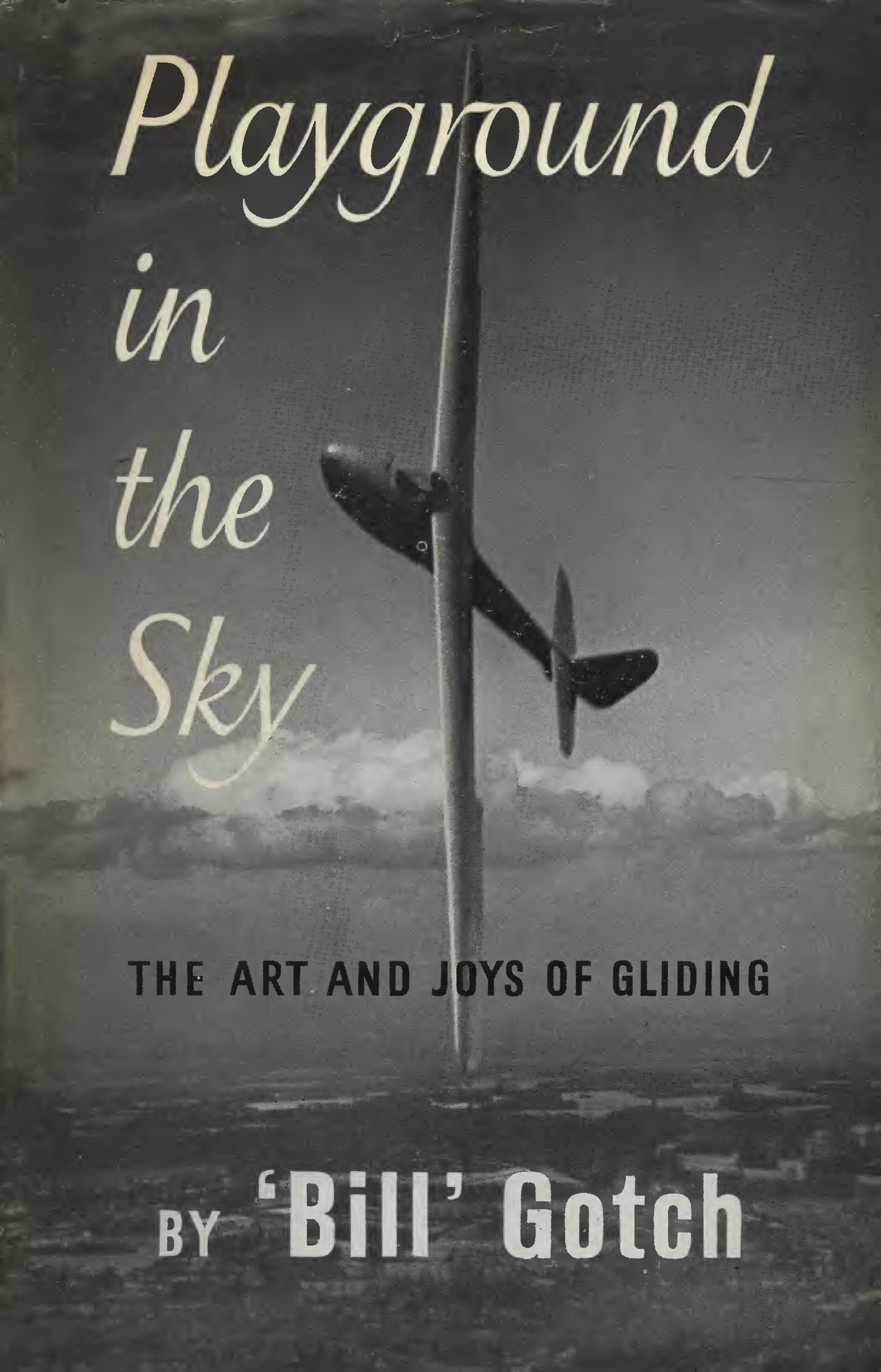
Playground in the Sky



THE ART AND JOYS OF GLIDING

BY 'Bill' Gotch

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PLAYGROUND IN THE SKY

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THE ART AND JOYS OF GLIDING

A. F. "BILL" GOTCH

WITH 34 PHOTOGRAPHIC ILLUSTRATIONS
AND 25 LINE DRAWINGS BY THE AUTHOR

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Silent and solitary he sits aloft,
Under a towering cloud that draws him upward,
Into its darkening dome,
He flies.
What is the hidden power up there,
Under that towering cloud that draws him upward?
Ten thousand silent horses,
In disguise.
Only the sailplane pilot knows,
Under the towering cloud that draws him upward,
This is Nature's gift,
In the skies.

A. F. G.

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INTRODUCTION

My principal aim in writing this book is to encourage this country to become more air-minded, and to have a love of the air in the same way that we have always had a love of the sea. There can be little doubt that the sport of gliding is a splendid medium through which to bring this about, as I hope to show in the pages that follow. The book is intended to be an explanation of what gliding is, rather than a text-book to teach people how to fly.

How pitifully little is known in this country about this fascinating, adventurous, and modern sport, right here on our doorstep! In this department of flying we lag well behind many other countries, although recently we have had a great achievement in the international field. When I returned to England in 1952 after a year in East Africa I found that nobody here knew that we had just won the International Gliding Contests in Spain; indeed it was not even known among the general public that such an event had taken place. During the year 1954 the International Contests were held in England, and this certainly provided an opportunity for the sport to become more widely known and appreciated.

No doubt many will say that I am rash to write this book after the publication of that excellent book about gliding—*On Being a Bird*—by Philip Wills, World Gliding Champion 1954. My justification, if any is needed, would be to say that I shall approach it from a different point of view; more a beginner's point of view. A beginner, however, with enough experience to have been thoroughly 'bitten by the bug', as Philip so aptly puts it.

I have tried to present the subject in such a way that even a reader who knows nothing about aircraft and flying will be able to understand it; readers who consider themselves to be in this category would be well advised to study Chapter IX first. I hope the book will also prove readable for the experienced pilot, for the simple reason that anyone who has a love of the air, and aircraft, likes to read about them.

CHAPTER I

FLYING WITHOUT AN ENGINE

Our remedies oft in ourselves do lie,
Which we ascribe to heaven: the fated sky
Gives us free scope; only doth backward pull
Our slow designs when we ourselves are dull.
—*All's Well that Ends Well*

RECENTLY, while on holiday, I found myself high above the green fields of Shropshire, floating quietly and peacefully in a world of blue sky and white, fleecy clouds. I had not attained this height by means of a screaming, rattling engine, or any other man-made power, but by using the power given to us by Nature: first, my friends, who had launched me in a sailplane from the top of a high hill; and thereafter the unseen power in the sky, that my gliding friends and experience have taught me to use.

During the space of about half an hour I had climbed quietly to 4,000 feet, and while enjoying the remarkable view across the distant hills of Wales I could not help thinking to myself: "What a pity that only a handful of people in this country have ever had this experience. What can I do to make it known that this is not just a trick, only to be learnt by a few, but that this is a modern sport, open to all?"

. . . . .

Most people think that gliding is beyond the reach of ordinary folk, both as regards cost and skill, that is assuming that they ever think about it at all. This is not true, although of course the cost will depend on how much you fly. I shall not go into details about cost here, because if the reader becomes sufficiently interested to want to fly, and continues reading, he will come to a chapter called 'Gliding Clubs', where all that sort of thing is explained in full. Gliding is a sport in which the whole family can take part. Children can learn to fly a dual control two-seater as soon as they are big enough to reach the controls and look over the side, though they are not allowed to fly solo until the age of sixteen. I know boys who have become quite capable pilots at the age of thirteen or fourteen, and the instructor, who must accompany them, just sits back and takes it easy. Girls take part in all gliding club activities, and often make good pilots.

As regards skill, almost anyone could learn to fly a glider well enough to be launched and to glide down safely to land. Such a flight would last from three to four minutes. I am sure it would not be so terrifying as one's first efforts on a bicycle—assuming one had not 'cheated' by learning first on a scooter—and the actual flying almost certainly not more difficult. Landing is a part that requires very good judgment. I should mention here that a friend of mine did his first solo and made a perfectly safe landing after doing only five instructional landings in a dual control two-seater. Whether the pilot can stay up for any length of time—in other words whether he can soar—is a question that can never be answered until he has been up and tried, and failed, and tried again, perhaps many times. But you would not expect the landlubber to get into a sailing dinghy and sail it out of the harbour and across the bay until he had had a bit of experience. Gliding is really airborne sailing, but with an important difference: if you are not very clever with your dinghy it will not matter if you stop a moment to get yourself sorted out, or if the wind drops you can sit still and whistle for it. But there is no stopping in a glider, and there is no whistling except that made by the wind as you return, willy nilly, to the ground.

At this point I should explain the difference between a glider and a sailplane. Strictly speaking a glider is only capable of gliding down from the point where it is released from its launching cable. Such a machine is only used for instructional purposes, and is almost obsolete, as nowadays instruction is

Photograph by Teddy Proll, Midland Gliding Club

"High above the green fields of Shropshire"

PLATE I

Photograph—Reuters

"Girls take an active part in all gliding club activities"

"Landing is a part that requires very good judgement" *Photograph by the Wiltshire Gazette*

PLATE II

The Slingsby Sedbergh 2-seater trainer *Photograph by J. Cochrane, Bristol Gliding Club*

usually given in a two-seater dual control sailplane. The sailplane is much more efficient, as a racing yacht is more efficient than a dinghy, and therefore has a much better gliding angle, probably about 1 in 25. That is to say it will fly twenty-five feet forward for every foot it loses in height. A pure and simple glider as is sometimes used for training purposes, usually known as a 'primary', probably could not boast of a better gliding angle than 1 in 8, which means it will only fly eight feet forward for the loss of one foot in height. It is quite correct, and in fact usual, to speak of a sailplane as a glider; it is in fact both. It is not usual, however, to call a primary glider a sailplane, although it may, in fact, be capable of soaring in exceptionally good conditions.

