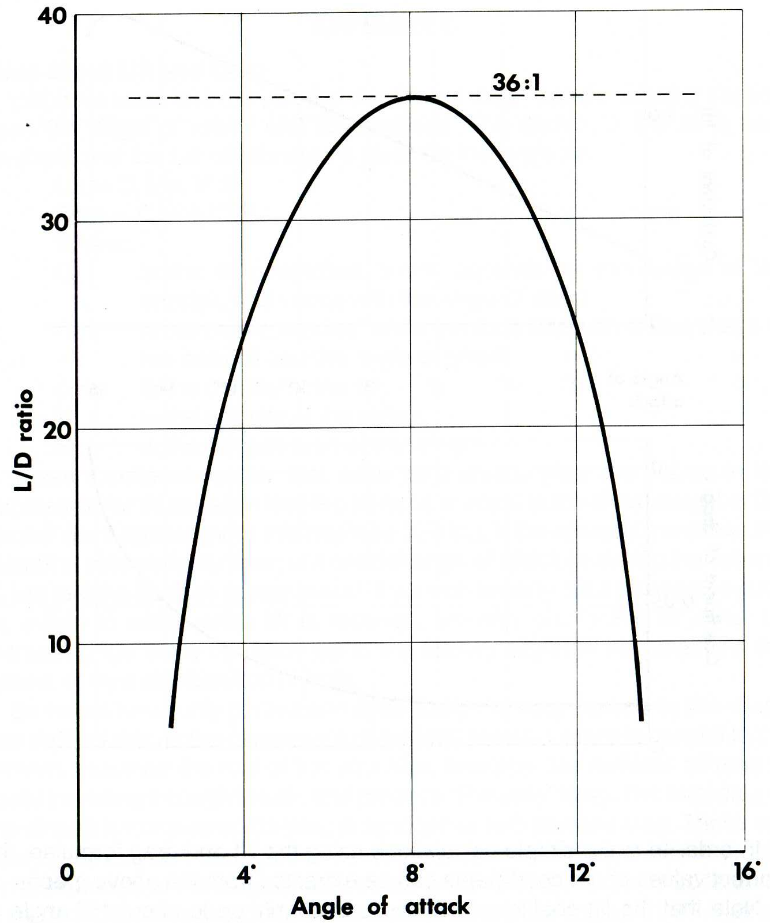
In order to make simple calculations using the lift and drag formulae, the correct values of the coefficients can be extracted from the above graphs.

Note that the lift coefficient increases uniformly up to about 15° angle of attack, and then falls off sharply. This marks the point of stall. The drag curve shows a progressive increase with angle of attack.

The angle of attack in normal flight is about 7°. C_D is therefore 0.7; the airspeed then has the appropriate value (about 50 kt.) such that the lift force is equal to the weight.

Lift/Drag Ratio

From the graphs (the curve of L/D (=C_L/C_D) we can find the ratio lift/drag at various angles of attack.



It was shown on page 13 that the angle of glide (in still air) is flattest when the ratio L/D is a maximum. Observe that this occurs at an angle of attack of about 7°; at normal loading this corresponds to an airspeed of about 50 Knots.

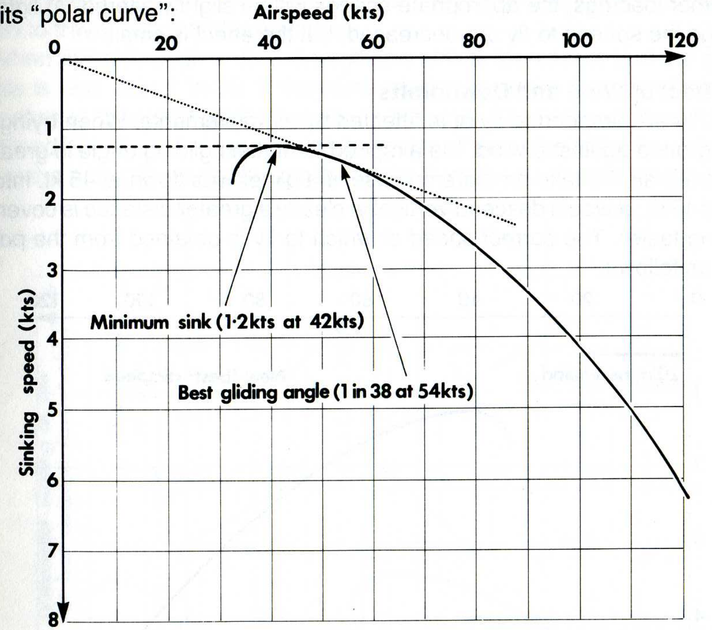
APPENDIX D

Making the Most of It

We here include a few notes showing how you may best utilise the performance of the glider under various conditions. The subject is treated in a theoretical way for the benefit of the technically minded. The results in general are of interest to any pilot wishing to make the most of his aircraft, but the values derived are not very critical. For instance, it is possible to calculate the "correct" airspeed at which to fly between thermals on a given cross-country. However, provided that the speed is within about 5 knots of the optimum, other factors (e.g. ability to find the best part of a thermal) are of much greater importance.

