# THE ABC OF GLIDING

BY FOX GEEN

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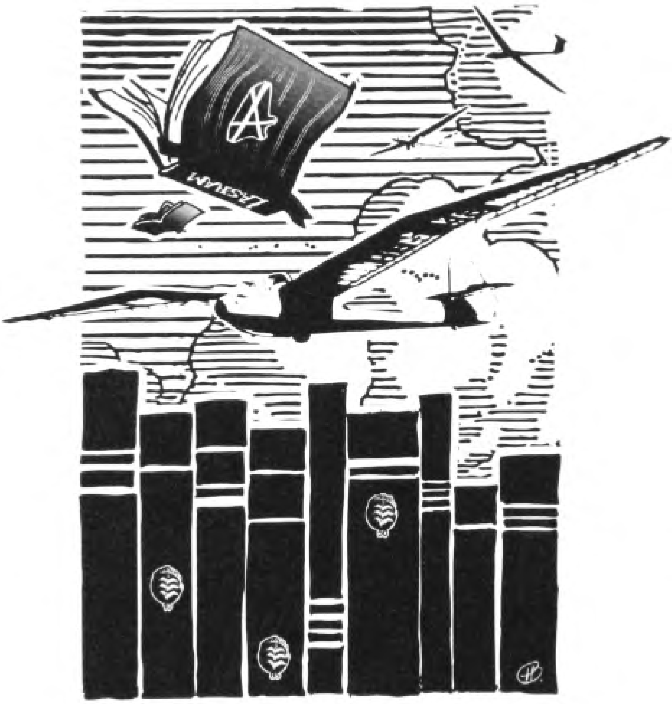

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*by Fox Geen*

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## *Foreword*

BY AIR COMMODORE L. R. S. FREESTONE, O.B.E.

It is with the greatest interest that I have read the manuscript of Mr. Fox Geen's book on elementary Gliding and Soaring. To my knowledge, there is no such book in existence at present, and the need of it is felt acutely, particularly where primary instruction cannot be carried out in dual-controlled gliders or sailplanes.

The book should be of the greatest possible value to the layman—and this includes the A.T.C. beginner—and to the many hard-working gliding instructors, who badly need some form of literature to be available to supplement their instruction.

I hope that the publication will help many thousands of men, women, and adolescents towards the enjoyment of the most fascinating pastime of soaring, in which I have found so much pleasure and comradeship.

# *Preface*

THERE are many books which deal with soaring and gliding, with aeronautics, aerodynamics, meteorology, and the rest of it; but I have never come across an easy book of reference for the beginner. One that the tyro, in the tedious hours spent away from the soaring-site, asking himself despondently, "What is the use of an A.S.I. if I'm not supposed to look at the beastly thing?" can refer to in the hope of getting the right answer.

This book is designed to fill that need. It goes through the process of learning gently, stage by stage; it deals only with what is needed to be known and practised at any one stage, and is non-technical as far as possible. A pupil pilot can have too much pumped into him at any one time.

Think back, if you can, you experts, to the days when a low hop demanded of you a concentration of mind and nerve now only called for in the midst of the hairiest cu-nim; to the days when the man on primary circuits was to be spoken to with respect, and he in the sailplane was a winged demi-god, no less. In other words, when you were a raw beginner. These pages are intended primarily for such beginners.

Gliding is learned not only in the evanescent period of briefing, flying, and de-briefing. It is learned in the club-house, during discussions and post-mortems; by retaining the odd pearl of wisdom dropped by the expert; in a thousand and one ways. In the end, however, and in the event, it is learned by the curiosity and determination of the aspirant.

This primer makes no pretence at being an authoritative work on the art of gliding and soaring, but it does try to be helpful. It is intended *as a supplement to proper instruction on the flying-field.*

During its preparation I suffered much chastening of the soul —I think it has been worth it; my thanks go to many friends for their advice and criticism.

FOX GEEN

*Oerlinghausen*, 1950

# *Introductory*

In gliding, as in most things, it is best to start at the beginning. When you first visit a soaring-site, you will see graceful machines sweeping through the air, singing a thin song of freedom and of joy. At that time there is born in you a desire to fly.

After the usual enquiries, you will likely find yourself taking a trip as passenger in a two-seater sailplane. During the flight you will be mystified, intrigued, and possibly more than a little apprehensive. After the enormous relief at landing safely, you will remember little of the trip, except that you wish it had not ended. You will want to do it again, and again.

(And here is a word for those wives and sweethearts who have been talked into buying this book for a present. Now is the time to take a firm stand, or reconcile yourselves to grass-widowhood and prepare for a diet of thermals, lapse rates, crossed controls, and so forth, during the infrequent periods when you will find your men on the ground. Of course, you *could* take sweet revenge and learn to fly yourselves!)

Ultimately, with a certain amount of trepidation, you will be introduced to a primary glider, and immediately remark that it looks very much like a pre-1914 aeroplane. It does look most monstrous in these days of sleek projectiles, I admit, but it flies admirably, and you will get to love it. Your instructor will tell you of its principles, capabilities, and limitations. When you go home, you will only remember part of what he has told you; then is the time to open these pages and refresh your memory.

To learn to fly, you must of necessity understand the basic principles of flight. Flying is a new departure for man, and before you can condition your body, nerve, and muscle to the new mode of movement in the third dimension, the principles behind it must be clear in your brain. Woolly thinking will lead to woolly reasoning; woolly reasoning to uncertain or incorrect action—a highly undesirable state of affairs.

So, in this book, you will find a certain amount of theory. It may be at the beginning of a chapter—it may turn up anywhere—but when it appears, *learn it.* To begin with, you may wonder whether it is really necessary; take my word that it is. The theory will sooner or later have to be put into practice. Soundly understood, it will turn you into a good pilot. That is the only type of pilot with a future.

The lessons are progressive. Emphasis has been laid on the early stages, for it is during this time that you must develop good habits, both of thinking and of action. Your instructor, like all gliding men, will be patient, persevering, and cautious. Trust him. If he thinks that you are not quite fit to pass on to the next stage, accept his decision cheerfully, and make sure in your own mind that you really do feel confident before going further. The sounder your basic training, the easier to assimilate each successive stage will become.

It is possible that part of your instruction will be in dual-seater aircraft. I have purposely omitted mention of this type of training; it is practical, and in the nature of a check and a polishing up of your flying. All the theory involved will be found here, however.

# *Contents*

# SLIDES

## *Lift*

ALL aircraft have wings, whose function is to provide "lift". This lift is a force which overcomes the weight of the aircraft, enabling it to fly. Consider diagram 1, in which air is flowing over a wing.

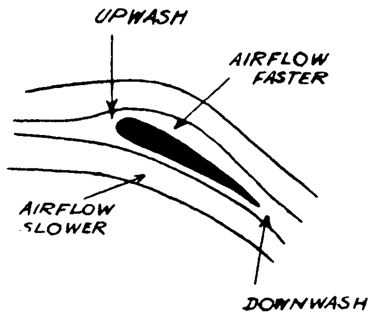



FIG. 1.

When the airflow passes over the wing, it causes an area of reduced (negative) pressure to be formed over the top surface of the wing, and an area of increased (positive) pressure beneath the bottom surface. About two-thirds of the total lift is derived from the top surface, and one-third from the bottom.

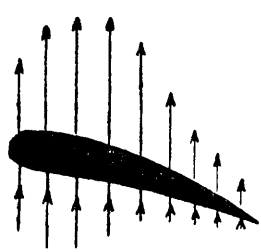


FIG. 2.—Distribution of Pressure over Aerofoil.

*Angle of Attack*

The amount of lift produced depends both on the speed of the airflow and what is known as the "angle of attack" of the wing.

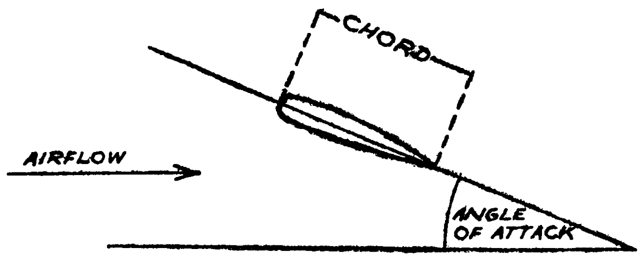



FIG. 3.

This is the angle between the airflow and the "chord" of the aerofoil. The chord is a line drawn from the leading (front) edge to the rear (trailing) edge of the wing.

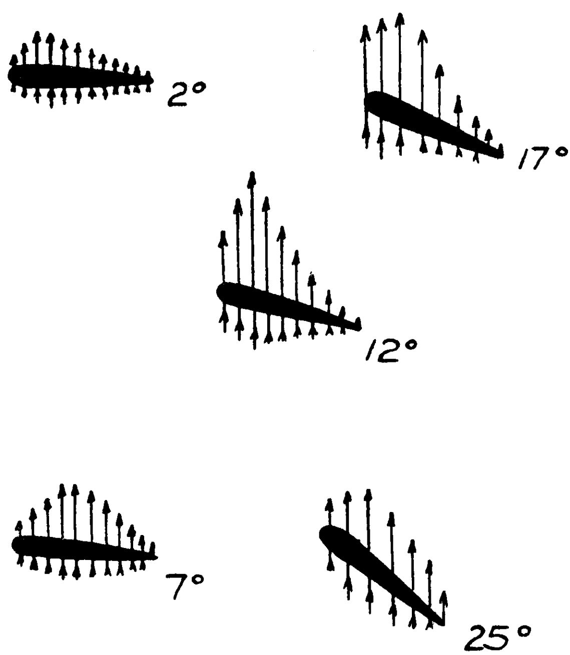



FIG. 4.

An impression of the variation in the amount of lift produced at differing angles of attack for a specimen aerofoil is shown in diagram 4, and again in graph form in diagram 5.

More will be said on this subject later, but you can see from fig. 5 that little lift is produced at small angles of attack. Use of this fact is made during your first exercises, to ensure that you do not become airborne.

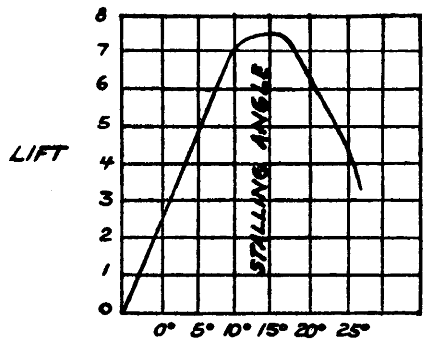



FIG. 5.—Angle of Attack.

*Aileron Effect*

On the outside of the trailing edge of each wing is a hinged flap, or control surface, known as an aileron. Its function is to vary the effective angle of attack of the wing. You can see from diagram 6 that a dropped aileron increases the angle of attack, and con-

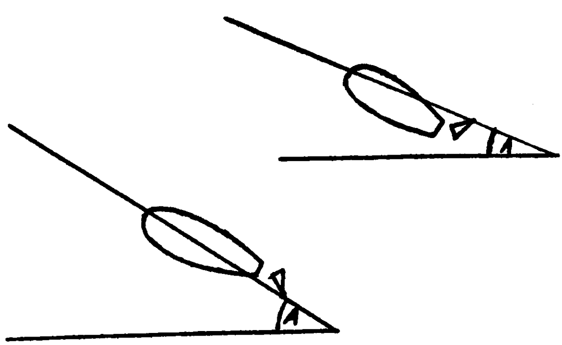



FIG. 6.

sequently the amount of lift. Conversely, a lifted aileron reduces lift by decreasing angle of attack. Ailerons are interconnected, so that when one is raised the other is lowered; the wings, therefore, are made to produce different amounts of lift.

*Action of Aileron*

This difference in pressure can be utilised to roll an aircraft about its longitudinal axis. Imagine a line cleaving straight through from nose to tail, about which the aircraft is free to pivot. In fig. 7 you have a head-on view of a glider; in (*a*), with ailerons neutral, it will fly straight and level. In (*b*) the starboard aileron is dropped and the port one raised; this action gives more lift to the starboard wing and less to the port one, and it begins to roll

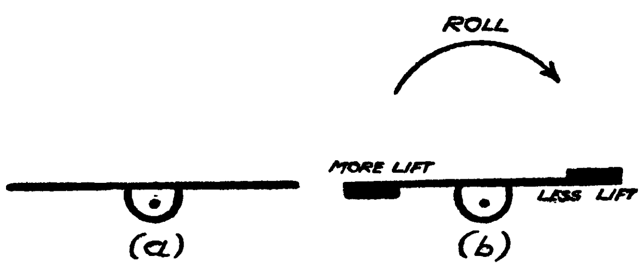



FIG. 7.

about its axis. The motion will tend to continue until the ailerons are neutralised again.

Now if an aircraft has one wing down, the pilot can, by increasing the angle of attack of that wing, roll the aircraft until it is level.

That action is what you are going to do during your first slides, and the way you go about it is this: the stick, or control column, which protrudes between your knees when you sit in the pilot's seat, is connected with the ailerons. If you move the stick to the left, it raises the left aileron and lowers the right one, and vice versa.

*Use of Aileron*

So, if you wish to roll the aircraft to the left, you move the stick to the left. Roll to the right by moving the stick to the right. Stop rolling in either direction by centring the stick.

*Airmanship*

Armed with this knowledge, you may now attempt your first exercises, which are known as Ground Slides. Before you start, learn a little about what is known as "airmanship". It means, basically, looking after yourself. It also means looking after your aircraft, and considering other people, whether in the air or on the ground.

*Safety Belts*

When you first sit in a glider, the instructor will strap you in. Notice how it is done. The straps should be fixed firmly enough to make you feel at one with your craft, but not too tightly for comfort. Whenever you get into a glider from now on, adjust your safety belt in this fashion. Never be careless. Once launched, you will find there is very little—if anything—that you can do about your straps.

*Control Check*

Then check your controls. Move the stick from side to side, making sure that the ailerons move freely and in the correct sense, i.e. that moving the stick to the left raises the left aileron. As a point of airmanship, you should also check the elevator and rudder, even though you will not be using them on ground slides. The rudder should move to the right when the right pedal is pushed forward, and vice versa. Moving the stick towards the nose of the glider should cause the elevator to drop, and pulling it back should have the opposite effect. Get into a habit of making this control check each time you sit in a glider—it is an essential drill.

*Ground Slides*

Your instructor will tell you that the purpose of ground slides is to instil into you the habit of keeping your wings level. He will no doubt rock the primary from side to side, making you go through the required correcting motions with the stick. When he is satisfied, he will insert the cable into the quick-release, and you are ready to go. Never allow anyone to fix the cable in until you are perfectly happy and ready to be launched. *It is the last thing to be done before you start to move.*

*Cable Release*

Incidentally, check this cable-releasing mechanism. Get someone to put a strain on the cable, and then give a tug at the releasing wire. You will find that the cable drops clear. Releasing gear is uncannily reliable, and on most primary gliders is fitted with an automatic releasing device. In any case, however, where this device is not fitted, you should get into the habit of pulling the release *three times* when you want to drop the cable.

At last you are ready to move. As the cable tautens and you hear the winch revving up in the distance, you will feel a thrill and a tensing of the muscles, particularly those of the right hand, which grasps the stick.

Relax!

You are not going to leave the ground. The stick has been set well forward, which will give your wings a very small angle of attack and negligible lift. Your speed will be in the nature of 10–12 m.p.h.

The glider starts to move, and soon is travelling faster than the chap who holds the wing can run. He lets go, and you are on your own. All you have to do is to keep your wings level, and there is a way to do it.

Keep your eyes fixed straight ahead—the winch is a good thing to look at.

Grasp the stick *lightly*; move it *smoothly*; make your movements *definite*.

That is to say—don't *clutch*; don't *jerk*; don't *jitter*.

Only by observing these rules can you ever hope to acquire the "feel" which is essential if you are ever to fly a glider properly.

Actively concentrate on what you are doing.

If a wing drops, move the stick away from it. Not too much—just enough to bring it level. Then centre the stick. Don't overdo the movements, or you will force the other wing down and set up a see-saw motion through over-correction.

If by chance a wing drops until it touches the ground, don't let it scrape along—release the cable at once.

At the end of a run you will no doubt feel mighty pleased with yourself, and wonder why the instructor frowns, and says:

DO—look straight ahead.
—make all movements smoothly.
—try to anticipate the dropping of a wing and correct with the minimum of movement.
—keep your feet still on the rudder-pedals.

DON'T—look at your hands or feet.
—jerk at the stick.
—over-correct.

* * * * * *

*Question Time*

*Q.* Why must I look straight ahead?

*A.* Because the only way you can tell if your wings are level is by reference to the horizon. Your eyes are level with the wings, and any inclination of the aircraft will appear to you as though the horizon has become tilted. Later on, in free flight, you will only be able to maintain a straight course by referring to a point on the horizon, so get into the habit now.

*Q.* What happens if I move my feet?

*A.* You actuate the rudder and force the glider from its straight path. Forget about rudder action for the moment—just keep your feet centralised and still on the pedals.

*Q.* When do I begin airborne slides?

*A.* As soon as you satisfy me that you can keep your wings quite level, by means of accurate corrections.

*Q.* Why is it so important to keep my wings level?

*A.* We come on to that a little later. Just remember for now that it is the first essential for good flying.

* * * * * *

After a few ground slides you begin to feel at home, and are judged fit to pass on to the next stage. Wing correction should have almost become second nature. It's really quite a simple matter, isn't it?

Before you proceed to airborne slides, it is necessary for you to know something about the action of the elevator, which, as you know, is controlled by a fore-and-aft movement of the stick.

*Action of Elevator*

The elevator unit, which is made up of a fixed portion—the horizontal stabiliser—and a movable portion—the elevator itself—comprises an aerofoil section similar to a wing, although of slightly different shape. When the elevator is brought into action, it produces some lift, which is used to rotate the aircraft about its lateral axis, i.e. in the looping plane. Imagine a line through the centre of gravity of the aircraft, parallel with the wings—that would be the lateral axis.

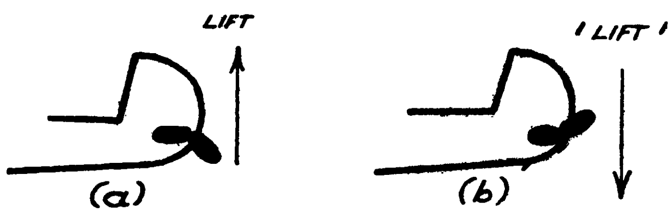



FIG. 8.