And now we come to the point that usually worries the layman, the 'groundlubber', and the uninitiated. A glider, *or a sailplane*, is always descending relative to the air in which it is flying. It cannot put its nose up and climb like a powered aircraft. True, it can climb for a brief period, by losing forward speed, as it must do in performing a loop or a stall turn, but it cannot hold, for any length of time, a climbing angle. It depends on the pull of gravity for its forward movement, like a car coasting down a hill, or a ski-er sliding down a mountain; if they were to turn *uphill* they would very soon stop, and so would a glider. But a glider or an aeroplane cannot be allowed to stop; they depend on their forward movement to make the air give the necessary support.

Now let us for a moment indulge in a flight of fancy. Imagine that you are coasting down a mountain on a bicycle that has no pedals. Instead of being on a road you are on nice smooth gently sloping ground, and so you can turn in any direction you like; naturally you must not turn up the hill, or you would stop, and fall off, so you keep going at a nice steady speed by steering slightly downhill. Now we will pretend you have got to get *up* your mountain. "Impossible," you say, "without pedals." But it's not impossible, because certain parts of the mountain are moving upwards, like a vast magic carpet. If you can get your bicycle on to one of these upward-moving parts you will be able to go up with it. You will have to find a piece of ground that is moving upwards a little faster than you are coasting down. If you are coasting down at 10 m.p.h. and you find a piece of ground going up at 15 m.p.h. you will be actually gaining height at 5 m.p.h. (*see* Fig. 1). Having found this convenient bit of ground you stay on it by zig-zagging about, always slightly downhill to give you enough speed to balance, but not too fast so that you will not entirely counteract the upward speed of your magic carpet. "This is indeed a flight of fancy," you will say. I agree. But get into a sailplane, and go up into the air, and it will be a flight of fact. The air, on a hot summer's day when you see those white fleecy clouds about, is full of such magic carpets, and very often going up at speeds far in excess of anything you could hope to achieve on your bicycle, even if you turned it round and pedalled uphill for all you were worth.

So the only way in which a glider pilot can actually gain height is by finding one of these magic carpets: a huge bubble of air that is going up, and going up faster than his glider is coming down. Having found it he must know how to stay in it. There are lots of these bubbles of air going up, and on some days there are more than others. There is also a lot of air coming down, but this is a good thing on the whole, because otherwise there would soon be no air left below for us to breathe! This descending air the glider pilot must avoid like the plague. Most people no doubt imagine that winds only blow horizontally; how would they know otherwise, walking about on the ground? But winds blow horizontally, vertically upwards, vertically downwards, and at all angles between.

While we are on the subject of winds I should like to dispel once and for all the mistaken idea, common among the non-flying fraternity, that a glider is at the mercy of the wind, like a balloon. There was a report in one of our daily papers some years ago which, apart from being laughable to a glider pilot, illustrated the complete ignorance about gliding of those

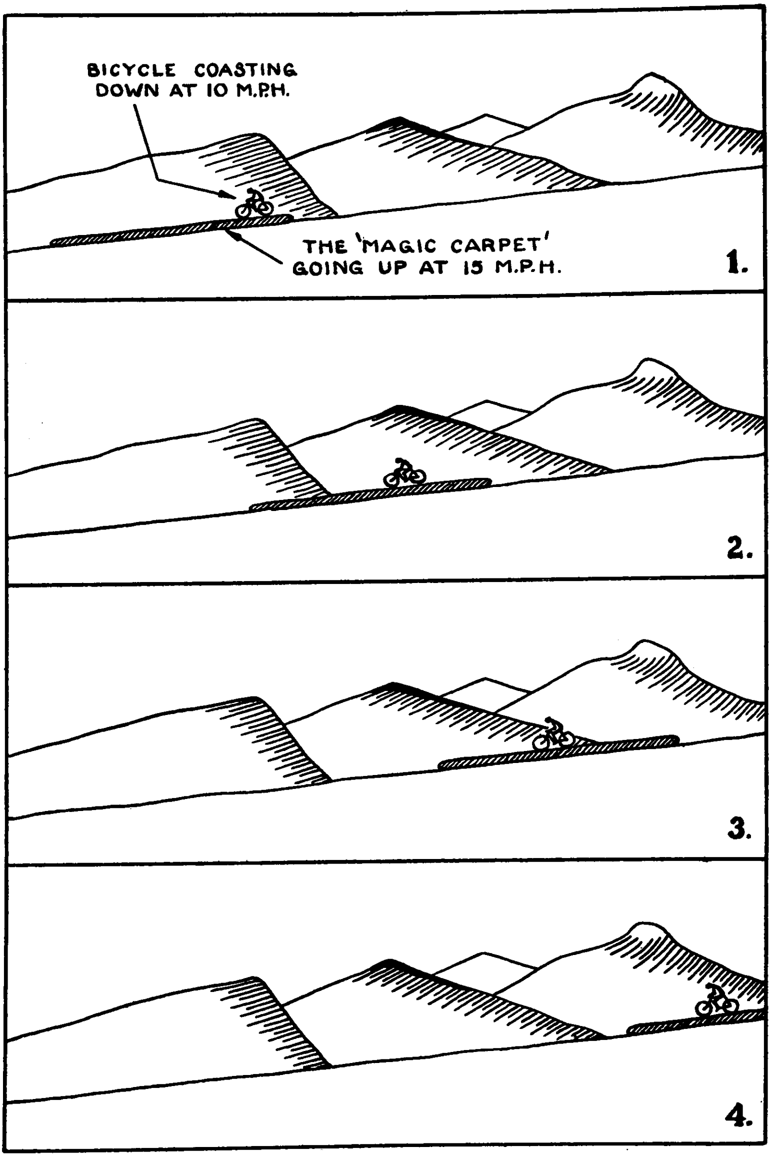


FIG. 1

What happens when he gets to the bottom of his magic carpet? Well, like the sailplane pilot, he must find another one, and quickly too

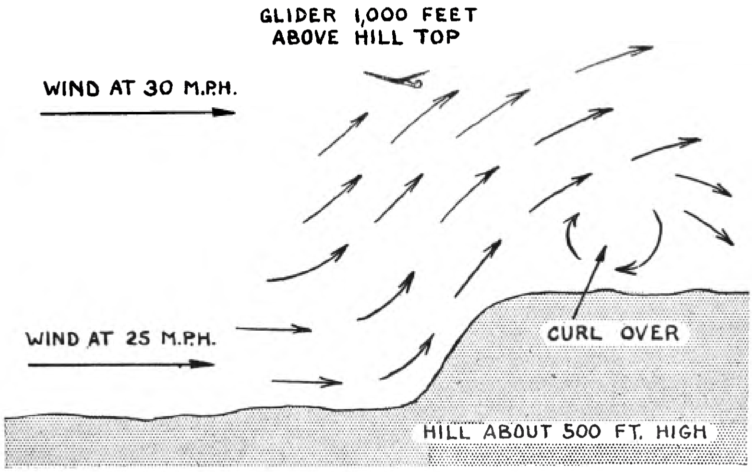


FIG. 2

Hill soaring

responsible for its publication. It ran: "Caught by a strong current when competing in the British Gliding Association Championships at Great Hucklow, Mr. Wills, a Londoner, continued a distance of 38 miles before his glider struck a stone and overturned." If this kind of thing is what the public get to read, naturally they are misled and ignorant too.

A glider can fly with the wind, against the wind, or across the wind. It is controlled and steered just like an ordinary aeroplane, and so long as the pilot maintains his forward speed *by gliding down*, he can fly it where he likes. He can also land it where he likes, providing of course that he gets to the selected place before 'running out of height'.

The simplest form of aerial magic carpet, or 'lift' as a glider pilot calls it, the easiest to find and the easiest to stay in, is the wind blowing up the side of a hill.

Flying by this method is known as hill-soaring. Fig. 2 shows it in diagrammatic form. Notice how high the glider can climb above the top of the hill given a sufficiently strong wind.

Then there is another type of wind going up caused by convection currents. Suppose you have a dry, chalky, ploughed field surrounded by grass fields. Sunshine will warm up the chalky soil more quickly than the grass, and a huge bubble of warm air gradually forms over the ploughed field. The warm air is lighter than the surrounding cool air because heat makes the air expand, and then finally it breaks free and goes up, like a hot-air balloon with no container. More air must now come in to take its place, and will in turn be drawn up by the rising air above it. This column of rising air is called a 'thermal' (*see* Fig. 3). Have you ever noticed on a hot summer day, when there is little or no wind, sometimes you suddenly feel a breeze spring up, causing a rustling of the trees, and then presently it dies away again. Somewhere in your neighbourhood a thermal has gone up, and the breeze you feel is the air rushing in to take its place. So this bit of horizontal wind will soon be a vertical wind. The sun on a tarmac road can cause the start of a thermal; you will probably have noticed on a hot summer day that you can actually *see* the hot air rising. Flying in this type of lift is called thermal-soaring.

There is one more type of lift, which has only recently been

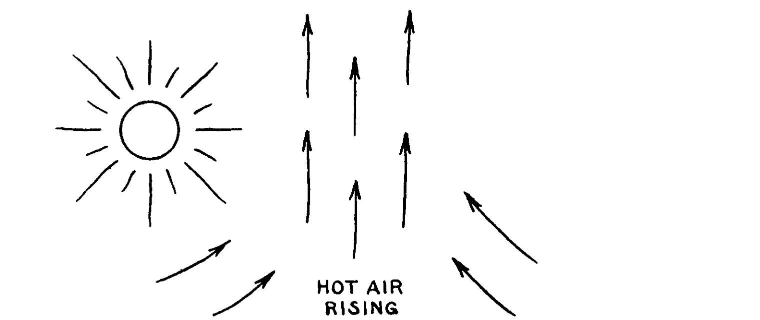


FIG. 3

The start of a thermal

discovered, or at least has only recently been given a name and recognized as different from the other two. Have you ever watched a fast-running stream and noticed how the water pours over a boulder and forms waves on the down-stream side of it? There is first a big dip, and then a big rise, and the subsequent waves get smaller and smaller and finally disappear. Fig. 4 illustrates this happening in the air.