THE POLAR CURVE.

We can carry out flight tests to determine the rate of sink (usually measured in knots) at different airspeeds. The graph obtained for a given glider is known as its "polar curve":



This graph gives a measure of the "penetration" of the aircraft which is the ability to increase its airspeed without an undue increase in sink. Thus at 42 knots the sink rate is 1.2 kt. and at 70 kt., 2.15 kt.; this corresponds to fairly good penetration.

Good penetration is obviously an advantage when travelling across country, as it enables the distance between thermals to be covered comparatively rapidly and with little loss of height.

The polar curve has the following properties:

1. If a line is drawn from the origin to any point on the curve, then the slope of the line is equal to the gliding angle in still air at the speed corresponding to that point. (The slope must be calculated using the same units on each axis).
2. The tangent to the curve from the origin touches the curve at the point corresponding to the flattest gliding angle (in still air).
3. The topmost point of the curve gives the airspeed at which the sink is a minimum.

Referring to the curve shown, we see that the speed for "best" gliding angle (in still air) is about 54 kt. while the speed for minimum sink is about 42kt. However, it makes very little difference to the rate of sink or the range which speed is used.

At other loadings, the appropriate speeds will be slightly altered. At lighter loadings the speeds to fly are decreased, but the effect is small.

The Effect of Wind and Downdrafts

The "best" airspeed to fly at is affected by air movements. When trying to cover ground against a wind, the airspeed for flattest gliding angle is greater than in still air. To take an extreme case, if a glider was flown at 45 kt. into a wind of 45 kt., it would descend vertically; clearly a greater distance is covered by flying faster. The correct speed at which to fly is obtained from the polar curve as follows:

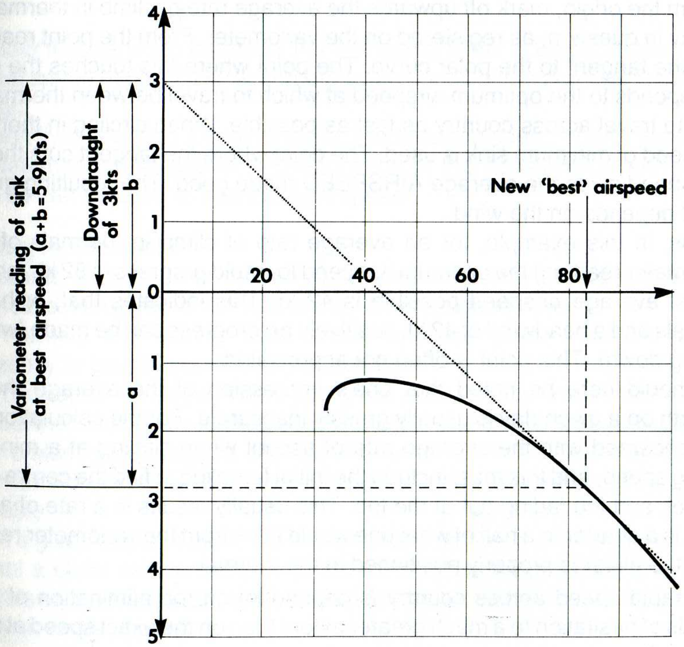
Along the airspeed axis lay off the amount of the headwind component; from this point reached, draw a new tangent to the polar curve; the point where it touched the curve corresponds to the "best" airspeed for those conditions.

A rough rule of thumb indicates that the airspeed should be increased above the best L/D by an amount equal to one third of the headwind component in knots. Thus for a 15 kt. headwind, the "best" airspeed from this polar diagram is 61 kt.

Note that however much the airspeed is increased, the gliding angle in a headwind can never be as good as the best glide angle of 1 in 36. The slope of the tangent gives the actual gliding angle.

The correct speed for flying in a tailwind can be found in a similar manner (by laying off along the speed axis in the opposite direction) but the effect on the best speed is slight; for maximum range in a tailwind is quite good enough to fly at the speed for minimum sink (42 kt.). For cross-country flying it is usual (see later) to travel rather faster than this.

When flying through a downdraught the sink is increased, and the gliding angle is less than 1 in 36. It therefore pays to increase the speed to some extent so as to pass through the area more quickly. The optimum speed can be obtained from the polar curve as follows: mark off the value of the downdraught along the sink axis, upwards from the origin; from this point draw the tangent to



the curve. The point where it touches corresponds to the speed for flattest gliding angle.

All the necessary information is usually provided on a speed-to-fly ring fitted to the variometer.

Flying for Speed

In keeping with the modern trend, gliders are being flown faster. It is recognised that long cross-country flights are often limited by the duration of thermal activity; the pilot should aim to achieve the highest ground speed possible under the conditions.

When travelling across country, the glider pilot gains height by circling in a thermal, then flies straight in the required direction, losing height. He counts on finding another thermal before he is too low. The race technique involves flying between thermals at a speed faster than that for best gliding angle. It is assumed that thermals are sufficiently plentiful to make the use of the flattest gliding angle unnecessary. The correct speed at which to fly a given aircraft depends on the average strength of the thermals on that day, and is independent of the strength and direction of the wind.