Consider fig. 8. In (*a*) the elevator has been lowered by putting the stick forward, giving the unit lift acting upwards. As the elevator unit, or tailplane, is situated at an appreciable distance from the axis of rotation, it exerts a considerable force on the aircraft, which lifts the tail, or, if you prefer it, lowers the nose.

Conversely, in 8 (*b*) the effect of downward "lift" is used to lower the tail, or lift the nose.

As a point of interest, as you will see later, all axes of an aircraft pass through its Centre of Gravity. Fig. 9 shows how putting the stick forward moves the aircraft about its axis.

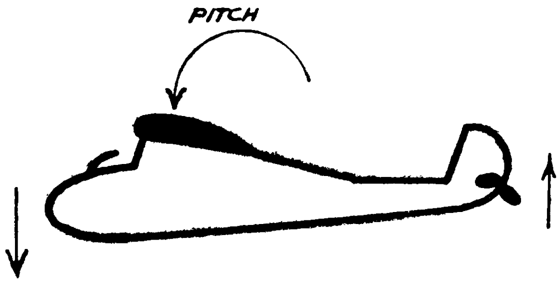



FIG. 9.

You can see that raising the nose of an aircraft will give the wings a greater angle of attack, with more lift produced, and that lowering the nose reduces both angle of attack and lift.

So, if you pull back on the stick, the end effect is to give more lift to the aircraft, which will make it rise more quickly, and pushing the stick forward will cause it to rise more slowly, than when the elevator is in the neutral position.

For the purpose of airborne slides you will have your elevator pre-set by the instructor, slightly forward of the neutral position.

*Airborne Slides*

Hop into the seat. Check your controls, adjust your straps; listen to the briefing. The cable is attached and tightens up.

Now you are for it! The fluttering of little butterflies in the tummy rises to a crescendo.

Relax! And think to yourself:

"By arrangement with the winch-driver, the instructor has pre-set my elevator to give a certain amount of lift to the glider. At that setting the driver will be able to lift me gently off the ground, tow me along a few feet above it, and set me down as lightly as a feather.

"If I fiddle about, moving the stick backwards and forwards, I will upset (*a*) the balance of the aircraft, (*b*) the winch-driver, (*c*) the instructor, and (*d*) myself, incidentally defeating the whole object of the exercise."

Leave the stick where it is except for lateral movements if you have occasion to pick up a dropped wing. There is a point to be watched here. Due to the shape of the human arm, there is always a tendency to take the stick slightly back when moving it to the left, and forward when moving it to the right. Watch for this from the beginning or you may fall into bad habits.

You are sliding along the ground. Suddenly the noise of the skid scraping vanishes, and your motion becomes smoother.

You are airborne!

Concentrate all the time. Forget about your queasy tummy and concentrate actively on what you are doing—keeping your wings level with a minimum of movement and a maximum of anticipation.

Good!

The winch slows imperceptibly and the ground suddenly seems very near, passing under you at enormous speed.

If you like, you can ease the stick back now. It will flatten out the glide and make landing smoother. But please remember that easing the stick back means *easing* it back. If you pull it back too far, the nose of the primary will rise and the wings present a very large angle of attack to the airflow. This may result in a stall, which will cause you to sit abruptly on your tail, which is both undignified and uncomfortable.

What you are aiming at in landing is flying the glider on to the ground, with a gradual easing back of the stick to make your glide flatter just before you touch down.

* * * * * *

*Question Time*

*Q.* What is this "stall" business?

*A.* Quite a thing. You remember that an increase in angle of attack means an increase in lift? This is only true up to a certain angle, known as the stalling angle. When the wing reaches this angle, the airflow starts to break up and become turbulent, instead of flowing smoothly over the aerofoil. I will draw it for you. The result of this is a reduction of lift, and the wings are no longer able to support the weight of the aircraft.

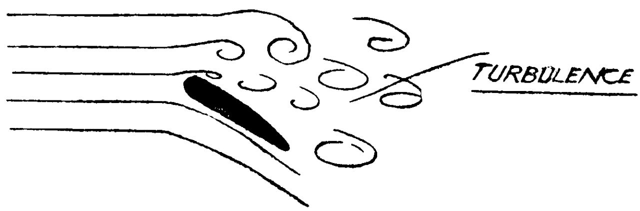



FIG. 10.—Breaking-up of Airflow at Stall.

*Q.* What happens then?

*A.* It stops flying and drops bodily. Owing to the stability of gliders—which I will tell you about later—it drops nose first, which reduces the angle of attack, and the wings again

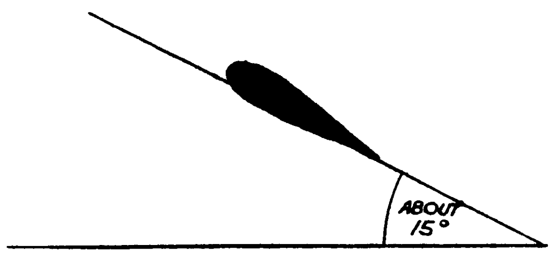



FIG. 11.—Stalling Angle.

begin to produce lift. However, it needs space to do this, and if you stall close to the ground you will dig your nose into it.

*Q.* I have heard people talking about "stalling speed". You say that stalling depends on the angle of attack. Is there any relationship between the two?

*A.* Definitely. In straight and level flight you must maintain a certain amount of lift to overcome the weight of the aircraft, which is constant. If you reduce your airspeed you reduce the amount of lift, because the airflow is travelling more slowly over the aerofoil. Therefore you must increase the angle of attack to maintain the required lift. If the air-speed falls low enough, you will ultimately reach the stalling angle. The speed at which any aircraft reaches this critical angle is commonly called its stalling speed.

*Q.* I suppose that is why you told me not to alter the position of my stick on the first slide?

*A.* Exactly. If you pull your stick back too far or too suddenly after take-off, you reach the stalling angle, and, as I have explained, this is dangerous if you are near the ground.

* * * * * *

Armed with this knowledge, you should now be able to approach your further airborne slides with confidence. Several trips will accustom you to leaving the ground, and to landing, whilst keeping your wings level the whole time. You are rapidly approaching the moment when you will embark on free flight, in the shape of hops or short straight flights.

# HOPS

It may seem a pity that you should have dry lessons at this stage instead of pressing on with your flying, but you should understand this:

Once you start free flight you are going to be very much alone up in the air. When you have released the cable, no one can do anything for you—it is entirely up to you. If you *know* what you are doing, and, more importantly, *why* you are doing it, you will be reasonably confident, which is a great help. You will also be laying the foundation of good pilotage, which is essential.

Hops do seem silly little things, I know, but please don't regard them as a waste of time. They teach you a lot—you learn to think quickly, act correctly, and acquire "feel". Take them very seriously.

You will make mistakes—everyone does, to start with. Profit by them. Find out why they were mistakes, and how to avoid them in future.

Gliders glide. They have no engine, and use their own weight to keep flying, which they do by descending at an angle towards the earth; this is known as the "gliding angle". In still air a glider cannot climb, only sink.

Now you know that wings in motion produce lift. They also, by reason of their motion through the air, create what is known as "drag", and you must learn something of the relationship between lift and drag.

### *Drag*

Drag—which is the resistance offered to the air by an aircraft in flight—is divided into wing drag and parasite drag. The latter term embraces all drag produced by non-lifting surfaces. Drag is affected by the speed of the aircraft, its shape, smoothness, and size.

*Wing Drag*

Wing drag is caused partly by the shape and smoothness of the wing (profile drag) and partly by certain induced drag caused by the movement of the airflow in passing over the aerofoil. Don't

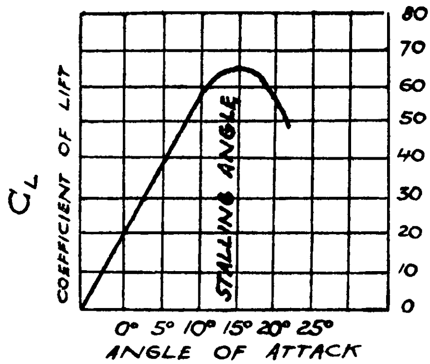



FIG. 12.—Development of Lift.

worry too much about the details—suffice it to say that wing drag does exist.

It is convenient to show the relationship between the lift and drag of a wing in the form of a "Lift/Drag Ratio".

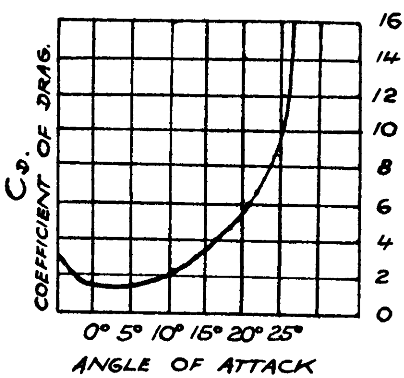



FIG. 13.—Development of Drag.

You have seen, in diagram 4, how lift varies with angle of attack. Drag also increases in similar manner, but not in the same proportion, as you will see from a comparison of figs. 12 and 13.

*Lift/Drag Ratio*

Fig. 14 shows Lift/Drag Ratio plotted against various angles of attack, and you see that the curve reaches a maximum value at about 4° (it will vary slightly, of course, for different wings). At

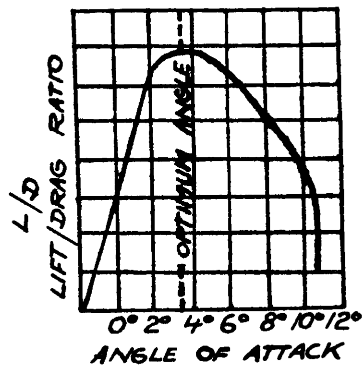



FIG. 14.—Development of Lift/Drag.

this point the wing is giving most lift for least drag, and is at its most efficient angle of attack. Note that this does not mean most lift or least drag—just the best ratio.

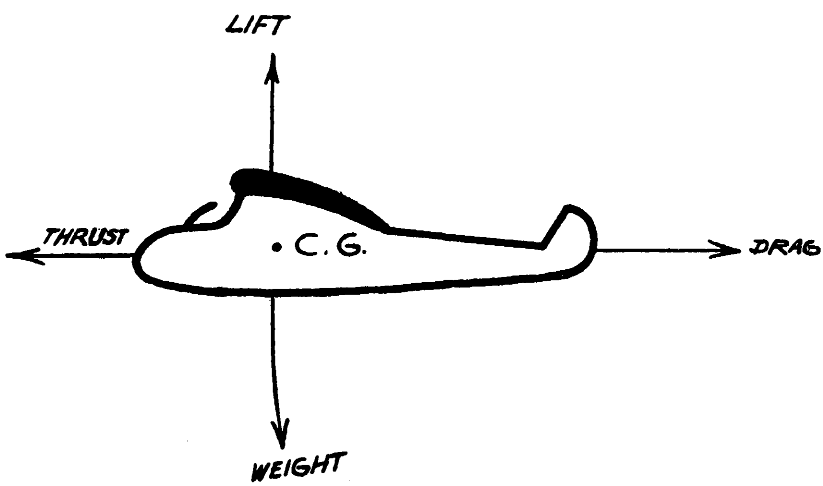



FIG. 15.

I have said that "gliders glide". If a glider could be propelled through the air by means of an engine (which provides "thrust"), it would be able to fly straight and level, in a state of equilibrium in which thrust negated drag and lift negated weight. (See fig. 15.)

However, no thrust is available, and therefore a glider cannot maintain height—it is slowed down by drag, and height is lost. We have to make the best of a bad job by retaining equilibrium between weight, lift, and drag; this is done by using part of the lift to overcome weight, and part to counteract drag. The way in which this is achieved is by allowing the glider to fly along a path inclined to the horizontal; the angle between them is the gliding angle.

*Gliding Angle*

The gliding angle is the angle between the *path* of the glider and the horizontal. Do not confuse it with—

*Attitude*

—the attitude, which is the angle between the *glider's longitudinal axis* and the horizontal.

At normal gliding speeds the gliding angle will be greater than the attitude angle. Putting it simply, the glider will land short of where its nose is pointing.

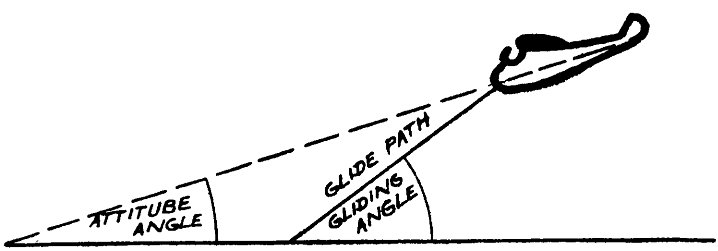



FIG. 16.

If you look at fig. 17, you will see the forces involved when a glider is in flight. The angle between the lift and the vertical must equal the gliding angle "G".

If drag is increased, the resultant lift required to overcome it will be greater, which will result in a steeper gliding angle.

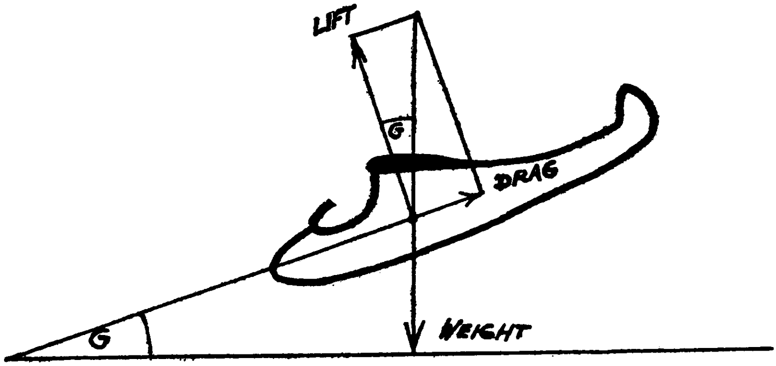



FIG. 17.

*Best Gliding Angle*

Thus you can see a very important point:

A glider will glide farthest at the speed at which the corresponding angle of attack results in *the most lift for the least drag.*

*Effect of Attitude on Glide*

Irrespective of whether you raise or lower your nose, you will not improve on the best gliding angle. Both actions will have the effect of steepening your glide path, because you will decrease your lift/drag ratio. (See fig. 14.)

However, raising the nose will also decrease your speed, resulting in a larger angle of attack being called for. Carried to extremes, this will cause you to stall. Get this into your head *now.* Flying too slowly may result in a stall, and is bad practice, especially for a beginner. It is better to fly too fast than too slow, but the ideal thing is to find the best gliding angle, and try to maintain it.

*Low Hops*

The low hop is designed to accustom you to:

(*a*) Taking off with elevator neutral.
(*b*) Releasing the cable.
(*c*) Gliding at the correct angle.
(*d*) Landing smoothly at the end of your flight.

The briefing for the first one will be on these lines:

"This time you are going to release the cable and land all on your own. The launch will be very much the same as for an airborne slide, but you will climb more steeply, and somewhat higher. Your elevator is now neutral—notice the position of the stick. Once again, keep it there during the climb.

"When you feel the winch stop pulling, put your stick forward to get the nose down, pull the release three times, adopt a nice gliding attitude, and fly straight ahead. Land exactly as before, easing back on the stick. Any questions?"

*Question Time*

*Q.* Why will I climb more steeply than on an airborne slide?

*A.* Think, man! Think!

*Q.* Because I shall have a greater angle of attack?

*A.* Of course. The tailplane, with elevator neutral, allows you to get more lift for the same cable speed than when the elevator was set forward; you will rise higher for the same amount of ground covered.

*Q.* How will I know when the winch has stopped pulling?

*A.* This is a silly question, but everyone asks it. Your speed will drop and you will hear a change in the wind note.

*Q.* Why do I have to put the nose down before releasing?

*A.* On tow you are in fact being supplied with thrust, and your attitude is more nose-up than is correct for gliding. When you release, you have to compensate for the loss of thrust, and you do so by adopting a good gliding angle.

*Q.* How will I know if I am in a good gliding attitude?

*A.* This is rather difficult to answer. To start with, when you have released, bring the stick back to the neutral position. This should allow you to assume roughly the correct attitude. If you feel that the controls are a bit sluggish, it means that you are nose-up and too slow—get the stick forward a bit. When you land, I will tell you how your attitude appeared to me, and you can adjust next time. After a few hops, your ears, and also your eyes, will gradually begin to let you know when you are gliding correctly. Don't worry too much for the moment—just remember that it is better to fly too fast than too slow.

*Q*. How far do I move my stick forward before releasing?

*A*. There is no answer to this—you must find out by experience. The stick is a delicate control—treat it fairly gently, and you will acquire feel in the course of time.

*Q*. What do I do with my feet?

*A*. Keep them central and keep them *still*.

* * * * * *

The man before you on the list is John Snoggins, the despair of the instructor, also about to make his first low hop. You watch with interest.

There he goes, rising into the air, forty or fifty feet. Watch his reactions.

For a moment he is undecided. The winch pull is missing, and Snoggins flaps. Hastily he crams the stick forward, pulls the release, yanks the stick back, realises that he is flying too slowly, rams the stick forward again. Then, seeing the earth rushing up at him, he once again yanks the stick back and stalls in on his tail from a height of two feet, rattling his teeth.

You listen to the instructor patiently chiding him, and decide that you are going to do better than that.

Off you go. The pull vanishes—there is no mistaking the feeling, but you have been waiting for it, and are not undecided. You put your stick forward, release, and find you are gliding gently and quietly towards the winch.

The winch! Someone must have moved it! Where is it? There—miles away on your left. The ground approaches and you land well, on the far edge of the field, pointing well away from your intended path.

*Q*. How did that happen?

*A*. Because you took off and climbed with your right wing down. When you released, this made you turn off to the right. Secondly, to aggravate things, you held on right rudder the whole time. Try next time to keep a straight path by keeping your wings level the whole time—and keep the rudder centralised.

*Q.* Why will a dropped wing make me turn? I can understand about the rudder, but surely . . .?

*A.* Finish your low hops, and then we will go into the whys and wherefores. Just concentrate for the moment on keeping a straight course, and above all on finding a good gliding attitude.

# MORE HOPS

Now that you are progressing slowly to medium and then to high hops, which means that you will be climbing higher and gliding farther, you must learn to exercise positive directional control of your aircraft. It must be made to obey your will, and you should know what controls are and what effect they have.

You have already learned something about the action of the ailerons and the elevator, but for the sake of clarity some of these points will be repeated in this chapter; it will help you to envisage the picture as a whole.