The waves remain stationary in relation to the river bank, and yet the water is running through them; just the opposite to waves in the sea, which travel along and the water remains stationary. This type of wave in the air remains stationary just like those in a river, and so they are called 'standing waves'. As they occur on the lee side of a hill they are sometimes known as 'lee waves'. But there is a very important difference between this type of wave in water and standing waves in the air: in water the height to which the wave can build itself up is limited by the surface of the water; in the air there is no definite top surface, but only a gradual falling off in density. If conditions are suitable standing waves in the air can build up to a great height; many times higher, in fact, than the hill or mountain that starts them off. The glider pilot must get into the part that is going up and try to stay there, but as you cannot see them this is not always too easy! Some indication of their existence and position is given, however, by 'wave clouds' which form at the crests.

More details about these three types of lift and how they are used will be given in Chapter III.

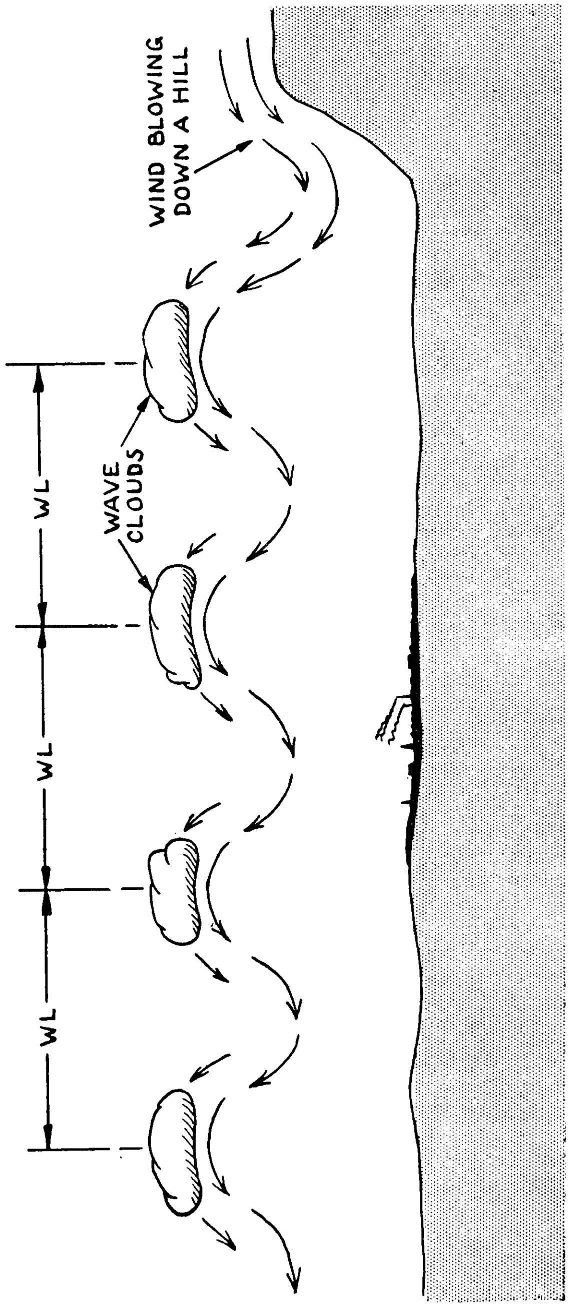


FIG. 4

The Standing Wave

The wave-lengths, marked WL, are always equal. The wave-clouds are seen in end-view in this diagram, consequently the characteristic cigar-shape does not show

CHAPTER II

GETTING INTO THE AIR

A GLIDER is helpless on the ground, like certain birds, and cannot get itself into the air. Once in the air, however, it is the most graceful thing that man has made, not excepting even the sailing craft, and for those who like thrills and adventure, gliding is one of the finest sports in existence today. The only other sports I know that can be considered in the same category are ski-ing and sailing. Far be it from me to decry these fine sports, both of which are among my favourites, but in these man is restricted to two dimensions. The glider pilot has no such restrictions; he has the complete freedom of the air in which to pit his skill against the force of gravity, and to use the vast and unseen power in the sky that only the glider pilot is privileged to experience.

To become airborne the glider needs a team, and, what is more, a team that know their job, and can work together in perfect co-ordination. It is remarkable how gliding fosters this team spirit, considering that a pilot, once in the air in a solo machine, must depend entirely on his own resources. Any budding enthusiast who is not prepared to take off his coat and get down to the donkey-work, of which there is plenty in a gliding club, will soon become an unpopular member. But it seems the reward more than compensates for the work, and in fact the work, carried out in the company of congenial kindred spirits, is a joy in itself to those who like *doing* things, rather than just watching other people doing them. Recently I spent a week's holiday at a gliding club, and one of my friends had been plodding up and down almost the entire day, helping with launching and retrieving, but buoyed up by the hope of getting a 'conversion', later in the day, to an advanced type of sailplane. He got his conversion; the flight lasted at most five minutes. That evening, while we all sat

Photograph by Swiss National Tourist Office

"Like . . . a ski-er sliding down a mountain"

PLATE III

"Gliding is really air-borne sailing"

Photograph—Becken

PLATE IV

"Four different things can be used instead of the small boy":

"Six strong men" (?)

"A motor-car"

"A winch"

"An aeroplane"

talking of the day's doings in the village pub, he said to me, "I would never have believed that a five-minute flight could have made a whole day's work on the ground seem worth while."

Well, after that preamble we had better get on with the business of launching.

The principle on which the launching of a glider works is exactly the same as that used by the small boy launching his kite; he runs into the wind, so that his ground speed will give the kite additional speed relative to the air. If the wind is blowing at 10 m.p.h. and he runs at 5 m.p.h. the kite will have an air speed of 15 m.p.h. For launching a glider four different things can be used instead of the small boy, namely:

(1) Six strong men.
(2) A motor-car.
(3) A winch.
(4) An aeroplane.

We will take these in order and explain in more detail what happens.

The Catapult Launch

This is always known amongst gliding people as a 'bunjie launch'. (If you don't like my spelling of the word 'bunjie' there are at least five other ways from which to choose.) Nowadays this type of launch is seldom used except from the top of a hill with a good strong wind blowing up it, therefore it will almost certainly be followed by a nice flight in hill-lift. But quite apart from this it is a most delightful experience; a few moments of joy regardless of the flight that may follow. Have you ever stood on the top of a steep hill, looking down on the green valley below, and wished you could launch yourself off to wheel and soar like the gulls you have watched at the seaside? If you have, you must become a glider pilot and your wish will be granted. If you have not, I suggest you go up to the top of the nearest hill and have another look.

All other types of launch are, to me, just a means of getting airborne.

As this book is not intended as a text-book, but only to explain to the uninitiated what gliding is all about, I am not going into full technical details of how the launching, flying, and landing is done. I shall give enough information, I hope, to whet the appetite without causing the reader to 'skip' because it is dull, or because he does not understand it. The bunjie launch is done with a strong elastic rope, attached by a ring at its centre to a hook on the glider. The six strong men then take the two free ends, a team of three on each, and arrange themselves in a 'V' formation just ahead of the glider and slightly down the slope. The tail of the glider is held in order to give the rope an initial stretch as the teams start to run. When the tail is released the glider moves forward, and if there is a good strong wind takes off almost at once. It is a remarkable sight. As the tension comes off the rope the ring drops from the hook, which faces downwards, and the glider flies over the heads of the launching crew scuttling along down below. They are trying to avoid falling headlong when the rope goes slack!

THE LAUNCH BY AUTO-TOW

Where a gliding club operates from an aerodrome with good runways this is an excellent means of launching. An old Ford V-8 is suitable and there is no need to tax or insure it provided you keep it on the aerodrome. The towing is done with a hard steel wire from 1,600 to 2,000 feet long. It is amazing what height of launch you can get by this method; 1,500 feet is not uncommon provided there is a good wind and the pilot and car driver both know their job. The climb can be made surprisingly steeply, so steeply in fact that in a sailplane with a comfortable 'lie-back' position you literally go up feet first! When the maximum height has been reached the pilot releases the wire by pulling a knob, and it floats down on a small parachute. But now there is no comforting hill-lift and he who wants to stay aloft must quickly find a thermal; however, more of this anon.

The Winch Launch

This method is used where there are no runways. A stranded steel cable is used, wound on a power-driven drum, and the cable has to be at least 3,000 feet long to get a good launch. It is a much more tricky business driving a winch than driving a car for auto-towing, and skill can make all the difference between a good launch and a poor one. Good winch drivers are worth their weight in gold. The pilot in the glider uses the same technique that he would for an auto-tow.

The Aero-tow Launch

An expensive method because an aeroplane is used. Apart from this it is a good way of being launched, and has the great advantage that you can choose your height, and if necessary a particular locality where you think there may be some lift. You can tell your tug pilot where you want to go by pulling his tail round; if you want to turn right you fly out to the left a bit and that pulls his tail to the left and makes his nose turn right. The first time I tried this manœuvre I was flying the tug, and a friend of mine was in the glider. When I felt my tail being pulled out to the left I responded by doing a gentle turn to the right. I expected my friend to tell me when we had turned far enough by flying over to his right and pulling my tail back again. But he didn't do this, and before long we were flying round and round in ever-decreasing circles! Both of us by now were using some very bad language, which translated would have meant: "What is that silly clot doing?" I then straightened out and all was well.

For an aero-tow launch it is necessary to have a good runway and, of course, an aeroplane. It usually costs about £3 per hour to hire one from a Flying Club, so your launch will cost you at least 10*s*.

CHAPTER III

THE ADVENTURE OF BEING AIRBORNE

WHEN I talk about gliding with any of my non-gliding friends one of the questions I nearly always get asked is, "What is the longest time you have stayed in the air?" When I tell them five and a half hours they are astounded. They have no idea that it is possible to stay up for that length of time without an engine, and yet flights of about this duration are frequently done. The World Record for duration in a single-seat glider is 56 hours, held by France. The three tests to qualify for the International Badge called the 'Silver C' are as follows: (1) Duration flight of five hours. (2) Cross-country flight of 30 miles. (3) Gain in height of 3,000 feet. It is usually considered that No. 1 is the easiest, provided it is done in hill-lift; once you have learnt the technique of hill-soaring it is only a matter of cruising up and down and praying that the wind will not drop. The other two tests can seldom be done by hill-soaring.