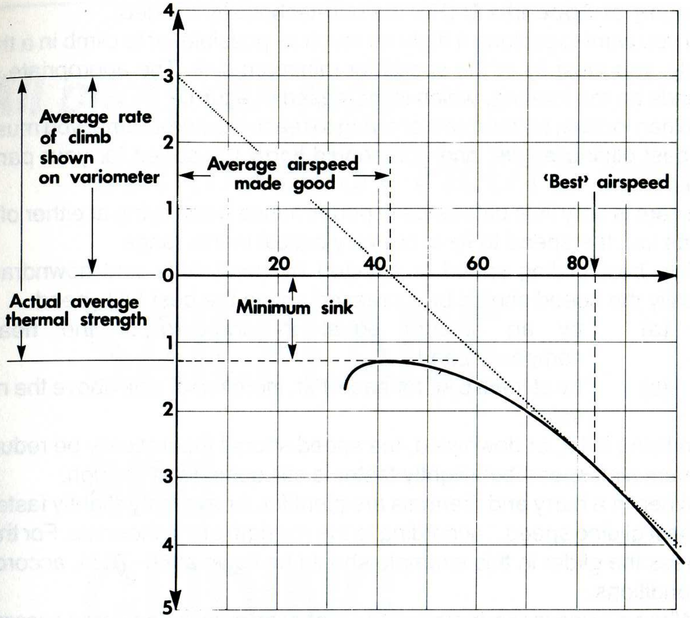
The appropriate speed at which to fly can be determined from the polar curve as follows:

From the origin, mark off upwards the average rate of climb in thermals for the day in question, as registered on the variometer. From the point reached, draw the tangent to the polar curve. The point where this touches the curve corresponds to the optimum airspeed at which to travel between thermals, in order to travel across country as fast as possible. When circling in thermals, the speed of minimum sink is used. The point where the tangent cuts the axis of airspeed gives the average AIRSPEED made good. The resulting ground speed depends on the wind.

Thus, in this example, for an average rate of climb in thermals of 3 kt. (variometer reading) the optimum airspeed for rapid progress is 82 kt., and the highest average airspeed possible is 42 kt. This indicates that, with 3 kt. thermals and a headwind of 42 kt. positively **no** progress can be made (without coming down). This point is often not appreciated.

It should here be noted that one's impression of the average thermal strength on a given day is usually grossly inaccurate. For the calculations we are concerned with the average rate of ascent when circling at a minimum sinking speed, and this must include the initial fumbling to find the centre of the thermal, and the fading out at the top. This usually results in a rate of ascent which is a quarter to a half of what one would think from the variometer reading when the glider is properly positioned in the thermal.

Thus rapid speed across country is dependent on the elimination of these periods of hesitation to a much greater extent than on the exact speed at which



the glider flies between thermals. For this typical glider in England, a between-thermal speed of 60 - 70 kt. according to the conditions is normally quite good enough.

When flying through a downdraught, the optimum speed to fly is faster than that determinded as above. A combination of this construction with that on page 64 can be used to find the right speed.

Turning in Thermals

Accurate calculation of the turning characteristics of gliders is practically impossible. However, a few points may be mentioned here:

1. Thermals are usually quite small, and the glider must be banked sufficiently to give the optimum radius of turn.
2. The greater the angle of bank at a given airspeed, the smaller the radius of turn, but the loading, the stalling speed, and the rate of sink are all increased. A compromise depending on the distribution of lift in the thermal must be achieved. 25°-45° of bank is the usual sort of range. More than 50° is seldom advisable.
3. At a given angle of bank, the radius of turn depends on the airspeed. In a thermal a glider will normally fly at the minimum sinking speed. This speed depends on the load factor, but is about 20% greater than the stalling speed for the given angle of bank.

Summary of Appendix D (For the non-technically minded).

1. If you want to prolong a flight as much as possible, or to climb in a thermal quickly, you must fly at the speed for minimum sink. The appropriate speed depends on the loading, which is increased in a turn.

2. When looking for thermals or trying to reach the aerodrome, you must fly at the "best gliding angle" and you should know the speed for your particular glider.

3. There is very little difference in performance when flying at either of these speeds i.e., the speed to fly is not very critical in this range.

4. The best gliding speed is affected by headwinds and downdraughts. Typically the speed should be increased above the best L/D speed:

   (a) by an amount equal to one-third of the headwind component,and

   (b) by at least 5 kt. for each 1 kt. increase of sink above the normal value.

When flying in lift, or downwind, the speed should theoretically be reduced to minimum sink speed but slightly faster is still quite good enough.

5. When in a hurry and thermals are plentiful, it pays to fly slightly faster than the "best gliding speed," according to the strength of the thermals. For the best progress the glider in this example should be flown at 60 -70 kt. according to the conditions.

6. When circling in thermals the angle of bank must be adjusted according to the distribution of lift (25°-45° of bank in the usual sort of range). For the best climb rate the aircraft should be flown at the minimum sinking speed. This is **increased** in a turn. However, better control of the glider will be achieved at a slightly higher speed without performance penalty and a greater margin above the stalling speed.