## *The Three Axes*

An aircraft can be made to rotate about three axes which are at right angles to one another:

*The Longitudinal Axis*—a straight line fore and aft through the centre of gravity (C.G.), which is horizontal when the aircraft is level. Movement about this axis is achieved by the ailerons and is known as "rolling".

*The Normal Axis*—a straight line through the C.G., which is vertical when the aircraft is level. Movement about this axis is called "yawing", and is made with rudder movements.

*The Lateral Axis*—a straight line through C.G. at right angles to the other two axes; movement about it is "pitching", and made by elevator movements.

## *Relation of Axes to Pilot*

There is an important point to be noted here. These axes are relative to the aircraft and not to the ground. They will change their position in space as the attitude of the aircraft is altered. Therefore when we refer to pitching, rolling, or yawing, it will always be with relation to the aircraft, and not to the ground.

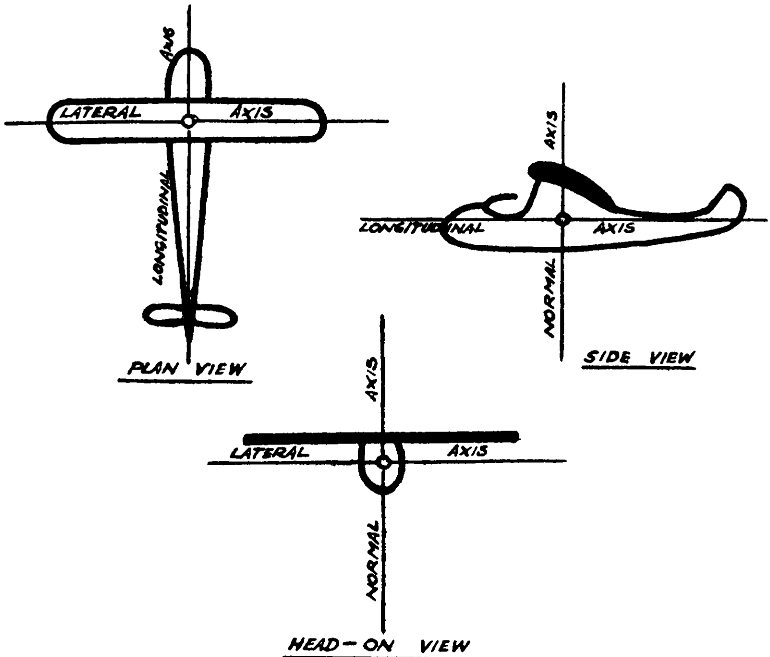



FIG. 18.—The Three Axes.

In the first chapter you learned how to use elevator and aïleron, and realise that they cause pitching and rolling, and how they affect the attitude of your glider.

*Action of Rudder*

The rudder is the vertically hinged flap behind the tailfin; together they form an aerofoil. The rudder is connected with the rudder-pedals so that if the left pedal is pushed forward the rudder moves to the left. In doing so it causes the aerofoil to adopt an angle of attack, which creates a certain "lifting" force, tending to move the tail to the right.

As far as you are concerned, this yaws the nose to the left. It is comparable to the dropping of the tail by means of elevator, which from your point of view makes the nose rise.

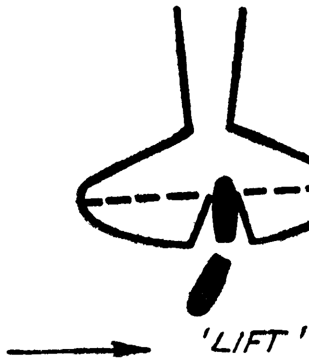



FIG. 19.

*Action of Plain Rudder*

Accept it for the moment as a fact that if you apply rudder without moving your ailerons, the glider will perform a skidding turn outwards. (More will be said later about this.) If you put on left rudder, for example, you will skid out to starboard, causing the outside, or starboard, wing to travel faster than the inside one; extra speed means extra lift, and you will tend to roll to the

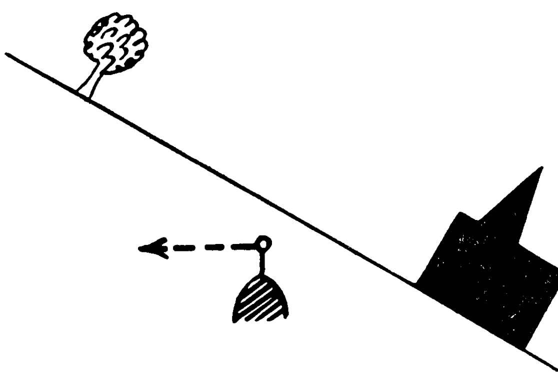


FIG. 20.—Direction of Yaw with Left Rudder.

left. A further factor which gives more lift to the starboard wing is the airflow created by the motion of skidding. However, this small amount of bank is in no way sufficient to compensate for the lack of correctly applied bank.

When you are banked to the left, you can see from fig. 20 that if you continue to hold rudder in, the nose of your glider will start to drop below the horizon.

*Effect of Aileron*

If you apply aileron when you are flying straight, the aircraft will bank and then sideslip in the direction of the lower wing. As a result of this slip, air will strike all side surfaces of the glider. Now the larger side surfaces lie to the rear of the fuselage, in the shape of tailfin, etc., and they will present more resistance to the airflow. As a result of this, the nose of the glider will tend to yaw in the direction of the slip.

Thus you can see that a yaw will tend to produce a roll, and a roll will tend to produce a yaw. This helps to explain why you turn away from a straight course if you do not keep your wings level and rudder central.

*Aileron Drag*

One of the very early lessons you were taught was to make your movements smoothly. This applies particularly to the use of ailerons. If they are used suddenly, or violently, they may cause the glider to yaw in the opposite direction from which bank is applied. The reason for this is really quite simple.

The aileron which drops causes more drag than the one which rises, as it drops into an area of positive pressure, while the raised one goes into an area of negative pressure. Additionally, greater angle of attack means more drag.

This yawing tendency can be countered by use of rudder, and you will go thoroughly into the subject when you start initiating turns. That happy state of affairs is not far off, but for now you merely want to be able to make the appropriate correction if you deviate from the straight and narrow on your hops.

The correct method of turning to the left is to apply left stick and rudder *together*. To turn to the right, right stick and rudder *together*.

*Mild Turns*

The combined action will cause you to roll and yaw in the same direction. When you have started to turn, take off both stick and rudder, and you will continue to turn with neither held in. To recover from a turn, apply opposite stick and rudder until you are level, and then centralise everything.

During hops, apply gentle stick and rudder—just enough to bring you back on to your course if you stray.

*Gaining Height*

Medium and high hops are essentially the same as low ones, except that you rise higher, glide farther, and will have more time to think of what you are doing, and to acquire the feel of the primary. One of the points these hops teach you is how to gain more height on launch for a given distance of ground covered.

You assist the glider to gain height by bringing the stick back behind the neutral position. This drops your tail (or makes your nose rise—as you like), causes the wings to assume a greater angle of attack, and consequently provides more lift. As a result, the glider climbs more rapidly.

Compare the launch-path of these two gliders:

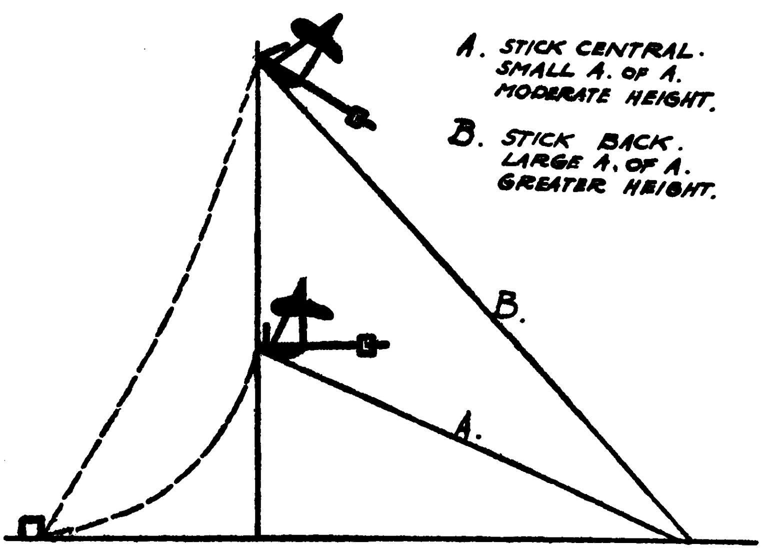



FIG. 21.

There is a note of caution to be sounded here.

If you take the stick back too abruptly just as you leave the ground, you will take up a very steep climbing angle, and there are two possible results. One is that you will drop the tail so suddenly that it strikes the ground, which is undesirable. The other point is that such an action can break the cable, which is constructed with a limited breaking-strain, for safety purposes. When a glider is launched, a load is applied to the cable. If applied gradually, it will be absorbed in like manner, but if suddenly applied, puts a quick strain on the cable, which may break. It should not, but it could, particularly if the wire has been frayed or stretched.

If it does, your thrust disappears, and you will have to get your nose down quickly to avert a stall. Unfortunately, just after leaving the ground there is no height to play with, and the glider will dig its nose violently into the ground.

### *Safe Height*

That is why you will be told, "Take off with stick *neutral.* When you have gained a safe height—say 30–40 ft.—bring the stick back smoothly and gradually until you are climbing fairly steeply. Then keep it there."

Another thing that you will learn from advanced hops is how to get your nose down smoothly on release. As hops get higher, and you make more use of your elevator to gain height, you will find that as the cable stops pulling you are in a nose-up attitude, and quickly lose speed. This loss of speed, added to the largish angle of attack of your wings, brings you in the neighbourhood of stalling-point; you must therefore learn to get your nose down rapidly and smoothly as soon as the pull stops. Then release the cable and assume a good gliding attitude.

It may seem to you that your instructor has kept you on hops far too long; you are anxious to press on. He also is eager to see you progress, but the foundation-stone of all gliding is the ability to master the basic elements of flying; until you are able to carry out a nigh-perfect hop you will not be allowed to go on to the next stage.

### *"A" Test*

However, the bright day will dawn when it is decided that you are fit to attempt to fly your "A" test. The requirements are that you shall make a straight glide of 30 seconds or more, ending with a normal landing.

Given a large enough field, the task is simple, but sometimes there is just enough room to make it. If this be the case, remember that:

1. You should get as much height as possible without ignoring the safety factor.
2. Don't fly too fast—this will steepen your glide and cut down your flying time.
3. On the other hand, "stretching your glide" by flying too slowly, although it will give you more time in the air, is to be avoided. Flying near the stall is very bad practice for a beginner.

Try to stay aloft by genuine means, flying at the best gliding angle. Don't worry if you do not make it the first time, nor the fifth time, for that matter. You are not interested in collecting certificates, which are only pieces of paper, all said and done. You *are* concerned, vitally, with learning how to fly correctly.

# TURNING—S-TURNS

No one can fly correctly until he has learned to turn correctly at will. The only way in which you will learn to turn is by turning, turning, and continuing to turn. Ensure that an adequate supply of criticism is available, especially in the early stages, when habits will be formed, good or bad.

The theory behind turning is simple, but rather lengthy—have patience with this chapter.

*Newton's Laws*

First of all, get familiar with Newton's Laws of Motion. They tell us that:

1. All bodies tend to remain at rest, or in a uniform state of motion in a straight line.
2. A force is required to change this state; it is proportional to the mass of the body, and to its *rate* of change of motion. That really means that more force will be needed to effect a rapid change of speed or direction than a slower one.
3. To every action there is an equal and opposite reaction.

*Centripetal Force*

Turning involves a change of direction. When a body travels along a curved path, it wants to fly off at a tangent, i.e. to follow a straight line in accordance with Newton's Law. To keep it turning, it becomes necessary to apply a force, or "acceleration", towards the centre of the curve. This is known as centripetal force, and the equal and opposite reaction is centrifugal force.

Perhaps I can explain this by means of a diagram.

In fig. 22 (*a*), imagine a body travelling in a straight line from A to B. At B it receives a push of force $f_1$, applied at right angles to AB. This starts it moving along another straight course, BC;

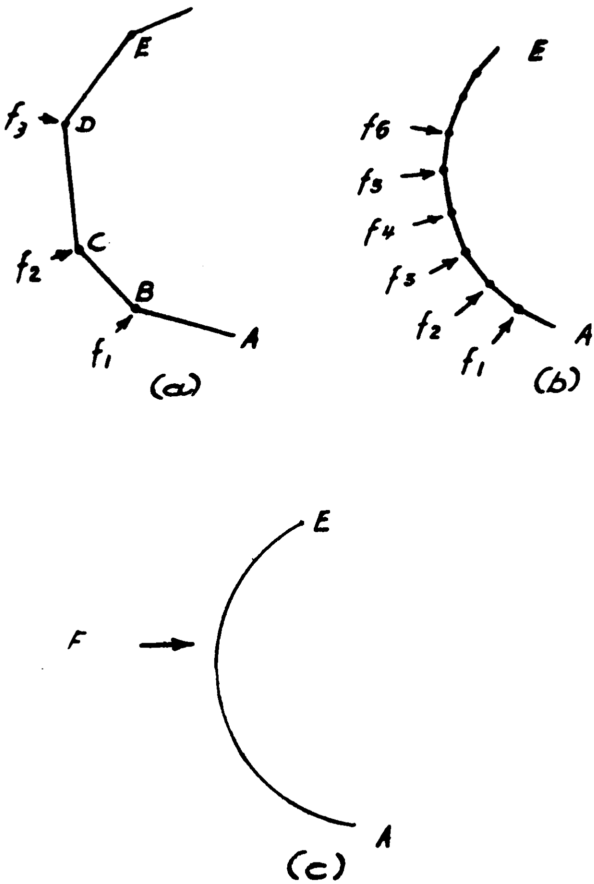



FIG. 22.

at C it is pushed by force $f_2$, and so on, until it eventually arrives at E.

If the path from A to E consists of a greater number of shorter straight lines, as in 22 (*b*), the forces $f_1$, $f_2$, etc., will have to be applied at shorter intervals during the journey. If the lines are very short, the path will become a curve, and a continuous force F will have to be applied to keep the body turning (22 (*c*)). This is centripetal force, and acts at a right angle to the tangent, i.e. towards the centre of the turning circle.

*Rate of Turn*

The amount of centripetal force needed depends on the *rate of turn*, which means the angular velocity of your aircraft. If it takes one minute to turn your glider through 180°—i.e. 3° per second—the turn is known as a "Rate One" turn. The greater the rate of turn, the more force needed to hold the aircraft accurately in place. (Newton's Second Law.)

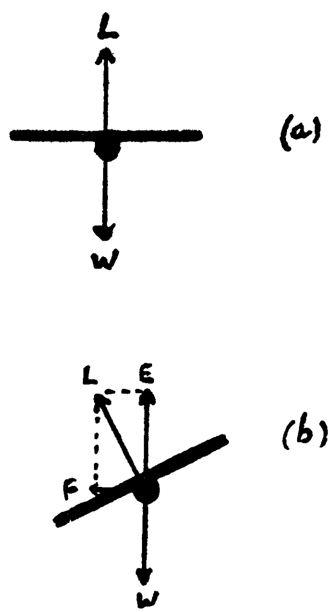



FIG. 23.

Now, where are we going to find the necessary centripetal force to hold us into a turn?

There is only one source—lift. Wing lift. Look at fig. 23 (*a*); the weight W of the glider is being counteracted by the lift L. (Ignore the component of lift needed to overcome drag.) If the glider is now banked, as in 23 (*b*), part of the lift is being used as centripetal force (F), which is going to hold the aircraft into a turn.

It should be plain from a comparison of 24 (*a*) and 24 (*b*) that the more bank applied, the more lift that is going to be needed, because, although the weight of the glider remains the same, F is increasing. In doing so, it will of course increase the rate of turn.

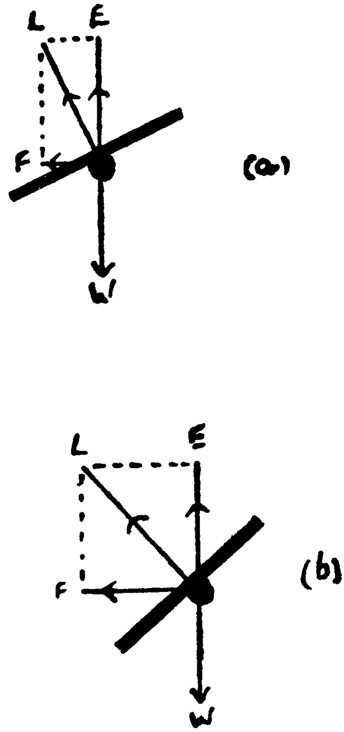



FIG. 24.

There is more to be said on this subject later, but for now understand that it is the application of the right amount of bank that enables you to perform an accurate turn.

You will by now have been promoted to the "boat", or nacelled primary, which gives you something in front of your eyes to relate to the horizon. Projecting from the nose is a handy thing called the Pitot head, and when you are flying in your correct attitude, you will see something like this ahead of you:

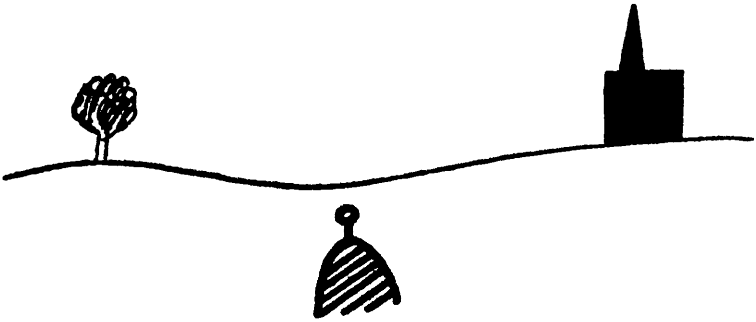


FIG. 25.