FLYING IN HILL-LIFT

Let us now suppose that you have just been bunjied off the top of a hill in a fair wind. As soon as you are clear of the hill you must turn to left or right and fly along the slope. Your rate of climb indicator, known as a variometer, should now be showing that you are climbing. If it is not you must do some quick thinking, because there are several things that may be the cause: (1) You are not positioned correctly in relation to the hill. (2) You are flying too fast, or in other words your gliding angle is too steep. (3) The variometer is not working properly. (4) The wind has dropped. In the latter case, unless you are lucky and it springs up again, you will have to land in a field at the bottom. You probably will not hear the shouts of derision from above as your friends watch you gradually sinking into the valley, but you will hear their curses when they come down with the trailer to collect you.

But let us not assume the worst, and we will suppose that your variometer shows a climb of three feet per second. As you climb you must gradually work a little out from the hill, because the best lift is usually further out the higher you go. It is a great thrill to see the ground steadily dropping away below as you sweep silently along, and now your altimeter will begin to register your height. In a strong wind I have climbed as much as 600 feet in the first minute.

There are a number of 'rules of the road' that must be observed by glider pilots, in the same way that there are rules for sailing boats, but they are a little more complicated for gliders because not only have you got aircraft to the right and to the left of you, but also above you and below you! These rules will be explained to you by your instructor, and it is extremely important to know and to observe them when hill-soaring because there may be fifteen to twenty gliders all cruising up and down the same ridge, and like soaring birds, they tend to cluster where the best lift is to be found. Indeed a group of soaring birds will often tell you when and where there is some lift.

Hill-soaring has a fascination all its own. At about 1,000 feet above a ridge the speed of the wind may well be 40 m.p.h., so if your glider flies comfortably at 40 m.p.h. you can choose yourself a nice spot and hover indefinitely by flying straight into wind. The delight of sitting quietly up there, the glider so still in relation to the ground below, and yet so alive and responsive to the slightest touch on the controls, and the magnificent view which stretches away to the far horizon, cannot be described by putting pen to paper; they must be experienced. Then if you tire of your lofty perch you have only to ease the control-stick gently forward and you will come sweeping down at 80, 100 m.p.h., to the singing accompaniment of the wind as you speed earthward. Many thrills such as this are there for your own personal discovery.

Flying in Thermal-lift

Now we must turn our attention to thermal flying, the most difficult type of lift to use but absolutely essential for cross-country flying. How do you find these invisible columns of vertical wind, and having found one how do you stay in it?

Near the ground, that is to say after an ordinary launch by car or winch that takes you to about 1,000 feet, you may have to look at the ground to find your thermals; when you get higher by climbing in one of them, say to 2,000 feet, the ground is of little help and you must watch the clouds. In both cases it is essential to watch your variometer, for this clever little instrument tells you whether you are going up or down, and at what rate; it will not help you to find a thermal, but it will tell you at once *when* you have found it.

It may surprise you to know that some thermals can be entered, and you will start climbing, without feeling any bump or 'push in the pants'; in other words you would not know if it was not for your variometer. Yet these same thermals could give you a nasty bump in an airliner, and if you strike a lot of them, and their stable-companions the downdraughts, some of the passengers will begin to look a bit green. They will turn to each other and say, "It's very bumpy", or "I don't like it when it's rough, do you?" But these 'bumps' are the very life-blood of a sailplane; cross-country flights would be impossible without them. There is a parallel case on the sea: passengers who are bad sailors will curse the waves that make them sea-sick, but those same passengers may be found at the seaside surf-riding on the waves and thoroughly enjoying it. This may give you a clue as to why the same bumps or waves can be most unpleasant, or very enjoyable, according to how you tackle them. The surf-rider, or the sailplane pilot, instead of battling through the waves at some fantastic speed and making life altogether unpleasant, rides *with* them and thoroughly enjoys it.

Now let us get back to our thermal hunting. I have already mentioned a ploughed field as a possible source, but there are many others; for example a factory chimney, a cooling tower, or the roofs of a town with the sun shining on them. We will suppose you have spotted a factory chimney, and you fly towards it hoping to pick up a thermal. You must make for the downwind side of it, because thermals travel with the wind. If you are lucky your variometer will register 'climb', and you must start flying round and round in a small circle in order to keep within the compass of the rising air. But unfortunately you do not know where the main mass of rising air is; it may be on your right, it may be on your left, or you may have flown through it. This elusive thing you are trying to find is *invisible*! So now comes your big test, the key to the success of all cross-country flying: having had a 'nibble' at your thermal, can you get properly into it and stay in it? Like a fisherman who feels a nibble at his hook, can you strike and land your fish? As this is the test which will finally decide whether you are a good sailplane pilot or not, it is worth a little explanation. I will try to put it in simple language.

The chances are that you will first strike the thermal obliquely, that is to say one wing will get the lift first (*see* Fig. 5). The port wing has just entered the thermal, and immediately this happens that wing will lift, so now you know the thermal is to your left; you must turn left and fly into it. If your starboard wing lifted you would, of course, turn right. It is not always easy, because as your wing lifts it tends to *make* you fly in the opposite direction; in other words to throw you out of the thermal. In fact, if it is a strong, rather narrow one, it will throw you out in a manner that would be the envy of many a publican at closing time. So you have to fight this tendency by forcing the wing down against the up-current. If you enter the thermal head on, the wings will remain level, but your variometer will register 'climb'. Whatever happens, once you are in you must circle.

Now comes the problem of getting yourself correctly placed, or 'centred', so that you are flying round the core of the lift, and not into it and out again. Fig. 6 will help you to understand how this is done. It is a plan of a thermal from above; the concentric circles represent the different rates of

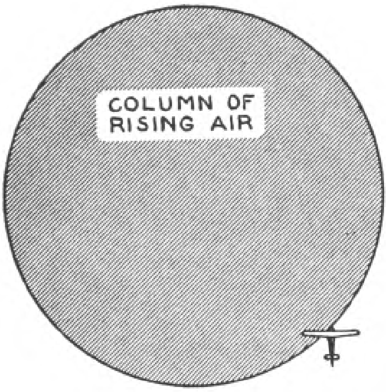


FIG. 5

Entering a thermal

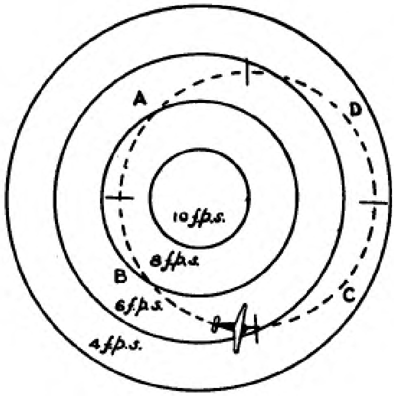


FIG. 6

In a thermal

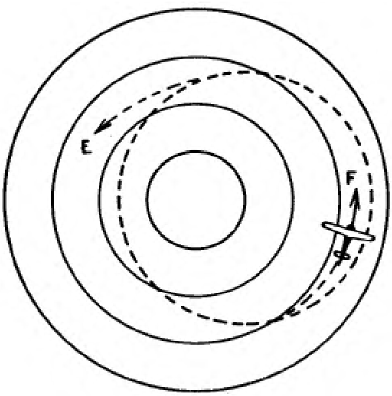


FIG. 7

Centring

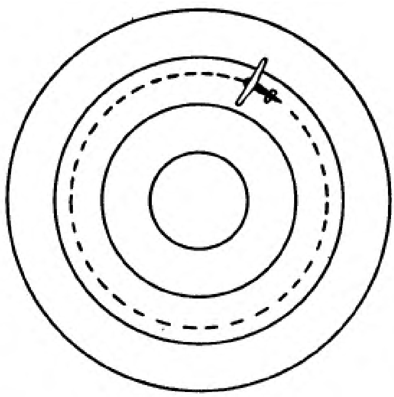


FIG. 8

Centred

lift in feet per second (usually written f.p.s.), and the dotted line the path of the glider. I have divided this into four sectors, A, B, C and D, for reference. As you can see, the glider is off centre; the pilot is getting good lift along the sectors A and B, and poor lift along C and D. But he is watching his variometer like a cat watching a mouse, and this is what it tells him: as he flies along sectors B and C his rate of climb gradually decreases, so he knows he must be getting further from the centre; he corrects this by tightening his turn a little. When he is flying along sectors D and A his rate of climb gradually increases, so that tells him he must be getting nearer the centre; he corrects this by opening out his turn a little. The result of these two corrections is shown in Fig. 7. You will see that the two new corrected flight paths, E and F, are going to give him a more central position. He continues this manœuvre until his variometer shows *equal lift all the way round.* He is then flying correctly round the centre of his thermal, as shown in Fig. 8.

In actual practice, of course, a thermal is not exactly circular, and the areas of lift vary in speed and shape. Even when you are centred it requires unremitting vigilance and constant correction to keep your position, and sometimes the most unexpected things happen. 'Copy-book' thermals are rare birds.

If you are able to keep your position for long enough you will probably reach the under surface of a cloud. This is your personal cloud; it is capping your thermal; it has grown there; it has materialized, apparently out of nothing, probably while you were busy climbing up from below. And this is because the warm air in your thermal has reached a higher, colder region, and the moisture in the warm air has condensed to form a cloud. If you want to see a small personal cloud without all the fuss of climbing up to one in a sailplane, step outside on a cold morning and breathe out. It forms for the same reason: warm, moist air, being cooled down.

Having arrived beneath the cloud, you may be able to see that the under surface has the shape of an inverted bowl.

This is because the up-current is strongest in the middle, and draws the central part of the cloud up faster than the outside. Any moment now you will be drawn up into the cloud, and the pilot who is equipped with the necessary 'blind-flying' instruments, and knows how to use them, will continue to climb inside the cloud. On this trip, however, you are not going to venture into that strange world; it can play the most alarming tricks on you. I shall have something more to say about this in a later chapter. So, to avoid being drawn up inside your cloud, you simply put the nose of your glider down and fly a little faster, which increases your sinking speed. Now you must find another cloud that looks as though it will have some lift under it. Any old cloud will not do, and you will learn by experience which kind of cloud is likely to be capping a thermal. They are sometimes called 'woolpack' clouds, which quite aptly describes their appearance; the correct name is 'cumulus'.