The actual position of the Pitot head is naturally different for each pilot, but when you have established your own gliding angle, you can relate the position of your marker to the horizon. An incorrect flying attitude will cause you to see:

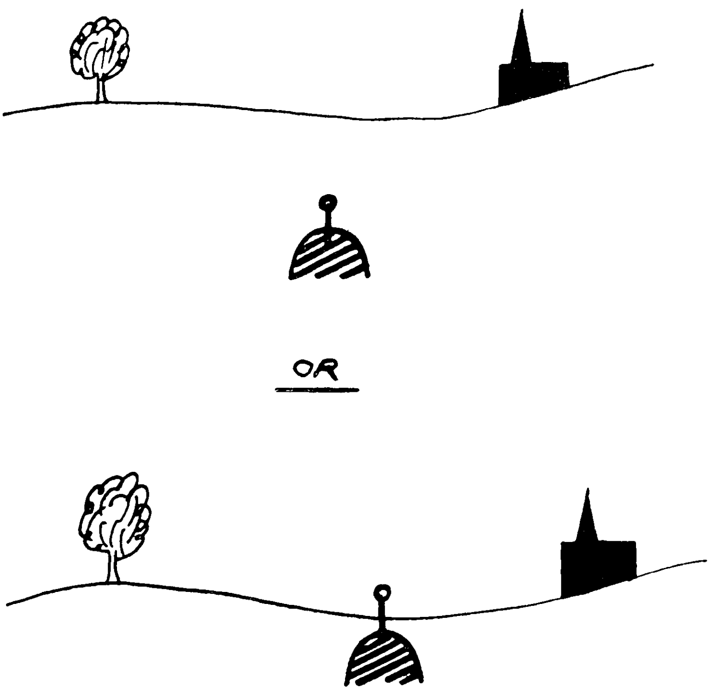



FIG. 26.

and you must concentrate on keeping the Pitot head at the right level at all times. It should be fairly easy for an "A" pilot!

One thing to remember when you start turns is that the controls always have the same function, no matter at what angle you are banked.

1. Ailerons control bank, and thus rate of turn.
2. Elevator causes you to pitch.
3. Rudder causes yawing, or corrects it if it appears in the form of a skid or slip.

The usual faults that you will find yourself making to start with are:

1. Skidding or slipping—correct with rudder.
2. Nose up or down—correct with elevator.
3. Coming out of a turn with nose up—this again is corrected with elevator.

Let us now launch you, and tell you to start with a gentle turn to the right. Pick a point ahead of you on the horizon (a windmill, say) and another on your starboard beam (a church).

*First Turns*

Apply some right rudder. You will see the Pitot head start to shift to the right of the windmill as the nose starts to yaw. At the same time put on right bank by moving your stick to the right. When you are turning, gradually take off both stick and rudder until they are neutral. You should then be in a turn of small rate, and the Pitot head will proceed around the tilted horizon. What you see is this:

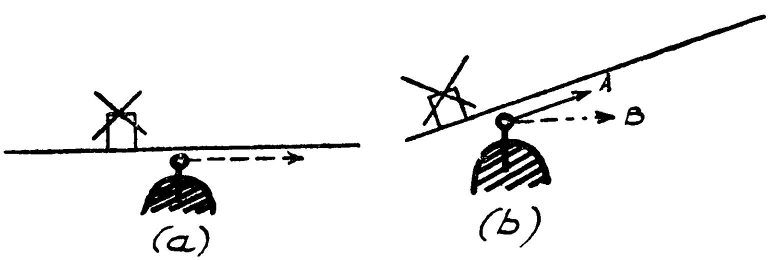



FIG. 27.

(*a*) Apply rudder and aileron. (*b*) Start taking them off.

It may prove a little disconcerting at first to be at an angle, and you should watch two things:

1. Don't lean away from the turn—nothing will spoil your flying as much as this. Only by keeping your body upright and your eyes level with the wings will you learn to turn evenly.
2. Keep your attitude by gentle use of the elevator. The Pitot head should follow arrow A in the sketch, not B.

Soon the church will come into view, and as it nears your nose you will want to recover from the turn and fly towards it. How?

Apply left stick and rudder. The glider will level out and stop turning. Remember that the effect of rudder will be to position your nose higher on the horizon, and you should use elevator to

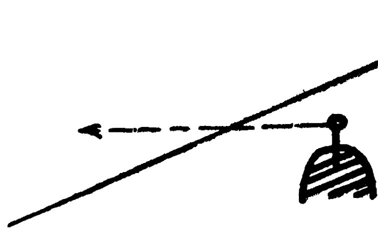


FIG. 28.—Yawing effect of Rudder on Recovery from Turn.

correct the tendency, because of course nose up will cause you to lose speed.

Naturally, when you have recovered from the turn you must centre your controls, or you will start to turn to the left.

*S-Turns*

The usual thing is for a pupil pilot to start his "B" lessons with a few S-turns. I think that if you now understand how to initiate and recover from turns, a series of drawings will be easier to grasp than a mass of words. Here is your field with three points on the horizon, and the path you want to follow.

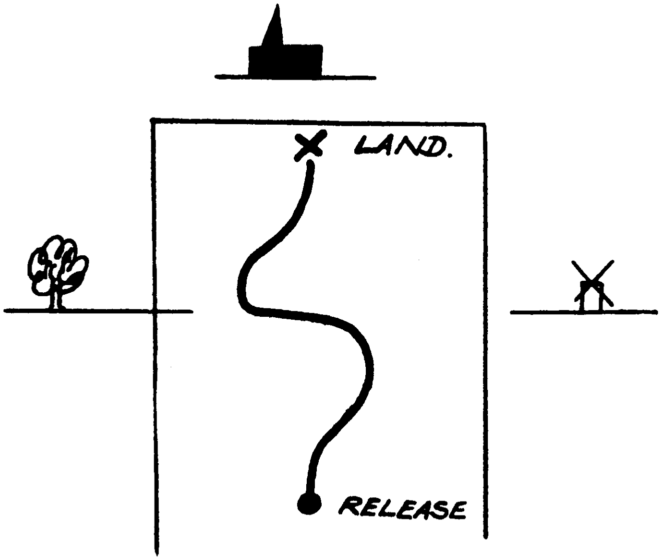
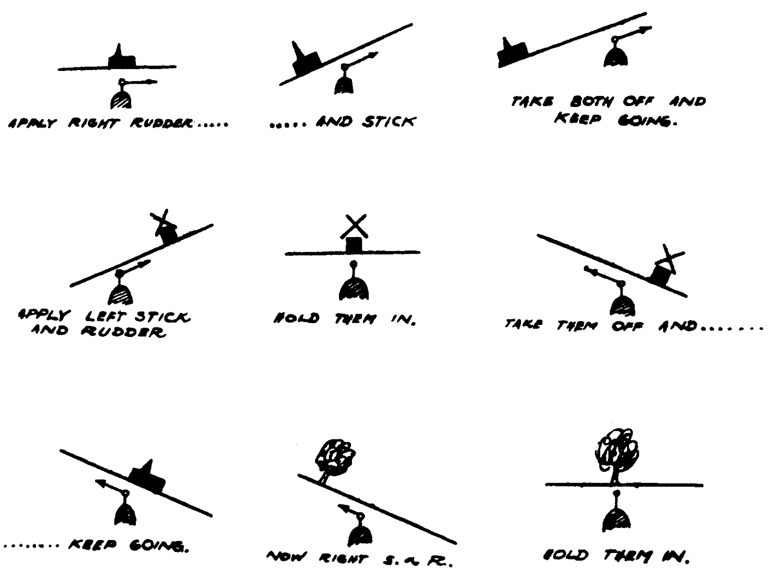



FIG. 29.

Get launched, and here you go!



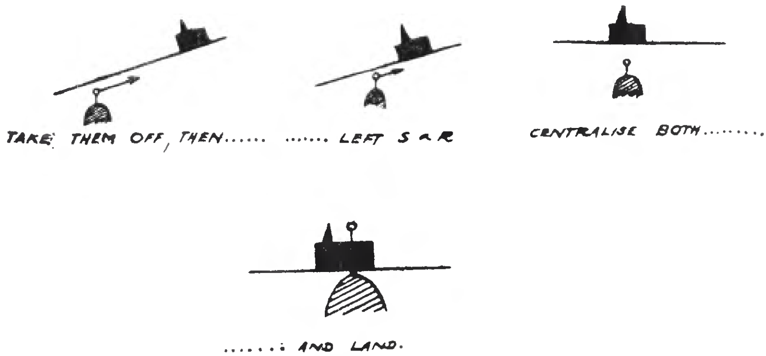



FIG. 30.

*Faults to Watch*

The following faults are prevalent during the early stages of training; watch for them and correct them right from the start:

1. *Leaning away from the turn.* Counter this by forcing yourself to remain upright on the seat—centrifugal force will hold you in, and securely tightened straps will give you confidence.
2. *Flat turns.* This is the result of too much rudder or too little bank. If your turns are flat, you will skid and take much too long to get around. Furthermore, you will be creating a lot of extra drag, which will have the effect of increasing your sinking speed.
3. *Slipping turns.* On the other hand, don't overdo the amount of bank in relation to the amount of rudder applied, or you will tend to slip inward. The symptoms are a cold wind on the side of your face and a sense of impending disaster.
4. *Final turn too low.* Leave yourself plenty of height—say, 70–80 ft.—for a straight approach and landing. Nothing is worse than a shaky turn with one wing close to the deck. Make up your mind in plenty of time to turn in and land, even though you have not completed all the turns for which you were briefed.

# THAT FIRST CIRCUIT

WHEN you have mastered the art of elementary turning, the time is ripe for you to make your first circuit.

The flight—like all flights—will consist of four distinct stages: launch, cruising, approach, and landing.

You are now quite familiar with being launched, but you will notice that the first circuit launch lasts longer, and you will find yourself much higher on release. It may seem a little strange to level out and find the winch beneath you, rather than ahead, and you will find it difficult to assess your height. None of this matters. Once released, concentrate on finding a good attitude and on what has to be done.

In an ideal circuit you land as close as you can to your start-point.

How to get there?

*Ideal Circuit*

Make a 180° turn; in order to conserve height, make this turn as soon as possible after release. Then fly back parallel with your path of launch, pick a landing-spot, turn in, making a nice straight approach, and land.

Look at fig. 31. Sketch A shows the ideal primary circuit. Sketch B shows the path of one, Snoggins, making what he calls a circuit. Let us watch closely.

He becomes airborne with his right wing down; this causes him to drift over to the right on launch. When he releases, he finds himself pointing in altogether the wrong direction and he panics, banging on hard left aileron and rudder, in that order. This causes him to lose quite a bit of height before he sorts it out, and his turn is much too wide.

The situation is not irremediable. Provided Snoggins keeps

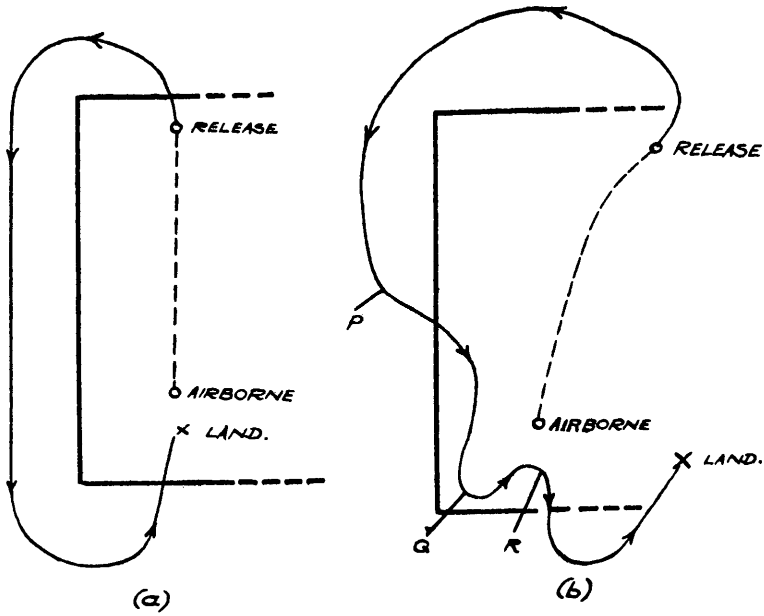



FIG. 31.

his head and watches the instructor's signals, as previously arranged, he may still complete a fair circuit.

Knowing that he has lost height, he starts (at P) to creep in towards the field, ignoring the instructor's frantic signals, and getting much too near. He finally decides (Q) to turn in and land. Having turned through 90° he realises that he is too high, and commits the unforgivable sin. *He turns away (R) and loses sight of his spot.*

His flight ends with a frantic turn, much too low and a bumpy landing in the rough.

"Why did you turn in so soon?" queries the instructor.

"I turned in too late last time," says the unfortunate Snoggins, "and undershot like mad. I didn't want to overshoot this time."

"In the first place," he is told, "you ignored my signals. That was just stupid. Having done so, however, instead of deciding on a plan, you changed your mind, turned off your approach, and got yourself into a terrible tangle. You should realise by now that, once committed to an approach, you *must* carry it through, even though it is obvious that you are not going to land on your 'spot'. Overshooting on a field as big as this makes no difference at all.

"Turning away and losing sight of your spot is a very bad thing—I've told you about it before. You can't fly if you are trying to look over one shoulder; no one can, not even an expert, and for you it is positively dangerous."

* * * * * *

*Approaching*

Let us consider this question of making an approach.

Realise now, for all time, that once committed to a landing, you *must not* change your mind. To do so is dangerous. Indecision is always dangerous in flying. Weigh up all the factors well ahead; decide on your landing plan; judge when the time is ripe to put it into effect. Then CARRY IT OUT, right or not so right. Spot landings, though gratifying, are not called for in these early stages.

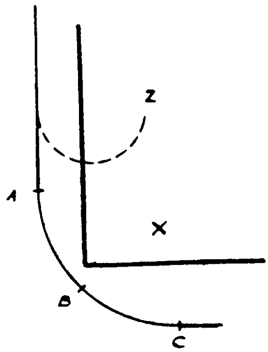
We will assume that you are flying down the field and have chosen a landing-spot which, by the way, should be well inside the boundary.

Take fig. 32 (*a*). You are following the arrowed path and decide to land at X. Follow the curve ABC, keeping your spot abeam. You will lose height at a steady rate and eventually reach a point where you can turn in and land.

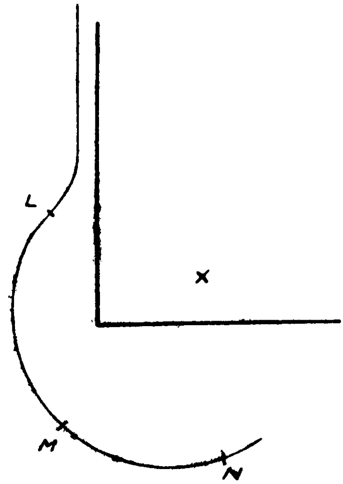
If it is obvious that you are going to have to land early, you can of course turn in at any time and land, say at Z, but this situation should have been apparent earlier on, and you will have chosen Z as your spot, not X.

On the other hand, you may realise before reaching A that you are going to have too much height in hand. The best thing to do is to edge away from the field and start a curve of greater radius —LMN in 32 (*b*). There are other methods of shedding height, but for the time being you will be well advised to follow this procedure.

To begin with, the instructor will help you with signals—use




(a)




(b)

FIG. 32.

them thankfully. Later on you will develop judgment and be able to weigh up the situation for yourself; however, that will only be when your eyes have accustomed themselves to estimating vertical distances.

Having turned in, *make a straight approach.*

Continue in that line at the best gliding angle. Don't try to adjust your angle of glide by varying your attitude—try to cultivate judgment so that you can be sure that you are turning in at the right time. For the present it doesn't matter about under- or over-shooting.

Soon you will have to land. There is only one method of landing, and that is correctly. You will by now have made a number of landings (of all types!) and possibly have mastered the art. However, a few words may not come amiss at this juncture.

*Landing*

Landing is a matter of concentration.

You have to fly yourself right down on to the ground, keeping a good gliding angle and plenty of airspeed the whole time. As the ground nears, the idea is to flatten out the glide until the skid is rustling the grass. Then hold your attitude, and wait for the glider to settle down on to the ground, which it will do of its own volition.

If you land with insufficient speed, or flatten out too soon—which will cause you to lose speed—your angle of attack will increase, and the nose come up. In extreme cases you will stall on to the ground and damage the glider.

If you do not flatten out soon enough, you will land on the front of the skid at higher speed than is needful, which again may cause damage, especially if you bounce.

Any type of landing other than the approved method is not recommended, and may cause alarm and despondency to the pilot.

It is important to approach at a speed rather higher than normal cruising speed. There is a very good reason for this, which will be explained in the next chapter.

The feeling of satisfaction at having made a good landing is always new. When you finally settle down three times in a row like thistledown on the exact spot that you have chosen, don't get swollen-headed. Every landing now, and in the future, will call for the same amount of judgment and of concentration from the moment you decided it was time to come down.

Carelessness in landing is unfortunately much too prevalent, and is at all times "fraught".

*Airmanship*

A few elementary points of caution:

1. Never land towards other objects on the ground, cars, other gliders, etc.
2. Never try to squeeze into a confined space. A slight error of judgment, a trick of the wind, can result in a broken wing.
3. Do not let your line of approach end in an immovable object—an overshoot will bring you up against it. Scan the ground critically in plenty of time before settling on your line.

4. Keep your wings level as you flatten out to land. As speed drops, the ailerons will get less sensitive, and a dropped wing will be scraped and damaged.
5. Look straight ahead until you are solidly on the ground.
6. If a small bush, dog, hummock, or like object comes into your view at the last moment, ignore it. It cannot cause much harm, but if you try to hurdle it, you will inevitably stall in from three or four feet.

# MEETING ATMOSPHERIC CONDITIONS

THUS far you have been flying in calm air, but as you trudge along the slow road to competence your instructor will allow you to fly under moderate conditions of wind and weather. Apart from the usual question of rain and temperature, there are two aspects of the weather which concern you vitally—wind and turbulence.

*Turbulence*

One side of turbulence—thermal currents—is very important to the glider pilot, and will be dealt with at length rather later. Turbulence, generally speaking, means disturbed air. The disturbance is caused near the ground, due to obstructions to air-currents in the shape of woods, hills, buildings, etc. On the lee side of such obstructions the wind is liable to change speed and direction in quite a haphazard manner, and these conditions have their effect on a glider, by trying to upset its attitude and airspeed. In heavy turbulence, your glider will sometimes be tossed about like a cork; large aileron movements are called for continuously, and you will find the nose wandering about all over the place, much in the fashion of a small boat in a choppy sea.

It is advisable to fly rather faster than usual through heavy turbulence, to avoid involuntary stalls.

In addition to turbulence, which you cannot yet put to any useful purpose, you must begin to consider the wind, which has both speed and direction; these components affect the performance of your glider.