Having spotted a likely one in the direction you want to go, you must fly a little faster than usual in order to get quickly through the area of downdraught that you will almost certainly encounter on the way. When you arrive under your new cloud, provided you have not lost too much height in getting there, you should see your variometer begin to register 'climb', and you then repeat the dose as before.

Flying in Wave-lift

I shall never forget my first flight in a standing wave; it has left a more vivid and lasting impression than either of my first flights in the other two kinds of lift, and yet one cannot say that flying in wave-lift is necessarily an exciting experience. Exciting is the wrong word. Incredible would be nearer the mark. It is usually absolutely calm; it is almost completely silent. To revert to our friend the yachtsman, imagine his surprise and wonderment if he found himself in a flat calm, his sails hanging limp, and yet travelling at a steady four knots! It would take a minute or so before he could thoroughly grasp the situation. He would probably turn to port and then to starboard to see how this affected the new phenomenon; no change; right round and back on his original course; still the steady forward progress.

Such is wave-lift to a glider pilot. It may be some minutes before you are really certain that you are in a wave, so smoothly does it operate, so gently does it lay its unseen hand upon you. But your instruments tell you: your variometer shows a steady climb of perhaps four feet per second; you watch fascinated as the hand on your altimeter creeps slowly but determinedly up and up. This happy state of affairs does not, of course, last indefinitely; there are limits to your wave, and you will eventually reach the top. On my first wave-flight I tried to find out its extent by flying in all directions, and each time when the variometer reading dropped to about 2 f.p.s. I turned back. During these explorations I climbed 5,000 feet! The strong lift appeared to extend for about two miles, and was about half a mile wide; all along to the leeward side of me was a big white wave-cloud. Unfortunately it lay in the direction that I wanted to go, and I could not get above it; when I climbed up nearly level with the top the lift petered out. So that left me no alternative but to fly through it. This means that when you come out on the other side you will probably be in a down-current; reference to Figs. 4 and 9 will help you to understand why this is so.

But this wave was really only a 'ripple'. Over big mountains, like the Sierra Nevada in California, standing waves rise to well over 40,000 feet. It was here that the World Height Record for gliders, 44,000 feet, was established. In England gliders have already soared in waves to a height of over 14,000 feet, and this is not necessarily the highest altitude attainable. It is remarkable that a wave of this height can be 'triggered off' by hills that do not exceed 1,000 feet. Some parts of a big standing wave may be very rough and turbulent, and the speed of the up-currents in them would certainly be far in excess of four feet per second.

I wonder if the reader has noticed how often I use expressions like 'Usually', 'Probably', 'You may find', which

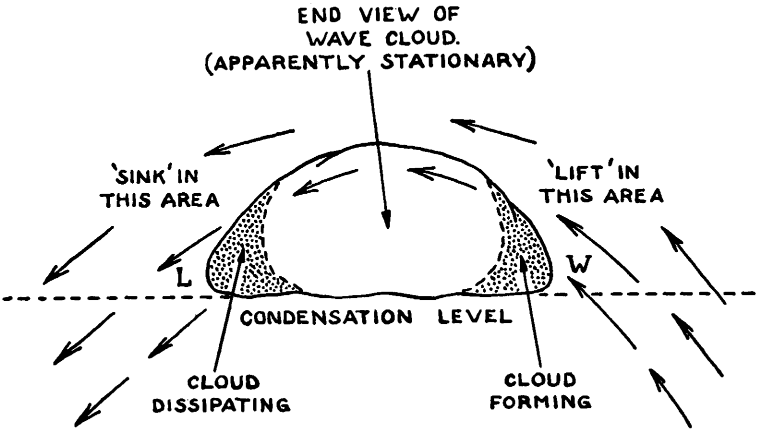


FIG. 9

A wave cloud

will give the impression that I am rather vague about what is likely to happen when you are flying a sailplane. If I have given this impression then I have certainly succeeded in conveying to the reader one of the things that make for the fascination of gliding. The air is full of the most unpredictable happenings, some of them unpleasant, others wholly delightful. However well-thought-out is your flight, however carefully planned are your manœuvres, the air is almost certain to spring a surprise on you. Whether it be in the take-off, during a flight, or while making your landing, if you are not prepared for changes of plan, for immediate decisions followed by instantaneous action, you are not going to make a good sailplane pilot. Having been in trouble, your conversation afterwards will contain such remarks as: "I didn't expect the wind to change so suddenly", "I didn't think there would be a downdraught just there", or "I'd have got in to the field all right if the wind hadn't suddenly sprung up."

But to return to our wave-lift. I mentioned before that the crests and troughs of the wave remain stationary in relation to the ground; consequently the wave-clouds that form at the crests are also stationary. This is perhaps difficult to understand considering the fact that the wind is blowing *through* them. It is certainly surprising to see a cloud apparently standing still above you when there is a strong breeze blowing at ground level. But this is not an ordinary cumulus cloud like the one that was capping your thermal. It is long and cigar-shaped; its longitudinal axis lies at right angles to the direction of the wind. It has somewhat the appearance of a lens looked at edgeways, and for this reason is known as a lenticular cloud. In fact, it is *not* actually stationary; it moves with the wind like any other cloud, but it is all the time building up, or 'forming', on the windward side, and dissipating on the leeward side, which gives it the appearance of being stationary. In Fig. 9 you will see that the wind is going up on the side marked W (Windward). This is where the glider pilot finds his lift. When the rising air reaches a certain height the moisture in it condenses, in just the same way that the moisture in a thermal condenses, so the cloud is continually forming on that side; at the same time on the other side, marked L (Leeward), the air and the cloud with it goes down again below condensation level, the droplets forming the cloud evaporate, and so the cloud disappears. The result of this continuous process is that the cloud *appears* to be standing still at the top of the wave.

Standing waves seem to have a tendency to form during the late afternoon, when ordinary thermal-lift is dying out, so it is a common sight at a gliding club in hilly country where waves are known to form to see pilots setting off at about tea-time in the hope of finding one. Even if you are not fortunate enough to be one of them, it is a fascinating sight to watch. If the wind is in the west they will probably set out towards the sunset; flying against the wind they do not appear to move, but hang, motionless in space, silhouetted against the evening sky. If they are flying overhead you cannot tell that they are climbing, but by watching patiently you will see presently that they are getting smaller, and smaller, and smaller.

CHAPTER IV

CROSS-COUNTRY FLYING

THE time will come when you want to venture away from your hill, or home aerodrome, like a fledgling that hovers around its nest until it feels bold enough to set out and come to grips with the world. For the glider pilot every cross-country flight is an adventure; even the most skilled pilots do not always reach their destination. Many flights have no predetermined destination; the pilot just sets out to see how far he can get. All manner of unexpected things may happen to you before you get safely back, with your glider, to your home base. You never know for certain what kind of weather you will encounter, and suitable weather is of paramount importance; and you never know where you may have to land. It might be a small village or farm where you will almost certainly get a hospitable welcome, or it might be in a remote and bleak spot where you are left to your own resources to get in touch with civilization again. I am sure a collection of stories told by pilots of what happened *after* they had landed at the finish of a cross-country flight would make interesting and entertaining reading.

I once incurred the wrath of a farmer by landing in his field of barley. I was completely deceived by this, as it was still green and looked just like grass from the air. Friends of mine afterwards made ribald remarks such as, "Had you forgotten your glasses?" I had passed a disused aerodrome about a mile further back, and this led to more rude remarks. I knew all about that aerodrome; it had looked very tempting. I had held a rapid committee meeting with myself while flying over it at about 1,200 feet, but as the flight was during the National Gliding Contests, when every mile counts one point to your team, I had decided to press on. The small town of Bawtry, on the Great North Road, lay just ahead, and I thought there was a chance of picking up a thermal over it. But I had no luck and I was soon down to about 800 feet, so I picked a field near the road and landed. Standing crops can do quite a bit of damage to a sailplane, but luckily I sustained nothing worse than torn fabric on the wing tip. When I returned from telephoning my retrieving crew and the farmer in whose field I had landed, I found a small group of people peering over the hedge, and one of them said to me, "Was the pilot killed?" "No," I said, "he survived." My farmer soon arrived, accompanied by the Arm of the Law, but he became quite friendly when I offered to pay for any damage.

A friend of mine once landed on the playing-fields of a girls' school. You can imagine the flutter that he caused in that dovecot! His description of how he was immediately surrounded by hundreds of girls (I would not say that he normally objects to that kind of thing), and the advent of a stern Headmistress ploughing her way through this throng, is a delightful bit of fun. He reports that the dismantled parts of his glider never before were carried by so many eager and yet gentle hands, and that subsequently he was invited to take tea with the stern Headmistress.

It is inevitable, whether your home ground be a flat site or a hill site, the day you break the bonds will be, to you, a momentous occasion. Gone is the friendly field where you have landed so many times; gone are the familiar landmarks that tell you where to come in and at what height; and to crown it all, gone is the faithful windsock that tells you the vital information for landing: *which way is the wind?* But you will not be permitted to set out on this trip until your instructors are satisfied that you know how to cope with the problems involved, and that you have a good working knowledge of thermal-soaring; and here is where the 'flat-site' man may score over the 'hill-site' man. Any flights made over a flat site that last longer than four or five minutes must be done in thermals, and so pilots trained on a flat site will of necessity have found out something about them.

For your cross-country flight you are going to use a whole series of thermals, one after the other, flying up in the thermals and down again between them. It is rather like a sailing-boat beating into wind; it does a starboard tack, a port tack, and then starts on the starboard tack again. In fact the progress of a glider is like a boat tacking into wind, only the zig-zags are made in the vertical plane instead of the horizontal. You are not necessarily flying against the wind; it is the alternate use of the power of up-currents and the force of gravity that gives you this apparently erratic course. If you *are* trying to do a flight against the wind then my sympathies are with you. Every bit of advance that you make in your forward glide can be lost while climbing up in the next thermal, because now, of course, the wind is carrying the thermals back in the wrong direction. It cannot be done unless the thermals are good and the wind not too strong; even then it requires a pilot of considerable skill and great tenacity to achieve any distance. Reference to Figs. 10 and 11 will help you to understand these points.

Under certain conditions you will find a whole line of cumulus clouds making an almost continuous chain; there are usually several lines and, unlike the wave-clouds mentioned in the last chapter, they lie parallel with the wind direction, and they stretch away as far as the eye can see. They are known to glider pilots as 'cloud streets', for obvious reasons, and provide ideal conditions for cross-country flying (*see* Plate IX). Having worked your way up to the base of one of these you head your sailplane along the 'street', but instead of allowing yourself to be drawn up into the cloud you can put the nose down and fly faster. If there is good lift you can scud along at 50 or 60 m.p.h., neither climbing nor descending; what would normally be a fairly fast rate of descent at this speed is counteracted by the lift. If my reader has done any sailing, especially in small boats, he will know the delight of a good beam wind. It is a similar experience; you can increase the speed of your boat by pulling in the sail, or paying off the head out of wind. I can suggest another example in ski-ing; if you are negotiating a long traverse in virgin snow, by pointing your skis more down

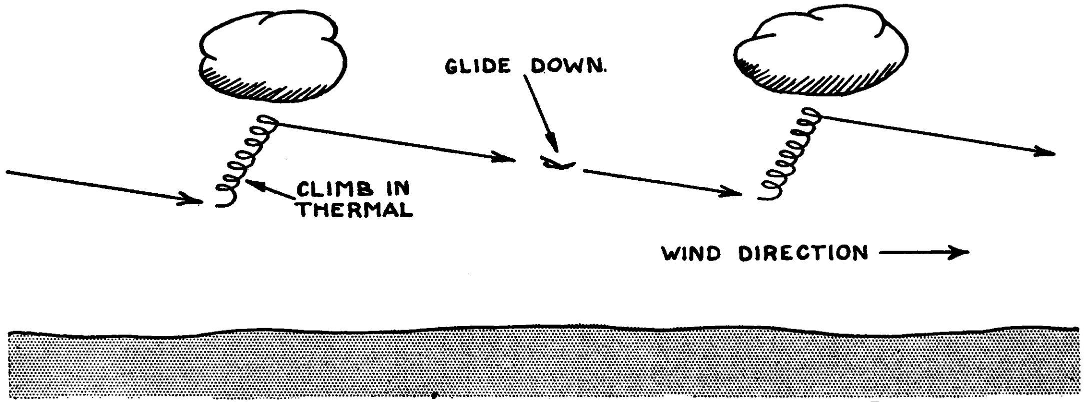


FIG. 10
Cross-country with the wind

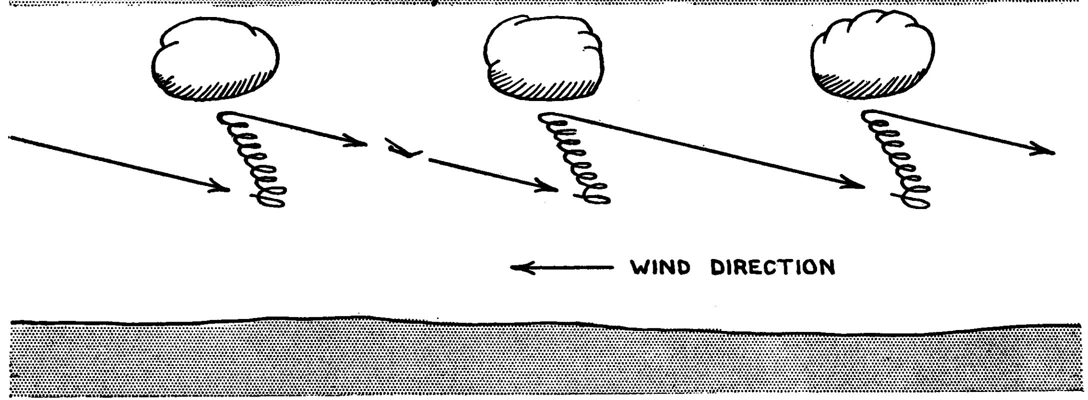


FIG. 11
Cross-country against the wind

the hill you can pile on the speed, or ease it off by pointing them less steeply. If you have not experienced these things for yourself it is difficult to convey the thrills and sensations by a written description: the swish of the soft snow under your skis and the wind in your face; the pull on your sheet as the wind fills your sail, and the flying spray; the feel of the immense power under a cloud as you sweep along in silent flight, the countryside stretched out thousands of feet below like a vast coloured map.

I feel like the man who was eating a vanilla ice cream, and his companion, seeing how much he enjoyed it, asked him what it was like. Can you describe a vanilla ice? "It's cold, it's sweet, it tastes of vanilla." "What do you mean, 'vanilla'?" says his companion. Suppose a friend asks me what gliding is like and I reply, "It's like gliding." No, there is only one answer, you must buy the vanilla ice and eat it.

• • • • •

I am going to give an account of a flight from Bristol to Newbury and try to convey some idea of what it is like to make a cross-country flight without an engine. Fig. 12 shows a map of my route, and also the barograph chart that records the height of the aircraft during the journey. An explanation of how a barograph works is given in Chapter V.

I started from Lulsgate Aerodrome at 12.10 p.m., in an Olympia Sailplane, and was towed up by an Auster. I took an aero-tow to be sure of getting up to a reasonable height, as I was going to attempt to fly at least thirty miles, which is the necessary distance for one of the qualifications to enter the National Gliding Contests. At 2,000 feet I released the tow-rope. I knew at this moment, and so did my friends of the Bristol Gliding Club down below, that I might well be back with them in eight or ten minutes. But I was lucky; I found lift almost at once under a nice fat cumulus cloud, and started to climb at three feet per second. This would be about equal to a slow walking speed, if you can imagine a man walking vertically upwards underneath a cloud. It is considered unwise

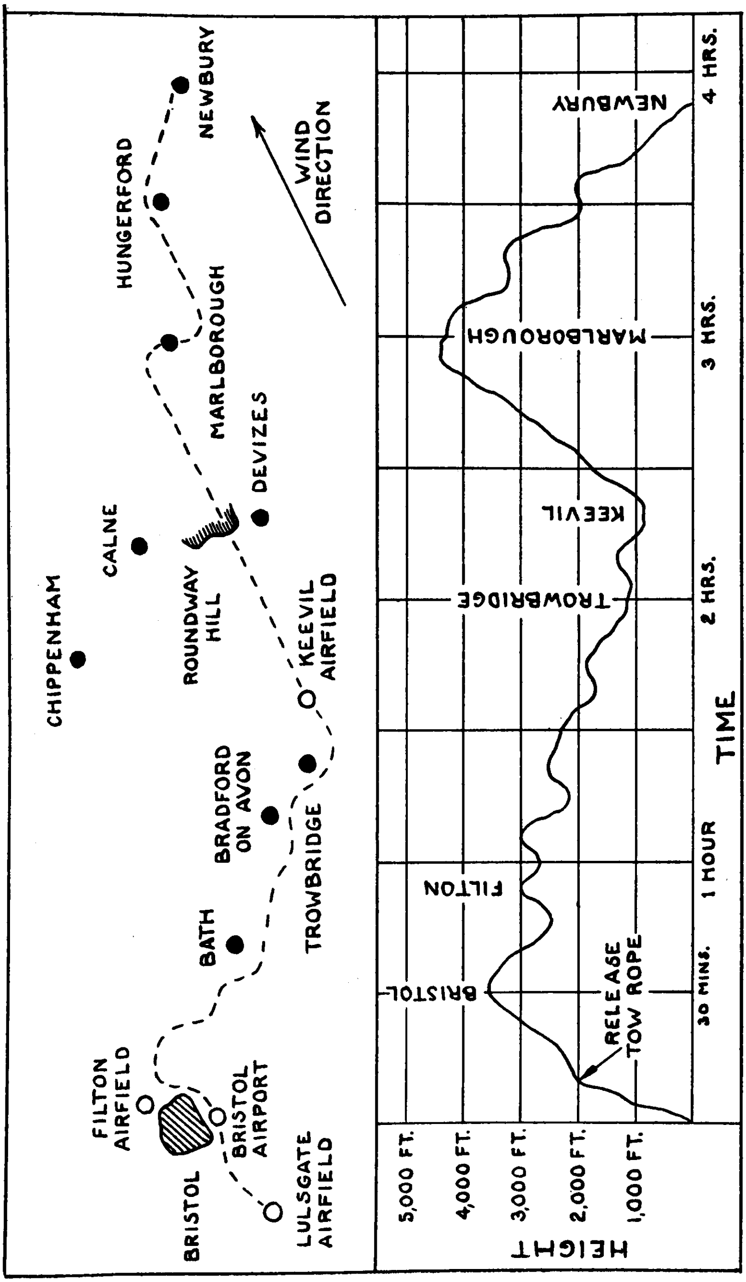


FIG. 12

Map and barograph chart of a cross-country flight to start on a cross-country flight at less than 3,000 feet, which meant that I must now stay under my cloud and try to keep in the lift for six minutes, which would bring me to 3,000 feet. Actually this lift lasted for about ten minutes, when the cloud dissipated and I found myself over Bristol Airport. The cloud, of course, travels with the wind. I must now find another cloud, and quickly. I could see a good one to the east of Bristol, so I put on extra speed by putting the nose down a little and flew towards it, but by the time I had reached it I was down to 2,500 feet. Filton Aerodrome and the Brabazon hangar were below me to the left. I started to climb again.

I have already explained that to stay in thermal lift it is necessary to circle, but the lift is not always directly under the cloud, so you have to find it and then you have to stay in it. This is done almost entirely by watching the variometer, as explained in the section on thermal-lift in Chapter III. After a climb of five or ten minutes, during which you have had no time to study the ground or a map, you come out of your 'circling' somewhat dizzy, and quite confused as to sense of direction; the compass, poor thing, is equally confused, like a dog chasing its own tail, so it's no good looking at that until it settles down. All this makes navigation a major problem.