*Winds*

Winds are caused by the horizontal movement of air from an area of high pressure towards and anticlockwise round an area of low pressure (in the Northern Hemisphere). If you want more details, you will have to refer to books on meteorology—the science is in itself a comprehensive and extensive study. For the purposes of these pages, suffice it to say that "the winds do blow".

Most gliding sites are carefully chosen with a view to the prevailing wind, and under normal circumstances you will both launch and land into wind.

### *Head Winds*

If you are flying into wind, your groundspeed is the difference between airspeed and windspeed. For example if you are cruising at 30 m.p.h. into the teeth of a 20 m.p.h. wind, your groundspeed is $30-20 = 10$ m.p.h. If you fly at the same speed into a 40-m.p.h. wind, your groundspeed will be $30-40 = -10$ m.p.h.—in other words, you will be going backwards with relation to the ground. That is an extreme case that you will not be likely to meet with yet awhile.

Take the case of a glider with the following performance figures:

Cruising speed—30 m.p.h.

Gliding angle at 30 m.p.h.—1 in 12.

In still air the glider will travel over $\frac{1}{2}$ mile of ground in one minute, losing 220 ft. of height in the process.

If it is travelling into a head wind of 10 m.p.h., its groundspeed will have dropped to 20 m.p.h. Therefore in one minute it will still have lost 220 ft. height but will only have covered $\frac{1}{3}$ mile of ground.

The difference is shown up in fig. 33. Although the attitude, airspeed, and sinking speed of the glider remain constant, the angle of descent is noticeably steeper in A than in B.

Looking at this from another, and more practical, standpoint, if you wish to land at point X (fig. 34), you will have to take the head wind into account, and turn in either higher or nearer than you did in still air. It amounts to the same thing.

Fig. 33 (*c*) shows the effect of a tail wind, which is to decrease the effective angle of descent. If you were landing down wind,

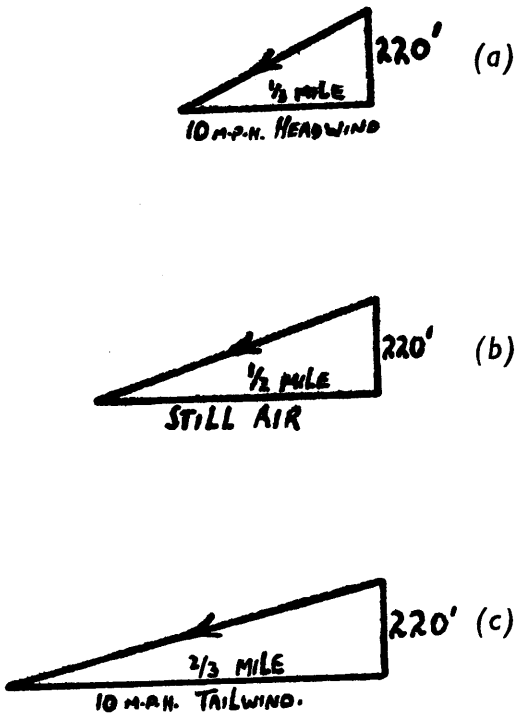

220'
(a)
1/3 MILE
10 M.P.H. HEADWIND
220'
(b)
1/2 MILE
STILL AIR
220'
(c)
2/3 MILE
10 M.P.H. TAILWIND.

FIG. 33.

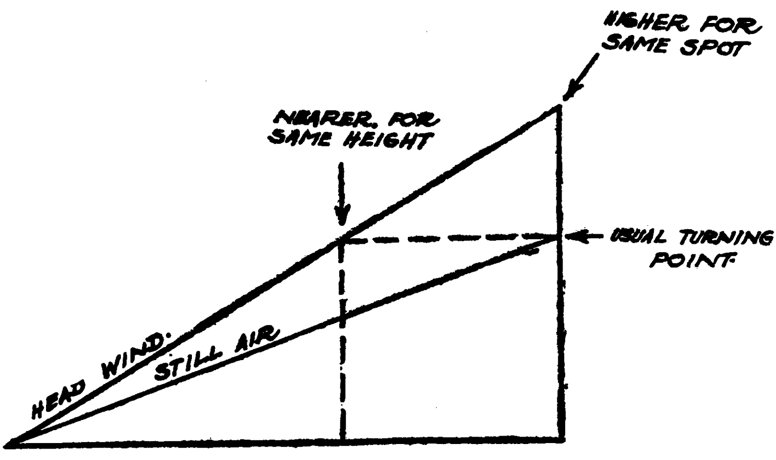

HIGHER FOR
SAME SPOT
NEARER FOR
SAME HEIGHT
USUAL TURNING
POINT
HEAD WIND.
STILL AIR

FIG. 34.

which is not recommended anyway, you would have to turn in either lower or later. Draw this one for yourself.

You can see the effect a head wind is going to have on your landings. It has similarly an effect on all your flying, so get into your primary and do a circuit at 30 m.p.h. with a 20-m.p.h. wind blowing down the field. Stalling speed is, say, 25 m.p.h.

The winch starts pulling. When your groundspeed reaches 5 m.p.h., you become airborne, which mildly amazes you. The reason is, obviously, that your airspeed is now 25 m.p.h. You go through all the motions of getting the best height, and find that you are higher than ever before. This is because your rate of climb has been as always, but you have been travelling at a lower groundspeed; by the time you have reached what would be the maximum height in still air, you have only covered half the ground, and are still climbing merrily. The winch-driver will tell you that the cable was being wound in at less speed than on a windless day, although the pull exerted was exactly the same.

You make a 180° turn. On straightening up you find that you are quite a way down the field already, and you lose less height than usual on the downfield leg.

Don't let these factors confuse you. The thing that you must be aware of is that your angle of descent will be much steeper on approach; make allowances accordingly. The extra height you can shed during the circuit in any way you please—more about that later.

Another complication does arise on windy days, in the shape of wind gradients.

### *Wind Gradients*

Near the ground the wind is slowed down because of the friction caused by unevenness in the surface of the earth. Wind gradients are more noticeable low down and gradually disappear as you rise.

If on launch you fly through a gradient, it will cause an increase in your airspeed, causing your nose to lift sharply, and it is up to the winch-driver to compensate.

A wind gradient is most likely to cause you trouble on your approach. Imagine that you fly from a level of 20 m.p.h. wind to one of 15 m.p.h. Inertia will carry your glider forward, and your effective airspeed will be lowered by 5 m.p.h. If you are flying near the stall, this can be awkward.

The remedy is to approach, on windy days, with speed in hand, which means that you will be in a nose-down attitude, and

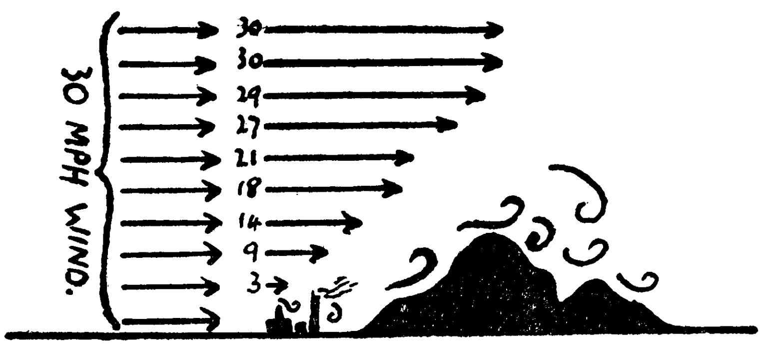



FIG. 35.

descending at a steeper angle. This, added to the fact that the effect of a head wind is in any case to increase your angle of descent, means that your approach will be quite steep.

You should take every opportunity from now on of experiencing winds of varying strengths.

*Cross Winds*

The wind will often, perversely, blow across the field, affecting both launch and landing.

On launch, the cross wind will make you drift away from the line start-winch. The best plan is to force the glider to follow its accustomed path, and you would do this by holding in, against the wind, a little rudder AND aileron—just enough to compensate for the drift. Rudder alone will not do it. What you really do is to keep turning into the wind at a small rate—just holding against the drift. Don't overdo the correction, or you will zig-zag all over the place.

*Cross-wind Landing*

If you have enough room to land across the field and into wind, it will pay you to do so. If you are forced, however, to land across wind, it will cause the glider to drift, i.e. travel at an

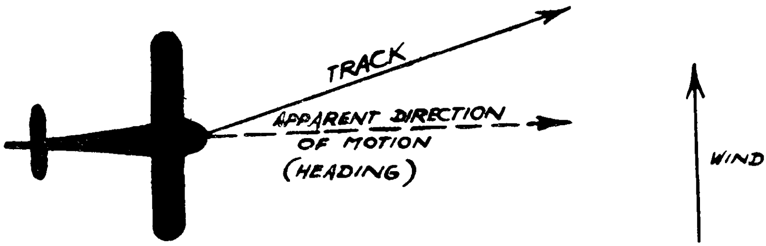



FIG. 36.—Drift.

angle to its apparent direction of motion, which is where its nose is pointing. Under gusty conditions, there may be a tendency for the wing which points into wind to rise.

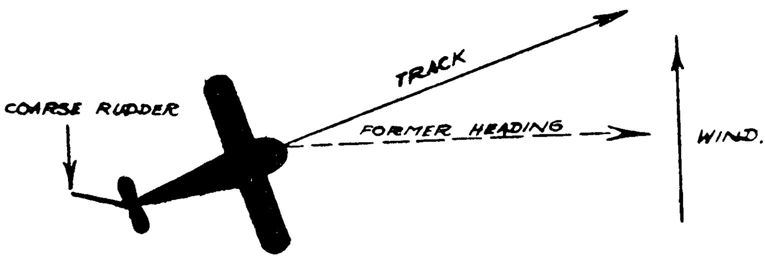



FIG. 37.—Correction for Drift.

*Countering Drift*

In order to avoid landing with drift on, which puts a sideways strain on the skid, it is the normal practice to apply coarse plain rudder just before touch-down; this brings the nose around until the glider is actually following its "track" or direction of motion.

Before leaving the subject of wind, just a point on the care of gliders.

Never forget that they are light and easily damaged. If you have occasion to land when a wind is blowing, turn your glider with a wing into the wind and rest that wing on the ground. If possible, weight it down with something that will not damage the fabric.

# MORE CIRCUITS—MORE TURNS

THE last chapter casually mentioned shedding the excess height which you should now be getting regularly with each launch. Extra height means more time in the air, and you should not fritter away these precious seconds in aimless flying. Use every moment to one end—improving your turns.

When you get past the "B" stage, you will find that the ability to turn in either direction, making turns of differing rates, becomes increasingly important. The lessons that you have so far learned have grounded you in the basic technique of handling a glider. A lot more polish is needed before you can hope to pit your skill and knowledge against the weather to the best ends.

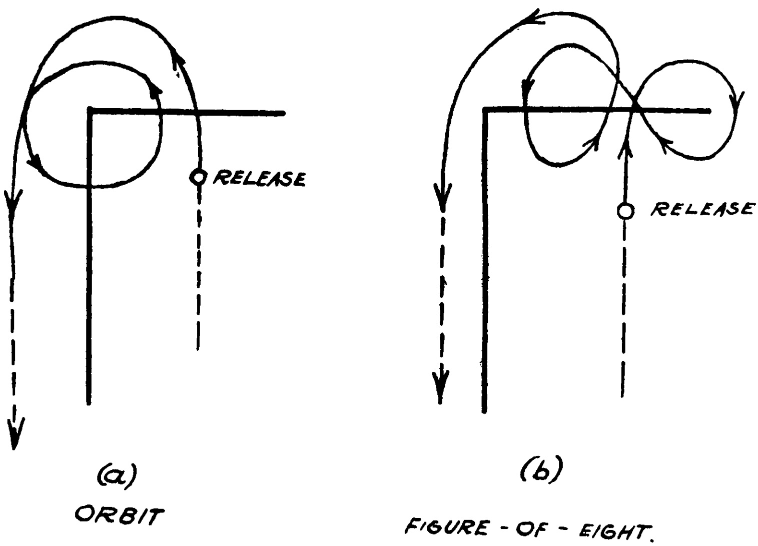



FIG. 38.

You will be briefed to perform more difficult circuits now, just to improve your turns. The more common of these are a circuit containing an orbit (or turn of 360°), and one including a figure-of-eight.

*Steep Turns*

You have only a limited time to perform such manœuvres, and therefore you must speed up your rate of turn. A 360° Rate One turn takes two minutes—at Rate Four it would only take thirty seconds.

Hark back to the first chapter of Stage "B"—the greater the rate of turn, the more centripetal force needed to hold the turn. That means that more bank will be needed, and it is here that you begin to run up against a few snags.

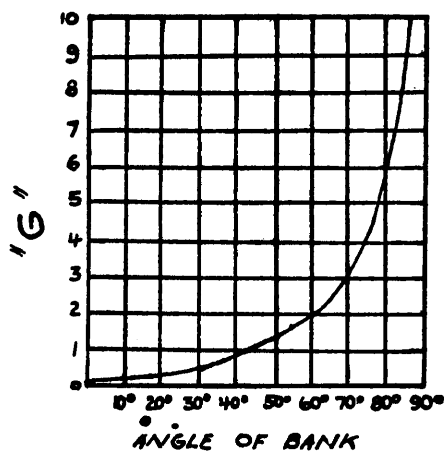



FIG. 39.

*Wing Loading*

At a given airspeed, the higher the rate of turn, the greater the angle of bank needed. As the angle of bank increases, wing loading rises.

Wing loading is the weight supported by the wings expressed usually, in lb. per sq. ft. Where gravity alone is acting on the aircraft, as in straight flight, it is common practice to say that the wing-loading factor is "$1g$". As turns steepen, wing loading rises appreciably. (See fig. 39.)

To supply the necessary lift to combat the increased wing loading, a greater angle of attack is called for. In steep turns use must be made of the elevator to position the nose so that this greater angle of attack is being presented to the airflow.

*Stalling Speed in Turns*

However, you cannot go on increasing the angle of attack indefinitely, as you will ultimately reach stalling angle. The speed at which you will reach this critical point is higher in a turn than it is in straight flight. The speed increases, as a point of interest, as the square root of the wing loading. See fig. 40—which shows stalling speeds at various angles of bank for a glider whose normal stalling speed is 40 m.p.h.

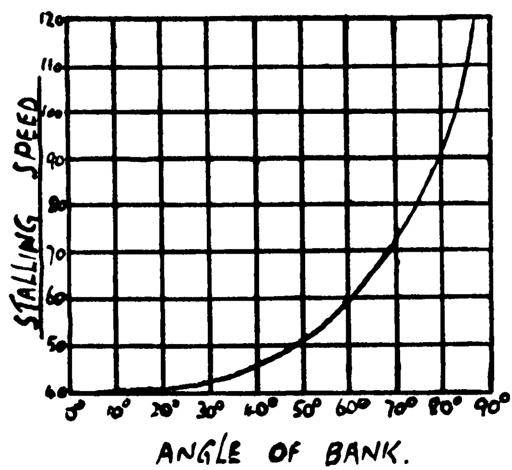



FIG. 40.

You can see that the rate of turn you are able to perform at normal flying speed is somewhat restricted. The tightest turn you can make at 50 m.p.h., for example, is one with 45° of bank.

The rate of turn can be increased if flying speed is increased, for this allows a greater angle of bank to be put on before stalling speed is reached. However, the only method by which extra speed can be obtained in a glider is by adopting a nose-down attitude, which means a steeper angle of descent with consequent greater loss of height.

Maintaining an accurate turn in unstable air is tricky work. Your nose will be inclined to wander from its accustomed place on the horizon, calling for the application of constant minor corrections.

*Effect of Controls*

It is important to remember, especially in steep turns, that the controls always have the same function, but relative to the glider and NOT to the ground. For example, if you find your nose getting way up over the horizon, like this—

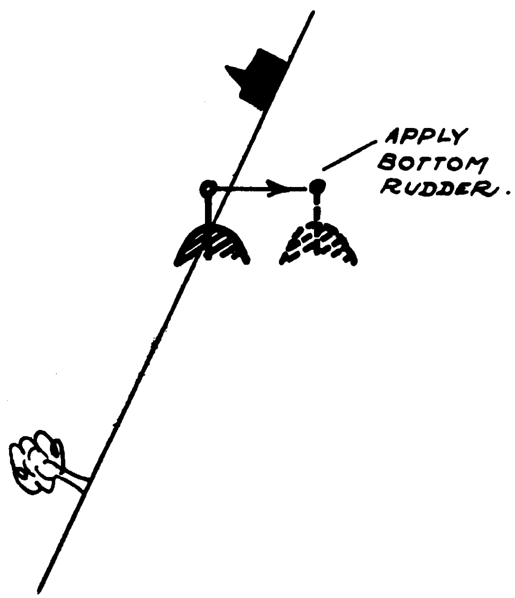



FIG. 41.—Correcting Attitude with Rudder.

—it will be causing you to lose speed, which is undesirable. The way to get it back into place is by *gentle* use of bottom rudder.

Early lessons still apply—don't jerk; don't jitter; and one other thing—until you are considerably more experienced, ***don't attempt tight turns near the ground.*** It is shocking how much height can be lost in a very short space of time in a badly executed turn.

Recovering from a turn of any degree of bank is quite simple. Apply opposite stick and rudder, gently adjusting your attitude to avoid a recovery with your nose stuck haughtily in the air.

You will now be polishing up your circuits, and should try to increase your rate of turn when doing orbits and figures-of-eight. If they are accurately made, you will have plenty of height in hand for your down-wind leg, approach, and landing.

Remember not to wait too long after release before initiating the first turn; don't worry about shedding the extra speed that you will have gained at the top of the launch. Adopt a good attitude with reference to the horizon, and go straight into the turn.

Incidentally, this habit of making a turn over the winch will be of untold value to you when you start thermal soaring; it will also be of use when you start making transport trips for beginner's hops, when height is very limited.

Now, if you have practised and learned all your lessons, you should be within reach of that second coveted piece of paper, the "B" Certificate. What is more important, your flying should be steady and accurate.

# THE FIRST CONVERSION

THE strange thing is that the more advanced types of glider are easier to fly.

Their performance is better, their controls are more sensitive, and to fly one of them after the primary is rather like changing your Baby Austin for a Rolls-Royce.

Normal practice on converting from primary glider to intermediate sailplane is for the pupil to do a few hops before progressing to circuits. This is in order to acclimatise him to the difference in feel, vision, gliding angle, etc., and to teach him what lift-spoilers are and what they do.