But to continue. My Filton cloud, and a series of others, brought me over the town of Trowbridge at about 2 p.m. The County Hall was a very prominent landmark, and shone white in the sun; the swimming-pool looked pleasantly green. I had now been flying for nearly two hours, and was beginning to feel hungry. I had a couple of bars of chocolate in my pocket, but so far I had been much too busy trying to keep myself aloft to waste time by eating it. I was now down again to about 1,200 feet and there was no time to lose. I could not find any lift, and I could not see any likely-looking clouds. The village of North Bradley lay just ahead, which is where I live, and I could see my little white cottage. This would be a good place to make a landing, and I could kid my friends I had dropped in for a cup of tea. I chose a field belonging to a farmer friend of mine and then my luck changed and the

Photograph by the Wiltshire Gazette

The auto-tow and winch launch. The small parachute is seen folded

PLATE V

The "bunjie" launch

Photograph by M. Hodgson, Bristol Gliding Club

PLATE VI

The
aero-tow
launch

Photo by Charles E. Brown

variometer kicked up to about three feet per second climb. It was not a very good thermal, and only lasted a few minutes before it faded away, or else I flew incorrectly and lost it; I was soon down again and looking for another field. Then I spotted Keevil Aerodrome. I was crossing it at about 800 feet, as I manœuvred into position for landing, when I caught another thermal; probably caused by the sun on the tarmac runways. This developed into something really good, and I finished up under a big cloud, climbing at nine feet per second. It was the best climb of the day, lasting about half an hour, and it took me to 4,300 feet. A copy-book thermal, everything working out according to the book of instructions. But now I was utterly and completely lost! I had fully expected to look down and see our hill-soaring site at Roundway, near Devizes, but there was no sign of it. I was in a strange land. There was a small town below me, but it certainly was not Devizes, nor any other town in that vicinity that I could recognize. I flew across it to get a better look; it was Marlborough. This was a big moment for me, as it meant that I had easily covered the necessary distance to qualify for the National Gliding Contests.

The remainder of the flight was uneventful, the lift gradually failing, and soon after passing Hungerford I was again looking for a suitable field. It is a good plan to come down near a village or town in order to get to a telephone, but it is also necessary to avoid standing crops or hay. There were three possible fields, but one had electric wires across it, another had a pond in the middle, and the third was full of cows. I had just decided that the pond was the least of these three evils when I saw another field with no hazards. There was no time to lose, I flew straight to the downwind side of it and landed comfortably, but the moment I was at rest cows appeared from all directions. They had been sheltering from the sun, under the trees. They came at a brisk trot, as though they had been expecting me all day, and then stood round in an enquiring circle; they were accompanied by a stern-looking bull. Gliders cannot be left to the tender mercy of cows, for they tear the fabric with their horns, and hungrily chew up anything that looks tempting, as for instance a nice rudder.

I got out and stretched my legs; the cows retreated two paces. I looked at my watch; it was ten minutes to four. There was not a soul in sight. Here was a nice dilemma; if I didn't fetch somebody it looked as though I might be there for the night; I couldn't leave the machine because of the cows. The cows? Somebody ought to come and fetch them for milking. I examined them more closely, with a keen interest; they looked to me as though they would not require milking for a *long* time. I was hungry; I pulled out my chocolate and began to eat it. The cows advanced two paces. By the time I had finished my chocolate there were several cows much too close for my liking, and it looked as though it was going to be a full-time job keeping them away. I suddenly noticed that one had come up behind me and was sniffing tentatively at a protruding dive-brake. I reached into the cockpit and shut them with a bang. The effect was magnificent! The dive-brake cow was scared out of its wits and turned and fled; all the others fled with it. But cows are inquisitive and persistent, and they kept coming back; I continued to use the dive-brake technique with good effect.

At last, to my great relief, I saw two figures coming through a gate in the far corner. I confess I was a little disappointed to see that they were women; I felt that the situation demanded the physical and moral support of men, preferably the farmer himself, if for no other reason than to deal with the stern-looking bull. I am not afraid of cows, but I admit I am not keen on trifling with bulls. However, two women it was, and they were now coming across the field towards me. After a few moments they turned and walked back again. "Ah," I said to myself, "they've seen that bull." Their next move left me nonplussed; they did not go away, they proceeded to pull some branches out of the hedge, and then started towards me again each armed with a branch. It then dawned on me that these must be for dealing with the bull. And so they were. His name was 'Willie', and they approached him with a strange mixture of sternness and caution, waving their branches and calling out, "Go on, Willie", "Be off with you, Willie." He went, but looking back over his shoulder, and he did not go very far.

At this point I must record that my qualms on seeing that my rescuers were women and not men were quite unnecessary; they turned out to be the farmer's wife and daughter, and I could not have been looked after better. They brought me tea and sandwiches; they kept Willie at bay, and 'Mum' looked after the glider while the daughter took me to the farm to 'phone for a retrieving crew. Willie was on the whole docile, but very persistent, and watched the proceedings from close at hand, long after his cows had grown tired of the whole business and cleared off on more important affairs. I asked if he was dangerous and likely to cause trouble. "No," was the reply, "he's only a youngster, and very good as a rule, but you never can tell with bulls." I was inclined to agree. At one stage both my hostesses had to go back to the farm for about an hour and attend to the milking, but Willie never left me. I felt more confident now, knowing his name. You can get on better with a bull when you know his name, and it's much more convincing to be able to say, "Go away, Willie", than just, "Go away." When they returned they were much amused to find him still in close attendance.

Soon after this my retrieving crew arrived. It was 9.50 p.m.; I had been in the field for six hours! However, all was well, and we were just able to get de-rigged and packed away before darkness fell.

CHAPTER V

THE INSTRUMENTS, CONTROLS, AND COCKPIT EQUIPMENT

MY NON-GLIDING friends are always surprised to hear that a sailplane has an instrument board. "You've got no engine," they probably think to themselves, "so you can't need an oil gauge, or a radiator thermometer, or an ammeter, or a rev. counter." No doubt they think of the dashboard of a car, so if you took away the engine you would not need much except the speedometer and mileage indicator. I doubt if you would need even that with no engine.

Actually a sailplane is well equipped with instruments, and it would be difficult, if not impossible, to manage without them. A typical sailplane instrument board is shown in Plate IX. Some people suggest that you ought to be able to fly by your senses, like a bird, without having to resort to artificial aids. It has been proved, however, that this is only possible to a limited extent. The sense of hearing will convey to an experienced pilot quite a lot of useful information; the noise of the air passing over the surface of the wings and fuselage changes considerably according to what the aircraft is doing. The sense of sight is obviously essential for normal flying, but a pilot in a cloud might as well shut his eyes if he has no instruments at which to look. Outside he is surrounded by a blank white wall which tells him *nothing*. The sense of touch is very important at times. Quite apart from the 'feel' of the controls, which varies according to the speed and attitude of the aircraft, there is the change of pressure on your seat. This is commonly known as 'flying by the seat of your pants'! But it can be very deceptive; it will tell you of certain changes, *while the changes are taking place*, but once the new movement is established it may tell you nothing. You will possibly have noticed this in a lift. When you start your upward journey you feel an additional pressure on your feet, but as soon as the lift settles down to its normal speed this additional pressure ceases. When you reach the top the effect is exactly opposite; the lift slows down but you tend to go on up at the same recently acquired rate of climb. This gives you a sort of 'light' feeling on your feet. If you took a weighing machine into the lift and stood on it you would apparently weigh quite a bit more than usual the moment the lift started, but it would register your correct weight once its normal speed was established. When you reached the top I fear you would apparently be sadly under weight for the last few seconds.

All this can be very confusing to the sailplane pilot. It means that even if a thermal or hill-lift is strong enough to give you a 'push in the pants' when you first strike it, it will not go on telling you anything while you are in a steady climb. Furthermore, at least in my experience, the rate of climb will ease off so gradually that you will not know when you have stopped climbing.

These mysterious changes of weight that take place in a lift, and to a much greater extent in an aircraft, are referred to in terms of 'g'. In case the reader is not familiar with the term I will attempt to explain it. I wonder if I dare begin by stating that there is really no such thing as 'weight'. What we call our 'weight' is a mutual attraction between ourselves and the earth; if the earth was not there we should not 'weigh' anything. This force which pulls two bodies together is what we call gravity, and scientists represent it by the symbol 'g'. As far as you are concerned you measure it as your 'weight', 12 stone for instance. They will tell you that it is an acceleration—our old friend that we learnt about at school—32 feet per second per second; and you do in fact know that if you fell off a cliff this force would make you accelerate while falling. The scientists will tell you that all the forces which apparently alter your 'weight' are really accelerations, and I hope you may be able to understand and agree with this by the time I have finished my explanation. However as we are not going to do any mathematical calculations we will not worry too much about this, but just call it 'a force', namely 'g'. From your personal point of view this force may change according to what you are doing; going up in a lift for instance.

Let us suppose a man weighs 12 stone. If he goes up in a lift, he will, for the first few seconds, apparently weigh more than usual. If the lift had a very fast acceleration (note that it must be an acceleration), he might, during those first few seconds while accelerating, record 24 stone on a weighing machine. (Heaven forbid that such a lift actually exists.) He would in that case be subject to a force *twice his normal weight.* Amongst the flying fraternity this has come to be known as '2g', but doubtless mathematicians would quarrel with this simplification. Another type of force which can alter your apparent weight is illustrated by the old familiar trick of swinging a bucket of water round and up over your head without spilling it. "Ah," you will probably say, "now I know what you mean; but I call that centrifugal force." So it is, and it subjects the water in the bucket to a force which alters what we call its weight. Along the bottom of the swing the total of the two forces may be as much as 2g, but going over the top probably less than 1g. In other words at the top of the swing the water is exerting a force on the bottom of the bucket *less* than its own weight, and at the bottom *more*, possibly twice, its own weight. The reason for this is, of course, that the centrifugal force is influenced by the force of gravity; it adds to it at the bottom but subtracts from it at the top. If you have never tried the bucket trick I suggest you go out into the garden and have a go; it's good exercise, but I advise you to wear your bathing costume.