Most intermediate types of sailplane have a detachable hood of the open type fitted with an aeroscreen, but until you have done a few circuits you will probably fly with the hood off. The view from the cockpit will then be very similar to that from the cockpit of the "boat".

In front of you, as you strap yourself in, is an instrument panel, comprising usually:

1. Air Speed Indicator (A.S.I.).
2. Variometer.
3. Altimeter; and, if you are fortunate,
4. Turn and Slip Indicator (T.S.I.).

When you start your hops, there is only one thing to do about these instruments—ignore them.

Learn to find your best attitude and fly by it; use your senses. They are much more sensitive in many ways than dashboard instruments, and the pilot who truly endeavours to fly by feel alone will profit in the long run.

Before you take off on your first hop, the instructor will set your spoilers about a quarter of the way out. Forget all about them and concentrate on the flying of the next few hops. The launch will be very much the same as ever, apart from the fact that your ears will have to attune themselves to a new wind noise —smoother and quieter. Once you are gliding you will have to find the best gliding angle for this new type of steed, and get your eyes used to the attitude. Landing will be shallower and rather faster, and you will certainly learn how much more sensitive this advanced craft is to control movements. The answer to this last point is not hard to find—better aerodynamic characteristics, larger control surfaces combined with smaller vertical and horizontal stabilisers.

When you have once mastered the new gliding angle and, more important, the new technique of landing, you should be briefed for medium hops—taking off with spoilers in and using them on the approach, to get used to their effect.

*Lift Spoilers*

Lift spoilers are vertical flaps which either fold or slot into the wing contour. According to design, they may project from the top surface only, or from both top and bottom of the wings when the operating handle is used.

Their effect is to spoil the lift being produced by the wings; the top spoilers confine themselves to this effect, but the bottom ones act mainly as air-brakes, being situated in an area of positive pressure.

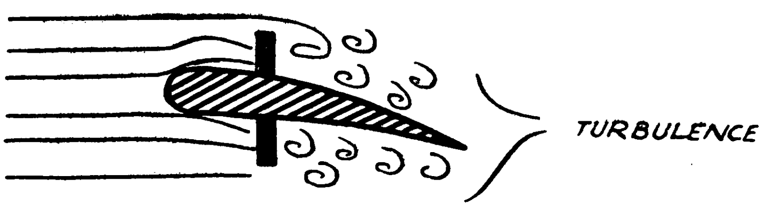



FIG. 42.

They achieve this effect by breaking the airflow over the aerofoil, which creates artificial turbulence and so increases the effective wing loading. The amount by which they do increase wing-loading is related to the extent to which they are exposed.

On their application, the gliding angle steepens noticeably; this enables a steeper approach to be made, which is useful for landing in small fields and restricted spaces. It also allows the pilot to adjust his angle of approach in the case of an error of judgment. They can similarly be used to increase the rate of sink of a sailplane when necessary, e.g. to avoid being sucked into cloud—to avoid being late for lunch, etc.

*Use of Spoilers*

A few hints on their use:

1. When you are flying near the stall (as you very often are on the ridge or in the search for thermals), the wings are at a large angle of attack. If you then pull out spoilers and increase wing loading, up will go the nose in search of extra lift, and you will stall. Therefore, if you wish to use them to shorten your approach, add 5 m.p.h. *before* using them, to obviate any chance of a stall near the ground. This only applies at normal approach speeds, of course, and not when you are carrying plenty of airspeed, e.g. when approaching from behind a ridge.
2. Use them gently at all times. "Pump-handling" the spoiler control lever will upset your attitude and make it difficult for you to approach steadily.
3. Think twice about using them at all if you are flying really fast. A sudden increase in wing loading near maximum permitted speed puts extra stresses on spars and wing roots.
4. Get into the habit of making an approach with $\frac{1}{3}$ to $\frac{1}{4}$ spoiler exposed. If you meet a down-draught or wind gradient on your way in, you can avert an undershoot by retracting them, thus decreasing your angle of descent. If you go through an up-draught, you can use them to keep your approach angle constant. This only applies in conditions where thermals are large. On a gusty day it is better to bore through both gusts and down-draughts without using the spoilers.
5. Advanced sailplanes have a habit of "floating". Their gliding angle is shallow and it is difficult to make them sit

down on landing. If you are carrying a little too much speed at the moment of touchdown and flatten out a shade too late, a high-performance sailplane will balloon into the air and float quite a long way. Use your spoilers to steepen the gliding angle and make the aircraft sit down. The air-brake effect will also shorten your landing run.

A few hops should accustom you to the new aircraft and, when you have satisfied the instructor that you can land properly, you will graduate to circuits. Eventually you will be flying with the hood on; although this restricts your vision somewhat, it keeps the wind out of your eyes, and slightly improves the flying characteristics of the sailplane.

During these circuits, having found your best attitude, check the speed indicated on the A.S.I., and remember it in relation to that aircraft *only*. Fly by attitude all the time, and use your A.S.I. just as a check on approaches, and sometimes on launches. It will come in handy later on, in competitions and things like that, but don't stare at the needle in fascination during your circuits.

Next, practise turns, turns, turns. Get the feel of your new steed in tight turns, wide sweeps; let every inch of surplus height be spent at an angle.

### *Wing Drag*

As a point of interest, the better performance of the more advanced types of sailplane is due to design. We have touched on the question of wing drag in the second chapter of this book. By carefully designing a wing, it can be built with as little drag as possible for a given amount of lift.

### *Parasite Drag*

However, in addition to wing drag, aircraft offer "parasite drag" to the airflow, which is the drag caused by non-lifting surfaces—fuselage, projections, etc. In well-designed machines parasite drag is kept to a minimum by the use of streamlining, surface finish, and so on. The difference between the drag offered by the primary with its array of wires, and that offered by the sleek, polished lines of a fine sailplane should be obvious to the naked eye.

*Effect of Drag on Performance*

Now, drag increases as the square of the speed of an aircraft. Great parasite drag will rise enormously with a fairly small increase in speed. Therefore, although your primary will glide well at about 25–30 m.p.h., if you raise its speed to 60 m.p.h. its drag becomes immense. Although the lift also increases as the square of the speed, it cannot hope to compete with this increased drag, and the angle of descent at highish speeds becomes terrifying. In other words, a primary has no "penetration".

On the other hand, a high-performance sailplane has beautifully clean lines and its parasite drag has been kept to a minimum. Thus it can reach a greater speed than a less efficient type before the mounting effect of parasite drag begins seriously to affect its performance.

The low gliding angle of a high-performance sailplane is due to a combination of wing efficiency and low parasite drag. Wing efficiency means a low ratio of drag to lift, and is achieved by careful attention to the shape, size, and finish of a wing.

*Effect of Weight on Performance*

It is worthy of note that the weight of an aircraft has no effect on its gliding angle. From fig. 17 you can see that an increase in weight has to be balanced by an increase in the resultant of lift and drag. The *proportion* of lift to drag remains the same, however, and so the angle of attack is unchanged. The increase in the lift/drag resultant is compensated for by an increase in speed, but the gliding angle remains the same, which means that the same amount of ground will be covered. The only thing that is affected is the speed; the glider will sink more rapidly.

* * * * * *

As you get on with your intermediate circuits, you will sooner or later be introduced to the Centre of Gravity launch.

Thus far you have been hauled to the angels by means of a cable attached to the nose of your aircraft. This provided the thrust needed to allow you to climb. The thrust overcomes drag, increases lift, and allows you to adopt a nice angle of climb by using the elevator.

Due to the limitations of a winch, its total thrust cannot be applied along the longitudinal axis of the aircraft, and varies in direction as the glider progresses along its launch path. At the top of the launch, where the glider is over the winch, it is obvious that all the winch effort is in a downward direction, and no resultant is being applied in the direction of motion of the tow. Thus the path of a glider has to take the form of a curve, with the steepest gradient at the start, and gradually getting flatter.

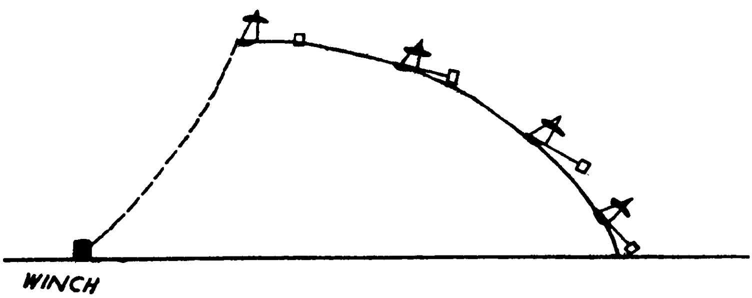



FIG. 43.—Path of Glider on Tow.

If the cable is moved from the nose and attached at a point nearer to the C.G., the downward resultant of winch effort has less leverage. This has the effect of allowing the sailplane to adopt a much steeper climbing attitude; also, the effect of the elevator is increased proportionately.

*C.G. Launch*

From the practical aspect, the C.G. launch will affect you like this:

Up to the point of becoming airborne you take off with stick neutral. The sailplane will slide along and rise into the sky just as for a nose launch. As lift builds up under the winch effort, the nose will tend to lift sharply.

You must counter this tendency *at once.*

Take your stick forward. Only experience will tell you how far and how quickly, but you must aim at a smoothly graduated curve, and not allow the glider to adopt too steep a climbing attitude until you have reached a safe height. Then you can allow the stick to come back to the neutral position, which it will do of its own accord. Do NOT put any backward pressure on it, but allow it to remain in neutral, which it will do quite happily, until you reach the top of the launch; then nose down and release.

You will be much higher than on a nose launch, and have noticed that the climb has seemed smooth. There has been no sensation of winch pull which was transmitted through the stick on a nose launch. This smoothness is one of the snags of a C.G. launch—it is deceptive. The winch effort is still very much there, and an equal and opposite reaction is being applied to your air-frame the whole time.

It may happen, for one of many reasons, that your speed builds up during launch. It is very difficult indeed for even the most experienced of winch-drivers to realise that he is towing you too fast under certain conditions of weather. On a nose launch you would start pitching; you would notice it, and so would the driver. On a C.G., your speed can build up unnoticed and cause excessive strain to be put on both cable and aircraft. One of two things will happen if the strain becomes too great—the cable will break, which is a nuisance, or the aircraft will break, which is highly undesirable.

Keep an eye open. Every sailplane has a maximum permitted cable-launch speed, which you should get to know. If you seriously exceed this limit and there are no signs of a reduction, release the cable.

In the same manner as for a nose launch, put strain on the cable gradually. If you jerk up into a steep climbing attitude as soon as you are airborne, the tail can strike the ground—I have seen it happen—or in the case of a cable break you will find yourself hopelessly stalled, nose well up, very near to the hard earth beneath.

*Cable Breaks*

Sooner or later you will experience a cable break, which may occur through no fault of your own. All cable breaks, especially the first one, can leave you in a state of indecision. It is a nasty feeling.

There you are—nose well up—no clues to how high you are, and if the break occurs in the early part of the launch, you invariably stall.

Getting your nose down when in trouble should by now be instinctive.

*Immediate Action*

Release the cable immediately by pulling the release *three times*. Releasing the broken end of cable is often overlooked in the urgency of regaining control, and the omission can be most dangerous. Once you have overtaken the broken end, the cable will trail behind you and possibly jam in the releasing gear. If it does, and the trailing end wraps itself around anything on the ground you will describe the first half of a bunt, or outside loop, into the ground. This is highly undesirable.

The moment your nose goes over and the horizon comes into view, decide how much height you have available and what you are going to do with it.

If you have enough height to make a circuit, do so by all means. If you think not, spoilers out and land straight ahead. But, whatever you decide to do, stick to it. Change of mind will get you into trouble.

Get into the habit of repeating the following formula as the cable tightens, on every launch, and repeat it as your stick returns to neutral:

"If my cable breaks—nose down; release three times; make up my mind and DO SOMETHING DEFINITE."

* * * * * *

*Other Types of Launch*

So far we have only dealt with cable launches. There are other types of launch in use, the most common of which is the rubber cable, or "bunje" launch. Car-towing is sometimes used, as is aero-towing, and the latter is becoming more and more popular although restricted at present by expense.

Car-towing is infrequent. It calls for a straight smooth surface for the towing vehicle, and a method of severing the cable at the car end, which often proves tiresome.

Aero-towing is an advanced technique, outside the scope of this primer.

Bunje launches will be touched on in the chapter on Slope Soaring.

To wind up this rather long chapter, here is a diagram, contrasting nose and C.G. launches:

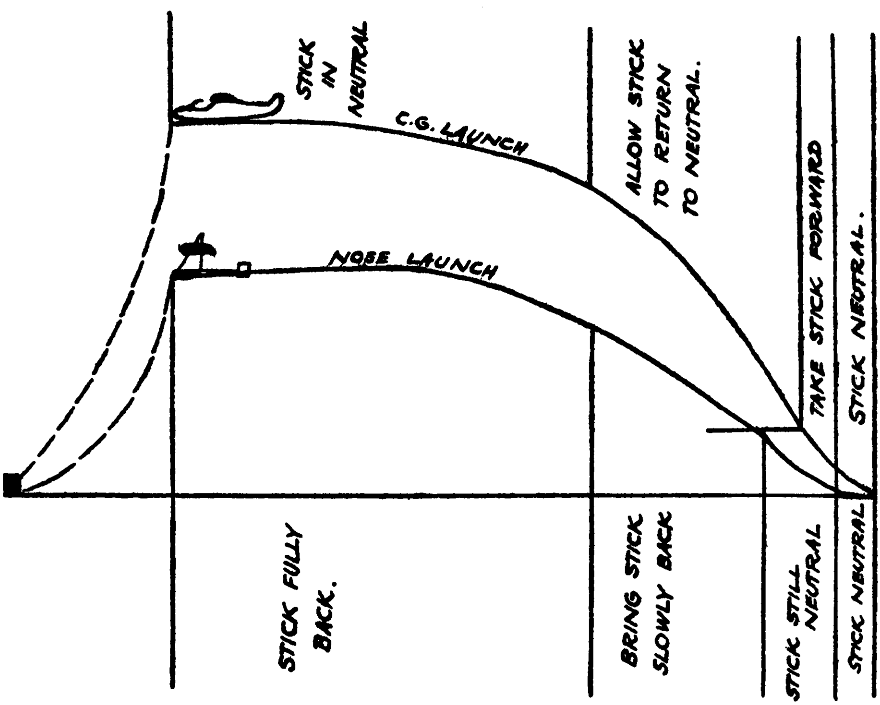



FIG. 44.

# A WORD ON INSTRUMENTS

## AIR SPEED INDICATOR (A.S.I.)

When an aircraft is at rest, air presses equally on all parts of its structure—static pressure. When it is flying an additional pressure—dynamic pressure—is exerted on all leading surfaces, varying according to airspeed and air density.

The difference between these two pressures gives an indication of airspeed, and is channelled to the indicating dial of the A.S.I. To look at, this is something like a speedometer, and is graduated in m.p.h., k.p.h., and in Russia, I have no doubt, in versts. It doesn't really matter.

The instrument registers instantaneously any variations in airspeed; it may have small calibration errors, but these are usually known, as a result of comparison with a master calibrator.

You have already been told to use it as a check only. Too often, unfortunately, do we see Snoggins with his "head in the office". He notices his speed dropping and puts his nose down. Up goes the needle on the A.S.I. By the time Snoggins has reacted and made a correction, he is flying too fast, and pulls back on the stick. So it goes on—"chasing the clock"—an uneven motion which costs height, looks bad, and is indeed bad. Be warned.

Rain or ice will often cause the A.S.I. to give up the ghost. If you cannot fly accurately by the horizon, you will be in a mess if this happens. Try to remember that instruments have a habit of packing up in bad weather, and so do not fall into the easily acquired bad habit of relying solely on them.

## ALTIMETER

This instrument tells you how high you are, and comes in two types—coarse and sensitive. A sensitive altimeter is equipped with two or three needles, and will tell your height pretty accurately to within ten feet; it can be used in place of a variometer. The more usual types indicate height up to perhaps 15,000 ft. in graduations of 200 or 250 ft.

An altimeter is actuated by the drop in barometric pressure which occurs with increased altitude. Barometric height varies from day to day, even from hour to hour, and so to enable you to set your altimeter to zero, or correct height above sea-level with respect to your point of take-off, it is fitted with an adjusting screw.

Before launch, set it to zero; tap it gently with your knuckle—it may move and need resetting. Altimeters get sticky, and you may find on release that you are a hundred or so feet higher than you thought at first glance. This tip also applies if you have reason to believe that you have lost height, say when ridge soaring, and have a plan to leave the ridge at a fixed height.

Like the A.S.I., it should be used for reference, but as it is infinitely more difficult to assess height than speed, don't be afraid to invoke the help of your altimeter at all times.

### VARIOMETER

A variometer tells you whether you are rising or sinking, and how fast.

It does this by registering a RATE of increase or decrease in barometric pressure, which it interprets in terms of feet or metres, up or down. Although a very useful instrument indeed, it has a considerable time-lag.

It consists mainly of an insulated pressure flask with a minute opening; from this a pipe leads through the indicating dial to the atmosphere. When the aircraft rises into thinner air, the air in the bottle exhausts into the atmosphere; on descent, air flows through the indicator and into the bottle. The insulation ensures that the flow of air is not influenced by changes of temperature. The dash indicator will be one of two types—dial or column.

The dial shows the rate of rise or sink by means of a needle moving around a graduated scale:

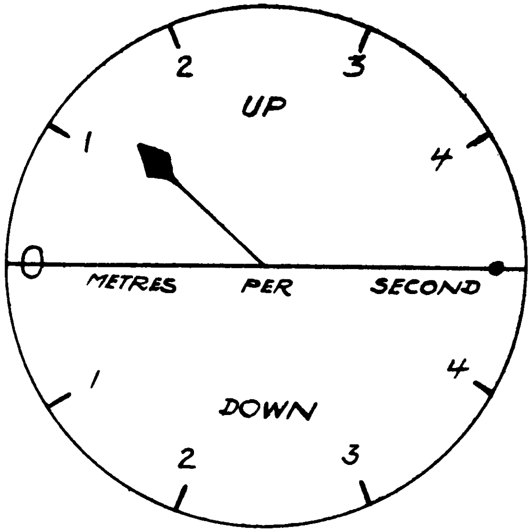



FIG. 45.

The column type is more popular. It consists of two tubes side by side, one containing a red ball and the other a green one. When the green ball lifts, it means that the glider is rising; and when the red one rises, it shows the rate of sink.

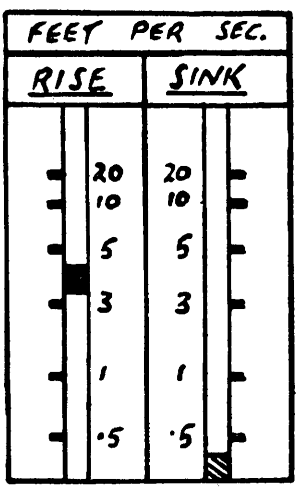



FIG. 46.

At normal gliding attitude in an intermediate you will get used to seeing the red ball staying at somewhere round the 4 f.p.s. mark in stable air.

### TURN AND SLIP INDICATOR (T.S.I.)

This indicator is a combination of two instruments, the readings of which appear on one dial.

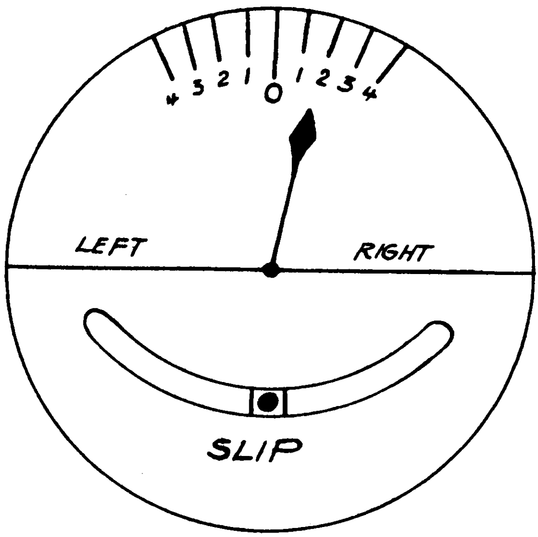



FIG. 47.

The turn indicator is actuated by a gyroscopic mechanism, which can be driven either electrically or by the suction of a venturi fixed on the outside of the fuselage. It tells you your rate of turn, which is useful knowledge when you are thermal soaring. For cloud flying, which you will not be indulging in for quite a time, it is essential.

The slip indicator shows whether you are flying level in straight flight. In a turn it tells whether you are applying the correct amount of bank for the rate of turn. If not, it will, if on the same side as the rate of turn needle, indicate the fact that you are slipping in towards the ground. If it positions itself on the opposite side from the turn needle, you have insufficient bank and are executing a skidding turn.

# STALLS, SPINS, SIDESLIPS

STALLS and spins are of two types—voluntary and "petrifying, my dear!"

In case you ever find yourself in an involuntary stalled position, or spinning madly without the slightest wish to do so, you will need to know what to do to recover. In order to do so, you should practise both manœuvres at a safe height, which is left to your discretion and that of your instructor.

*Stalls*

You very often suffer minor stalls in unstable air, or on flying through wind gradients of a high order. Very early on in the proceedings you were told what a stall was, and how it appeared at the critical angle of attack: how the airflow broke up and became turbulent, with loss of lift.

To practise a stall, fly ahead and ease your stick back. Your speed will drop, angle of attack increase. When the stalling angle is reached, the nose of your sailplane will drop. Perhaps one wing will stall momentarily before the other, due to individual variation, such as inaccurate rigging, atmospheric conditions, etc. You will know that you are nearing the stall by the increasingly sluggish effect of the controls, particularly the ailerons.

*Recovery*

Recovery is simple. Ease the stick forward until the aircraft regains flying speed. A sailplane becomes unstalled almost at once, and all you then have to do is to regain your attitude, which you will find you can manage without undue loss of height.

Next time, put on more speed and bring the stick back more sharply. Inertia will take the sailplane up well past the critical angle, and your nose will drop much more. Practise this type of stall until you are quite satisfied that you could cope with a stall during the steepest part of the launch, in the event of a cable break.

If you are flying near the stall, either in turbulence or on the ridge, it may happen that one wing will stall. As it drops, you may be tempted to pick it up with aileron. Don't do so. You will only aggravate things by increasing the angle of attack of that wing, thus precipitating the stall. Apply opposite rudder immediately, and increase speed by getting your nose down; if by then a turn has developed, apply opposite bank. If you do not, it is quite on the cards that you will develop a spin.

### *Stalling in Turns*

Owing to the increase in wing loading, you can stall a sailplane when in a steep turn, and as has been pointed out, this will occur at higher speed than normal. As a result, the inside wing will drop severely; however, recovery action is just the same—take the stick forward until you become unstalled. You will have lost more height than in a straight stall.

### *Spins*

A spin can occur unintentionally, but it is a comforting thought that most sailplanes will not spin involuntarily. To induce and hold a spin in an intermediate, for example, is quite a task, due to its inherent stability. They can be spun, though, and you want to realise that *the ideal way to induce a spin is to fly near the stall.* If you always fly with speed in hand, the danger of a spin is remote.

Proceed to a safe height and fly a straight course. Bring your stick back very easily—speed will fall off and angle of attack increase. When you are almost at stalling-point, bring the stick right back and apply hard rudder.

The nose will drop and the sailplane descend in corkscrew fashion, with rapid loss of height.

### *Recovery*

During the time a sailplane is spinning, the wings remain stalled, and the two things that have to be done are to stop its rotation and to unstall it. It is usual to stop rotation first by application of opposite rudder, and then to ease the stick forward, which will decrease the very large angle of attack. When you have done this, you will be in a dive, and all that is necessary is to pull out.

You should be able to recognise an incipient spin before it has time to develop into a full-blooded one. The stalling of one wing when you are close to stalling speed is the most common cause. As the stalled wing drops, its angle of attack to the relative airflow becomes greater, with a large increase of drag.


FIG. 48.—Increase in Angle of Attack of Dropping Wing.

The angle of attack of the other wing is reduced and the combined effect of the unbalanced lift is to try to roll the aircraft about its longitudinal axis. At the same time the differential drag causes the sailplane to yaw towards the stalled wing and slip in the same direction. The combination of these motions makes up a spin.

*Sideslips*

Sideslipping is a useful dodge for losing height rapidly, especially on the approach. It enables you to increase your rate and angle of descent, while still continuing to travel in the required direction.

To perform a straight slip you must deliberately cross your controls. Put on, say, plain right rudder. This yaws the sailplane and creates extra parasite drag. Then apply left bank. You will lose height rapidly. By the correct balance of stick and rudder you can follow the track you desire.

Sailplanes vary greatly in their slipping characteristics; you may have to hold the nose up quite a bit to avoid too great an increase in speed, which is not wanted on the approach.

To recover, merely centre all controls.

*Slipping Turn*

A slipping turn is one in which too much bank is applied for the rate of turn. Height is lost very quickly, but the method is not so well suited for approaches as the straight sideslip.

Stalls and spins, as well as sideslips, can be employed to lose height if you wish. A spin is very useful to drop you out of a cloud, but the method is a little tedious on the breakfast. If you find yourself in violent uplift with which you do not wish to become involved, a steep slipping turn will be of great help.

Practise all these manœuvres. Not only are they of great practical value, but they will give you an astonishing amount of confidence in the aircraft that you pilot.

# THE PAY-OFF

HERE at last is the reward of all your labours and pains—soaring.

Staying up in the blue sky by means of skill and knowledge combining to defeat the pull of gravity; co-operating with the kindly winds and sun and clouds, to vie with the birds in the joyous freedom of the heavens. All those hours of standing around in the hope of a few seconds' flight—the tedious weeks of watching and waiting—all are forgotten as you receive your first soaring brief.

Thermal soaring or slope soaring—it makes no difference. Perhaps you are lucky enough to have a handy ridge or slope, perhaps not. In either case, all you ask for is the chance to try to stay aloft for five, ten, thirty minutes. The longer the better.

This is the way to go about it.

## THERMAL SOARING

This is the most difficult type of soaring. If you win your soaring badge by means of the canny use of thermal currents rising from a flat field, you may hold your head high in the presence of the man who was thrown into the steady lift of a ridge and could not help but stay aloft.

### *Thermal Currents*

What are invariably called "thermals" are masses of air moving up, more or less vertically. They will be present when the air is unstable—you can see when they are occurring by the formation of cumulus clouds in the sunny sky. They occur more frequently when the air is moist, but it is possible to encounter them on the driest of cloudless days—they are then more violent, and smaller, and more difficult to make use of.

A thermal takes the form of a bubble of air detaching itself from the ground and rising, just like a hot-air balloon. On a windless day it will rise straight up—with a wind it will drift along.

Unlike a hot-air balloon, a thermal is invisible. Your big problem is to find one, recognise it, stay in it. It will take you up with it to the clouds.

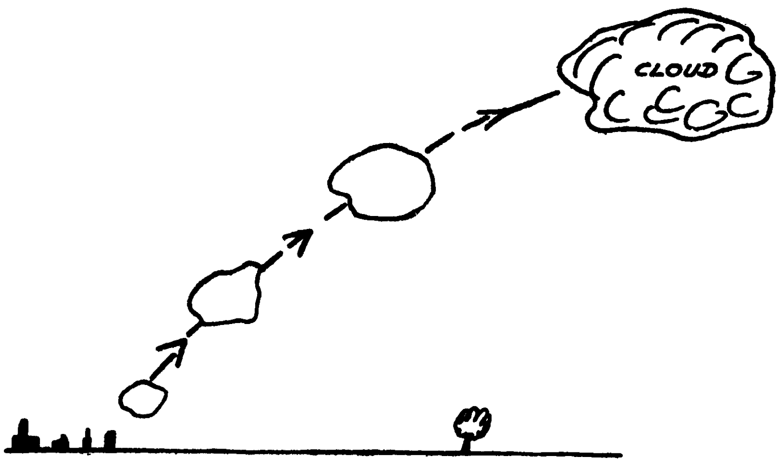



FIG. 49.

Thermals expand with height; therefore, the more height you obtain on launch, the wider will be any thermal when you run into it. You may recall that you have fallen into the habit of making a 360° turn directly over the winch. It often happens that the hot gases exhausted by the winch are unstuck when the cable falls, and ascend as a thermal.

On launch, your variometer shows a very high rate of climb, and takes some seconds to regain the true picture after you have released. If, when you have completed your 360°, it shows the normal rate of sink, fly off in search of thermals. If it stays above zero, you have been lucky and connected with the winch thermal.

A thermal announces itself with an upward surge. You hear it, you feel it in the seat of the pants, and after a brief interval the variometer rises above zero. Happy day!! The first indication you will get is the upward surge, with a slight increase in air-speed. Your nose will tend to rise slightly with the additional lift—keep it down and maintain your attitude.

You may enter a thermal squarely, or at the edge. In order to take the correct action to get centred in it, and so to take the greatest advantage of the lift it offers, you must understand what goes on inside the thermal.

It is a convection current and in constant turmoil. If you have seen water heating in a glass beaker over a Bunsen burner, you have some idea of convection currents. The air on the outside of the thermal cools more rapidly than on the inside, due to loss of heat through contact with the surrounding atmosphere. The warm air in the centre therefore rises more rapidly. Vertical and horizontal sections of a typical thermal are shown below—it is the horizontal section that you are more interested in.

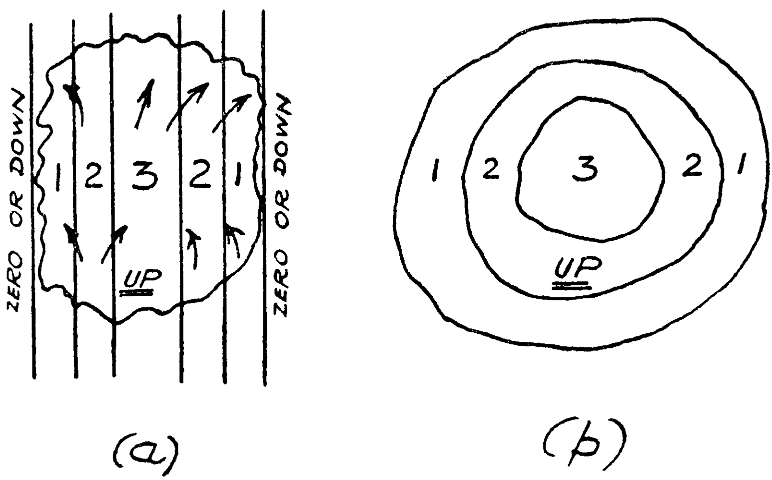



FIG. 50.

It can be seen that the centre of the thermal contains more "UP" than the rest of it. Your plan should be to circle tightly round the centre, and there are a couple of things to be taken into account. Firstly, the tighter the circle the greater the rate of sink. Again, the slower you fly the more effect the thermal will have in raising you vertically with it. You must, by dint of hard experience and according to the types of thermal you meet, decide the happy medium—whether a tight turn will give more "UP" than a wider, less steeply banked one. This takes a lot of learning. Once you are circling, keep an eye on your variometer, which will indicate your absolute rate of ascent, and keep in mind the fact that it has a time lag. When you do finally get centred and have an even rate of ascent all the way around, try varying the rate of turn until you get the best lift. Remember that the thermal will expand with height, and so you may expect to make wider circles as you get higher. You can make a check on your rate of turn by counting the seconds between the appearance of a fixed point on the horizon—the faster the turn the quicker it comes round.

Equipped with this knowledge, you enter your first thermal, say quite squarely, and surge up.

TURN!

Hold your turn and wait. Your rate of ascent will vary as you pass through the different parts of the thermal, and if you fly out of it you will find yourself in zero, or down. Keep the same rate of turn until you re-enter it, then straighten up; fly straight ahead for two or three seconds, and turn again in the same direction. Repeat this procedure until you are getting "green air" all the way round. You can then take time to adjust your track, in the same fashion, until you are getting even lift all the time, and rising steadily. (See fig. 51.)

If you meet the edge of a thermal, its effect will be to kick up the wing which touches it. Dig it down immediately and turn in that direction—you will then be in the thermal, and can proceed as before.

Thermals can be very turbulent indeed, and try to upset your attitude, bank, and comfort. Only time will help to get you used to this, but in the midst of all the bucketing about, which may make you feel a little queasy, try to maintain a critical mind. Apply your knowledge to what is happening, and acquire skill in forcing your will upon the sailplane—make it do exactly what you are intending it to do all the time. It is not hard, and the feeling of elation at watching the finger of the altimeter creeping

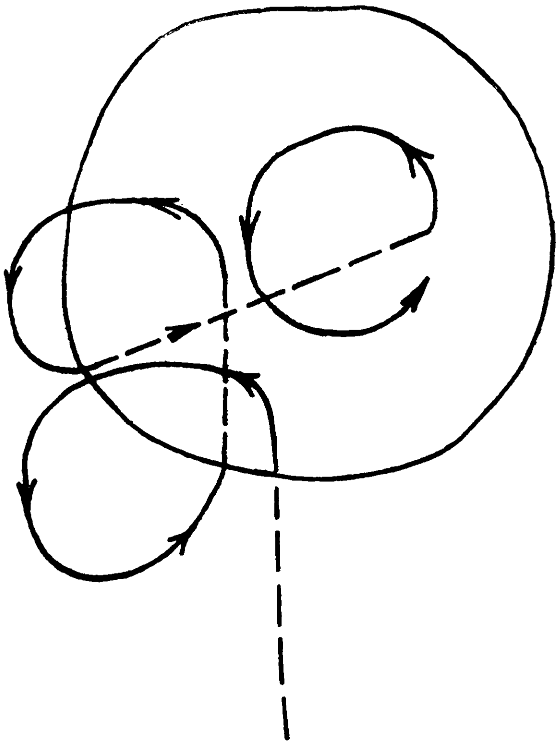


FIG. 51.

higher and higher is something to think back upon in the cold, thermal-less winter days.

When you pass the "C" stage and turn eagerly to thoughts of cross-country flights, remember that quick recognition, and expert use of thermals will get you farther than the man who has not mastered them.

In these early stages, don't let your enthusiasm run away with your discretion. In your determination to win all the height you can from a thermal, you may easily find yourself being carried along on the wind. There is a limiting factor of rise against drift which you should beware.

Take the sad example of Snoggins, circling merrily in a thermal which is drifting at 30 m.p.h. His sinking speed in still air at 50 m.p.h. is 3 f.p.s. and at 80 m.p.h. is 8 f.p.s. The thermal is lifting his machine at an average rate of 3 f.p.s.

In twenty minutes the sailplane has risen 3,600 ft., which, added to the 500 ft. at which the thermal was encountered, gives a total height of 4,100 ft. Snoggins is now 10 miles away from the field, and has to turn back and fly into a head wind of 30 m.p.h.

He suddenly wakes up, removes his head from the office, and starts to fly back at 50 m.p.h.—his groundspeed is then 20 m.p.h. It will take him half an hour to travel that 10 miles, and in that time he will sink 5,400 ft.

Realising that he is flying a sailplane and not a submarine, he puts up his speed to 80 m.p.h. Now it will take him twelve minutes at 50 m.p.h. groundspeed; in that time he will lose 5,760 ft.

After a lot of fiddling about, and perspiring, Snoggins finds that the best thing he can do is to fly at 70 m.p.h., at which speed he sinks at only 4½ f.p.s. His groundspeed is 40 m.p.h., and it will take him a quarter of an hour to return. In that time he will lose 4,050 ft. and scrape in over the boundary with 50 ft. in hand, IF he does not meet a down-draught.

Where there are thermals, you can be sure that the downward currents also exist, and will increase one's rate of sink considerably.

Leave your thermal immediately you think you are getting too far away from the field—you may meet another one, but if not, it is better to be sure than sorry.

## RIDGE AND SLOPE SOARING

Although in the main rather less skilful than thermal soaring, this type of sport has its own problems and, in many ways, advantages. In flying along the ridge you may often meet thermals. Unlike the pure "thermal type", who operates from some barren expanse of flat land, if you fail to get into the thermal the first time, you can return to the ridge and stay up until you meet another. Even if you don't, it doesn't matter—as long as the wind holds, you can fly.

*Ridge Lift*

Ridge soaring depends basically on the wind. When it blows hard enough, in the right direction, lift in abundance is available over your local ridge. The quality of the lift depends on atmospheric conditions, but as long as there is wind, there will be usable lift.

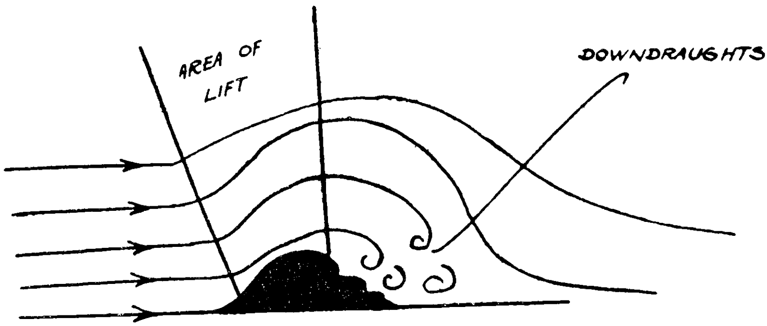



FIG. 52.

The wind travels over the surface of the earth, and on encountering a ridge or slope is thrown up, forming a kind of wave over the rising ground.

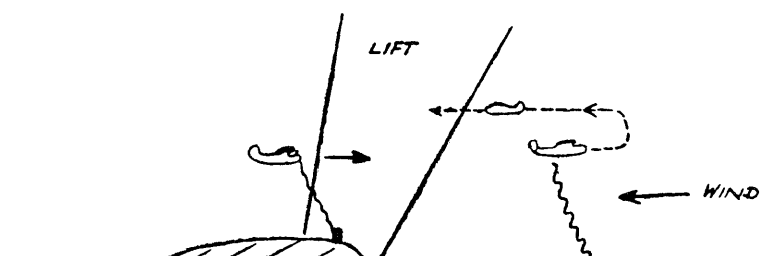



FIG. 53.

Above the front edge of the ridge will be the lift, its upper limit depending on the wind and weather and the shape of the ridge. Regardless of local features affecting it, assume that it is there, you want to get into it.

You can be launched from the bottom of the slope and fly back into the lift, or be launched directly into it from the top. Either method is satisfactory, and the only difference in the two kinds of site is in the manner and method of landing.

Once in the lift, you turn and fly along the top of the ridge. The lift will be smoother and less turbulent than thermal lift, but you may meet with gusts and encounter thermals. Fly steadily, and by using your variometer, you will be able to see along which line the best lift lies. A local contour map will help, and the knowledge of resident experts will be worth untold gold. Rise until the lift expires and then tour the ridge with interest, accustoming yourself to the local geography.

There are certain rules to be observed when you are ridge soaring. Usually many sailplanes will be using the ridge at the same time, and safety precautions are essential.

1. When you wish to turn and retrace your path, turn away from the ridge. It is advisable to increase your speed slightly when doing so, to obviate any chance of getting blown over the back of the ridge into the down-draught.
2. If you overtake another aircraft, pass it on the inside.
3. The aircraft with its starboard wing into the ridge has the right of way. Keep clear of it.
4. If you meet a thermal, don't start circling madly until you are sure that you are clear of other craft approaching along the ridge.

Behind a ridge is normally violent down-draught, and the whole time you are soaring you must keep an eye open to see that you are not creeping back into it. If you are, just increase speed and fly straight away from it.

### *Landing Behind*

Landing below the slope is simple, but landing on top of the ridge is made tricky by the presence of down-draughts. On returning from the ridge, keep plenty of speed on the clock. Check the wind direction from the windsock, chimney-stack, or other local indicator, and then choose your landing spot.

Turn back over the ridge, and once you have chosen your approach, *put on plenty of speed.* Your approach angle is likely to be extremely steep, and the down-draught variable in the extreme. Use your spoilers intelligently and maintain a straight approach. Remember that in big down-draughts you will have the gliding angle of a brick, and if you jink about on the approach, you will undershoot madly.

Sometimes you may have to land uphill on the reverse side of a slope.

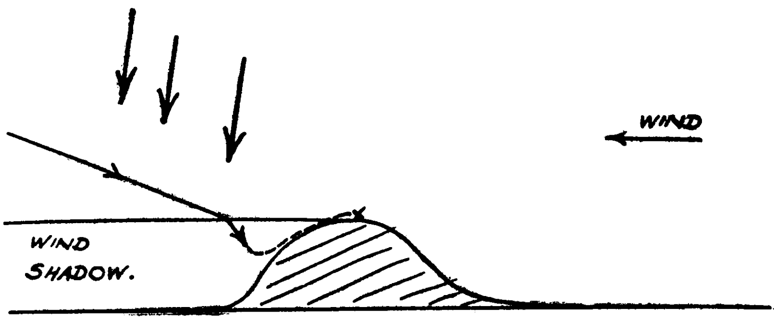



FIG. 54.

Realise that in addition to down-draught you will then have to fly through a wind shadow, which will cause a gradient. This again will have its effect on your approach, and the answer to it is speed. Level out some way below the top of the slope with at least 50–60 m.p.h. on the clock, and fly parallel with and *close* to the earth. Your increased angle of attack will quickly kill your speed, and you will make a normal landing up the slope.

*Bunje Launches*

A "bunje" is nothing more than a large rubber catapult. It is hooked into the nose of the sailplane, and a strong man holds the tailskid. Six or a dozen volunteers take the loose ends of the rope, first walk away with it, and then start to run downhill. When the strong man can hold on no longer, he lets go, and the sailplane is hurled forward and up over the edge of the ridge into the lift.

It is a crude method of launching, but cheap and effective. It can be used for primary training, but is not recommended.

One thing—if you have been brought up on bunje launches, where the cable falls away of its own accord, remember that you must release the cable when being launched by winch. Elementary possibly, but an easy trap to fall into.

This is where you take time out to go and win your "C" Soaring Badge.

*Airmanship*

Don't let it go to your head—there is still a lot to be learned. Always think of the fundamentals of good airmanship, and take no chances. Most "prangs", major and minor, are caused by over-confidence, and inattention to detail.

ALWAYS—

Ensure that your aircraft is in all respects fit to fly.

Be sensible enough to ask your instructor, or a more experienced pilot, if you are in any doubt at all.

Concentrate on launches and landings.

Keep an eye on the weather.

Look out for other aircraft.

Remember that the good pilot is the safe pilot—showing-off is unsafe, and as bad form in this sport as in any other.

And now—Good Luck and Happy Landings!

## WINCH-DRIVING

If you can learn to drive a winch, do so. It will not only help your fellow pilots, but give you a better understanding of the principles of launching, the effect of weather conditions, and will improve your feel and flying in some intangible manner. A good winch-driver is an asset to any club.

A winch is very much like a car in that it has an engine, a clutch, gears, a throttle, and a brake.

Sit beside a qualified driver and watch him nose-launch the primary for a circuit.

On the signal, he puts the gear in mesh, selected according to the wind and type of glider to be launched. Slowly he increases revs and lets the clutch take up *gently*. As the drum starts to revolve, he eases the clutch a little and lets it slip a bit. As the slack of the cable vanishes, he holds it taut by increasing revs without altering the position of the clutch. On the next signal, he raises revs quite a lot and lets the clutch out S-M-O-O-T-H-L-Y. The glider begins its slide along the ground. Revs are increased and the clutch let out until it is fully home. Soon the glider lifts and begins its climb.

The winch-driver keeps the revs constant. Look at him—on his face is an expression of taut concentration.

By experience he knows that the amount of sag in the cable is right for the correct launching speed. Suddenly the glider kicks its nose up—wind gradient or thermal? Revs are dropped smoothly; the cable reassumes its sag. It was a wind gradient. Had it been a thermal, the glider would have flown out of it, and there would have been no need to decrease revs—the cable would have sagged again of its own accord.

You speak to the driver and distract his attention, just as the glider hits another wind gradient. The driver looks back at the glider, and it is pitching. This is a sign that the speed is too fast, and he cuts down the revs.

On a C.G. launch that distraction might have caused a cable break, for the increase of speed would not have been apparent.

Winch-driving demands fierce concentration and an understanding of every movement of the aircraft on the end of the cable.

Soon the glider is approaching maximum height, and you notice that revs are getting progressively lower without any apparent effect on the speed of launch. The reason is that the drum has more cable wound on to it, and therefore the length wound in on each turn of the drum is progressively increasing.

It is difficult to attempt to teach winch-driving except by precept, and you should sit beside an expert and watch him patiently until you think you have the general idea. Then let him sit by your side while you learn, stage by stage. The easiest launch is a full-height nose launch—the hardest, by far, an airborne slide.

Here are a few tips to assist you:

1. Taking up the slack entails bringing in the cable slowly, and it is done by maintaining a balance between throttle and slightly slipping clutch. Once the cable is "all out", keep it taut while you increase revs preparatory to commencing the tow.
2. Jerking on the clutch or throttle is upsetting to the pilot of your tow. It may also break the cable or stall the winch motor; the effect on the pilot is the same.
3. Give your "customer" a smooth groundslide at progressive speed until he rises from the ground. Don't yank him off in a hurry, especially if he is a novice.
4. Once he has become airborne, increase speed slightly to obviate any chance of a stall on the cable, and thereafter maintain a steady speed of launch. The sag in the cable is due to its own weight, but the winch effort is nevertheless being transmitted. As the cable shortens, the sag will decrease because (*a*) there is less weight of cable, and (*b*) the angle between the winch and the glider is becoming greater. When the tow is almost overhead, the cable will appear

quite taut. Changes in the amount of sag are due to weather. In turbulent or gusty conditions it will alter quite often during a launch. Keep the speed constant and let the aircraft accommodate itself to the variations, except in the case of a wind gradient, with which you will have to deal—already mentioned.

5. Get to know your "customers". Soon you will be able to tell who is on the end of the cable by the manner of his launch, and make allowances accordingly. Similarly, see that you are *en rapport* with the instructor; each one of them has his own way of teaching, and it is important with beginners to see that what happens is what the instructor has told them will happen.
6. Excessive speed can be signalled by the pilot dipping his nose up and down; insufficient speed by rocking his wings. He knows how fast he is going—help him out. Don't mistake corrections to turbulence as a request for more speed—you should have an idea of current conditions.
7. Before commencing a spell of winching, check that you have plenty of petrol and that the motor is warm. This will avert winch-stalls. Make sure that the guillotine is in working order. You may never need to use it, but if you do, it will be imperative. *In any case, where the pilot forgets to release, or passes over the winch before releasing, use the guillotine immediately.* A cable can be spliced—a neck cannot.
8. See that the driver of the cable-towing vehicle understands that the cable should be laid out in a straight line. Kinks in the cable will set up harmonic vibrations and cause a yawing launch. This can be corrected, but it is better if the pilot starts off in a straight line.
9. When you decide to end the launch, cut the revs rapidly and smoothly. Once again, think of the chap on the other end.
10. *Airborne slides.* You will sooner or later have to give these, and hops. The safety of the novice is then in your hands, and no matter how careful the briefing has been, he may act

unexpectedly. Give him a longer groundslide than for an experienced pilot, and then lift him smoothly. Never mind if he goes higher than you intended—he may be playing around with the stick. Keep a steady tension on the cable and let him down gradually.

If he panics and pulls back on the stick, he will start to shoot up in the air. DO NOT SLOW DOWN. Whip up the revs to accommodate the increased drag until you are lifting him; then slowly cut down until he is on the ground. Keep an eye on his climbing attitude from first to last.

11. Always give your whole attention to a launch; suffer no distractions. Put yourself in the pilot's position—he relies wholly on you for his safety.
12. When the wind is high, it is advisable to use a lower gear than for still air. The same pull will be needed on the cable, and running more slowly in high gear is bad practice; it strains the winch and control is less sensitive. Always have plenty of torque on tap.

## KITE LAUNCHES

With a really high, steady wind, which is faster than the stalling speed of your tow, you can carry out what is known as a "kite launch", enabling the pilot to reach a great height—sometimes as much as 3,000 ft.

It needs co-operation between pilot and winch-driver, and should be agreed beforehand.

You know by now that winds are faster above than on the surface. On a day when the surface wind is 20 m.p.h. it may be blowing at 40–50 m.p.h. at 800 ft. This will be the wind that you want to use. You also know something that you were not told prior to gaining your "C"—that quite a few feet can be added to your height on a C.G. launch if you put a backward pressure on the stick during the last third of your climb. As a winch-driver, you have noticed experts using this dodge—which is intrinsically dangerous, and must be used with understanding and care.

Give your tow the best height you can. When he is nearly at at the top of the launch, slow down the revs and slip the clutch delicately until the sailplane is holding the cable stationary. Then apply the brake to the drum and release the clutch simultaneously until you have the aircraft flying like a kite on the end of a cord. The passage of the wind will be producing enough lift to keep it flying. Release the brake and allow the cable to run slowly off the drum. The sailplane will fly with negative groundspeed and take the cable with it. When the cable is all run off the drum, recommence towing. Repeat this procedure until the aircraft is at maximum height, with almost all the cable off the drum. Then abruptly cut your revs and release the clutch. This will give the pilot a definite signal to release.

One important point is this: when the sailplane is drifting back, it must be allowed to do so SLOWLY. All that keeps it flying is its airspeed. Take this example:

| | |
|---|---|
| Wind speed over 350 ft. . . . | 55 m.p.h. |
| Stalling speed of tow . . . | 40 m.p.h. |
| Cable speed (i.e. groundspeed) . . | 10 m.p.h. |

On the tow, over 350 ft. height, the airspeed will be $55 + 10 = 65$ m.p.h. Groundspeed 10 m.p.h.

As you bring the cable to a halt, airspeed is windspeed only, 55 m.p.h.—still enough to produce good lift. Groundspeed nil.

Now then, when you allow the tow to drift back towards its next start, if its groundspeed exceeds 15 m.p.h., it will stall, as its airspeed will be less than $55 - 15 = 40$ m.p.h.

If you remember that one important feature, you should be able to execute a kite launch without difficulty. It can be used on a day of good cloud but high wind. On an ordinary launch, thermals would be useless—blown to bits and weak. Under the clouds, however, is good lift and the avenue to many a fine cross-country.

### WINCH MAINTENANCE

Take care of your winch. Remember that it needs lubrication at all bearing points; water, oil, and petrol for the engine. The tyres should be kept at the right pressure. Give it periodic overhauls and keep a maintenance log-book of hours run, fuel and oil consumption, repairs, modifications, and all other history.

Watch your cable for fretting, stretching, kinking, and all signs of wear. Do this each time it is being retrieved, and periodically have it run right out for the express purpose of examination. If it breaks during a day's flying, you can effect a temporary repair in a thin cable by putting a knot in it, cutting the knot out at the end of the day and making a proper spliced job of it.

Put in a reef-knot; haul it tight; bind the running ends to the standing parts with soft copper wire, and cut the frayed ends off with a wire-cutter about an inch from the binding. After a launch, this knot will pull up tight and be very little wider than the cable itself.

## CARE OF AIRCRAFT

TAKE great care of your machines. They are strong, but easily damaged. Sensitive, but easily put out of adjustment. Beautiful, but can be soiled and made bedraggled.

On their integrity depends your safety. On their response, your flying. Their beauty is not only æsthetic, but purposive; a good skin finish means improved performance.

Keep them away from small children, inquisitive dogs with great questing paws, curious old ladies with shooting sticks and umbrellas. Allow no one to poke a finger into the fabric, fiddle with the controls, or otherwise interfere.

Treat them as you would a beautiful woman—with care, with sympathetic treatment, and with dutiful attention.

Major and minor inspections are matters for those skilled in such things, but you can learn to make daily inspections. Not only will this help the club, but will give you confidence in the machines that you fly.

Go about it methodically. The principle is the same for all types of glider, but start with a primary.

1. Check all flying wires for tension, fraying, or wear.
2. See that all cotters have a retaining split-pin or safety-pin.
3. See that all turnbuckles are bound with wire, and that the binding wire is secure and unbroken.
4. Check all control cables for wear, tension, and free movement.
5. Check all flying controls for free movement and correct action. See that all hinges on control surfaces and flaps are secure.
6. See that the seat and safety straps are firmly secured.
7. Examine wingroot junctions.

8. Test wings for sprung ribs, punctured fabric, and soundness of spars. Hold the wingtip and give it a shake. If ribs are damaged the fabric will ripple. Apply torsional strain to the wing with a view to testing stressed parts.
9. Do the same with tail and rudder.
10. Look carefully at the skid, A-frame, and all wooden components for cracks, warping, etc.
11. Check the releasing gear.
12. Before signing the Daily Inspection Book, ask yourself if the aircraft is in all respects airworthy. If you are satisfied that it is, test-fly it yourself.

When carrying gliders, don't leave dirty marks on the paintwork. Don't lift the wingtips, trailing edges, tail, or anywhere but at recognised lifting points. Make sure that wingtips and rudder are well clear of hangar doors, other aircraft, and all obstruction.

When gliders are being towed behind a vehicle, see that the driver takes up the strain gently and tows slowly, especially if the ground is rough. Slip a safety-strap over the stick to hold the elevator still, and put a lock on the rudder. Never let the driver swing around sharply and bring the sailplane round in a tight circle with the tailskid on the ground; this will put a lateral stress on the fuselage, which is not built to take it. Keep the wings at right angles to the tow, or you will strain and damage the skid.

Never leave a sailplane in the open without full spoiler exposed, and wing down into wind. If the wind is strong, weight the wingtip.

In heavy rain, close the spoilers, or water will seep into the wing. If possible, get the machine under cover, or at least put a coat, tarpaulin, or even a piece of board over the cockpit where you have an open hood.

Skids come in for a lot of heavy work, and a damaged skid can spoil a day's flying. The following faults are the most common ones which damage skids:

Landing with drift on.

Stalling on to the ground.

Towing at an angle.

Landing too steeply. The back of a skid is sprung, the front is anchored.

Swinging a glider around on its skid; always lift them.

### RIGGING AND DE-RIGGING

Due to lack of storage space, many gliders have to be de-rigged at the end of each day and reassembled next time. Treat them gently, and remember:

Locking-pins are meant to fit. Do not knock them out with a hammer, or drive them home without the aid of a soft metal drift.

A spot of grease, regularly applied, saves a lot of hammering and frayed temper.

Safety-pins and nuts and bolts should be put back immediately on the place they have been removed from.

If wings and rudders and things are left lying around, they are bound to get trodden on. Lean them against a wall where they are out of harm's way.

When you have rigged a machine, get someone else to check over it for you; it is so easy to leave out an essential piece of the works.

When stowing on a trailer, ensure that all parts are in the right place and securely strapped down. And don't tow too fast.

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