At this point I can hear the reader saying to himself, "I don't see how that's an acceleration; if I swing the bucket round at a constant speed it works just the same." Yes, the bucket may go at a constant speed; it is its *change of direction* that accelerates. It goes faster and faster *away* from the theoretical path that it would follow if it were not for your arm pulling it. If it is going faster and faster *away* from something then it must be accelerating. To find out about this theoretical path it is necessary to let go of the bucket when it is about half-way up, or half-way down, the swing. (Up is the more spectacular.) For this part of the experiment the spectators should also wear bathing costumes. The force that your arm was exerting previous to letting go of the bucket is called 'centripetal force'. I hope Fig. 13 will help you to understand this. Actually, of course, the theoretical path is continually changing, in the

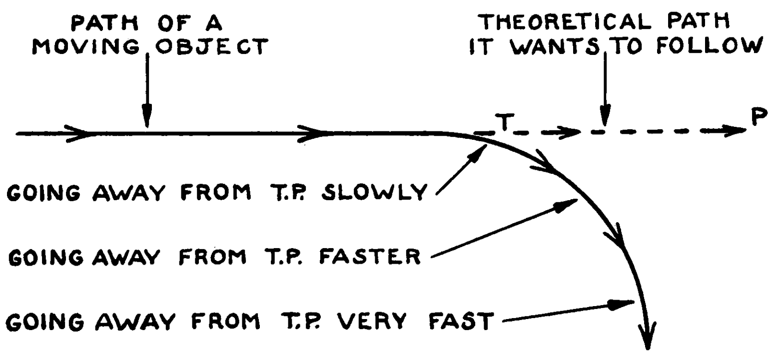


FIG. 13

same direction as that in which the moving object is being turned, and for as long as it goes on being turned.

The bucket experiment is a very good illustration of an aircraft doing a loop. In a properly executed loop the pilot will not feel that he is going to fall out of his seat at the top, although at the bottom he will certainly feel that he is being pressed down by an unseen hand. It is this pressure, of course, that can cause the pilot to 'black-out' in a very fast aircraft levelling out after a dive. The same pressure that forces the water down onto the bottom of the bucket in the lower part of the swing forces the pilot's blood down towards his feet, and the heart is not able to pump the blood *up* to the brain against this pressure. When the brain fails to get its full blood supply it ceases to function properly; the sight fails first, and if the pressure continues the pilot will lose consciousness.

All this talk about 'g', acceleration, and centrifugal force boils down to this: any object, when it is stationary, likes to remain stationary; when it is moving, it likes to continue moving, at the same speed and in the same direction. If you shut off the steam in a railway engine when the train is travelling at 60 m.p.h. there is nothing *inherent in the train* that makes it slow down; it is only *outside forces* that do this, like the friction of its wheels and machinery, and air resistance. On the earth there are lots of these outside forces at work: the pull of gravity, the wind, air pressure, friction, engines, men pushing and pulling things, and possibly even swinging buckets round their heads. If you lived in outer space and could get away from the pull of the earth, and the moon, and other heavenly bodies, things would be very different. You could throw a stone and it would just go on travelling at undiminished speed in the direction in which you threw it; a most helpful thing for house-agents advertising the proximity of the railway station. If you wanted to visit a friend you need only give yourself an initial push in the right direction and away you would go. The astute reader will now ask, "But what do you push against?" Aha! Space Men are going to be equipped with little rockets which they can let off, and these will push them in the direction they want to go, and stop them when they meet their friends. Did I hear you say that rockets won't work when there is no air for the gases to impinge on? I hope not. I will tell you something more about rockets and jets 'impinging on the air' (?) in the chapter on Power Flying.

It is an odd thing that I have started this chapter on instruments by talking about 'g', since there is no instrument in a glider to record it. Your variometer will tell you, with considerable accuracy, whether you are climbing or descending but it will tell you nothing about g. The reason for this omission is that on this particular point the human body is quite sensitive and capable of looking after itself; here the seat of your pants really comes into its own! Your body tells you all about the variations of g, if they are big enough to matter, and then as a sort of final warning, rather like a light indicator on the dashboard of your car which tells you about oil pressure, your own light goes out; you get a 'black-out'. One can imagine a dial in the brain marked something on the lines of Fig. 14.

The Variometer

If any of the instruments on the dashboard of my sailplane were to go wrong during a flight I should hope and pray that it would not be the variometer. I am not speaking, of course, about flying in cloud. If your turn-and-bank indicator fails when you are in a cloud it is not only unpleasant, but might be dangerous, and for this reason some sailplanes are equipped with two of these instruments, in case one goes wrong. For the ordinary flight, not involving anything more than brief journeys into or through a cloud, the variometer is the key to soaring flight. Indeed the same is true for cloud-flying, but in this case the variometer *must* be supplemented by 'blind-flying' instruments.

As already mentioned in an earlier chapter, this instrument

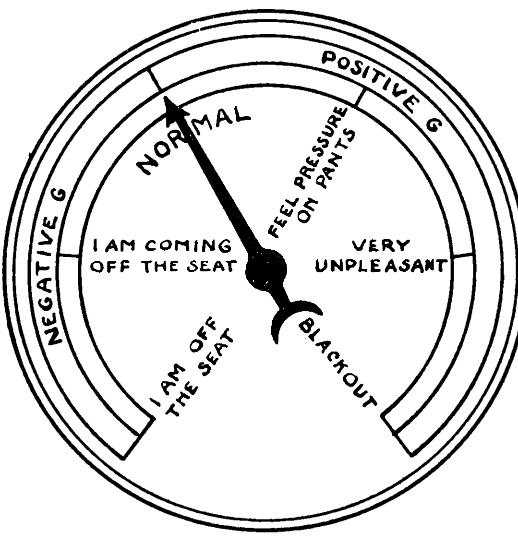


FIG. 14

The seat-of-pants indicator

tells you whether you are going up or down, *in relation to the earth*, and at what rate of climb or descent. To the uninitiated this would seem to require a very remarkable instrument, involving radar or some similar form of scientific magic. But it is in fact quite a simple device. At the earth's surface, the pressure of the air is approximately 14 lb. to the square inch. The reader is probably aware that this pressure decreases with height; hence the need for pressurized cabins in air-liners, so that the passengers shall not suffer any discomfort. The variometer consists of a bottle about the size of a thermos flask; it is, in fact, a type of thermos, so that variations in temperature will not cause variations in pressure inside the bottle. There is a little tube leading out at one end. If you take this bottle up a hundred feet to where the pressure of the air is less than 14 lb. per square inch, some air must flow out through the little tube to equalize the pressure in the bottle with that outside it. The faster you take it up, the faster the air flows out. When you bring it down, air flows back into it. The little tube is led up to the back of your instrument board, like the tube leading up to the back of the oil pressure gauge on the dashboard of a car. A special device tells you whether the air is flowing into the bottle or out of it, and at what speed; it is calibrated to read off in feet-per-second climb or feet-per-second descent.

The instrument most commonly used in this country has two little coloured balls, one green and one red, situated in transparent tubes. These tubes are coupled to the tube from the thermos bottle in such a way that if you are climbing the green ball is blown up its tube, and if descending the red ball is blown up its tube. The faster you climb or descend the higher the ball rises in its tube. Plate IX shows what the instrument looks like.

Strangely enough, the human body has two tubes similar to the one leading out of the thermos bottle of a variometer. They connect the inside of the mouth to a space *behind* the ear-drum. Their purpose is quite simple: to equalize the pressure on both sides of the ear-drum. There used to be a cryptic remark, or rather a question, on the Medical Examination Form for the Private Pilot's Licence. It was, as far as I can remember, "Are the eustachian tubes capable of equal inflation on both sides?" This intriguing question has now been dropped—why I cannot say; but the reason for its original inclusion is obvious. If the eustachian tubes become blocked the pressure behind the ear-drum cannot be equalized with the pressure of the air outside. Climbing or descending in an aircraft might be quite painful, and in fact could cause a certain degree of deafness. Have you noticed a peculiar feeling in the ears when climbing or descending in mountainous country in a car? Occasionally it is accompanied by a 'popping' sensation, and when the 'pop' occurs the sense of hearing becomes more acute. The popping is caused by a slight blockage in the eustachian tubes being cleared by a change in the atmospheric pressure. You can produce the clearance artificially by holding your nose, shutting your mouth, and blowing.

What a pity we are not equipped with a device to measure the air flowing in and out of our eustachian tubes; it could warn us of changes in the weather as well as changes of height. It is possible that soaring birds are equipped with some such device which tells them when they have found an upcurrent. Biologists believe that the swimming-bladder in certain kinds of fish acts as a sort of altimeter, and warns them of the danger of swimming in very deep water, or in the case of deep-sea fish of coming too near the surface. But man, who for thousands of years has crept about on the ground, has no such device, and has to rely on the instruments he is able to devise.

The ordinary variometer, however, has a fault: if you pull the nose of the glider up into a climb it will of course register 'Climb' on the variometer dial; this sort of 'artificial' climb has come to be known amongst glider pilots by the rather derogatory term of 'stick thermal', because the climb is caused by pulling back the control stick. It can be misleading because what you really want to know is whether the air you are flying in is climbing. In your little 'stick-thermal' climb you are losing kinetic energy by slowing down your speed, and if you do a dive you are building up kinetic energy by increasing your speed; a modified instrument has now been devised which takes this into account, and so is called the Total Energy Variometer. With this instrument if you deliberately or accidentally vary the attitude of your glider so that it is not at its normal gliding angle this will not show on your indicator.

Let us now illustrate the instrument in action by taking a concrete example. Suppose you are doing a steady glide in still air and your variometer shows three feet per second sink; you now dive and then do a loop. The kinetic energy of the aircraft will increase during the dive, decrease on the way up in the loop, and increase again on the way down; this will cancel itself out approximately, but with a slight total energy loss, and you will finish up lower down than when you started. The ordinary variometer registers all these fluctuations, but the total energy variometer, theoretically, should register 'sink' during the whole of the manœuvre. I am told that it does, though I have never had the opportunity to loop a sailplane equipped with this instrument, so I cannot speak from experience.

Put in simple language, this rather remarkable result is achieved by making the decreased or increased air speed of the glider work against the air flowing in or out of the variometer bottle, thus preventing it from being affected by these temporary fluctuations. The fact that all this is of extreme importance to the sailplane pilot shows to what a high degree of skill and scientific accuracy the sport of gliding has already developed. Philip Wills considers that this instrument helped him greatly towards victory in the 1952 World Championships. In those days very few people knew about it, so it was a sort of Secret Weapon.

Another type of variometer is now being tried out which indicates climb and descent by flashing green and red lights, the rate of climb or descent being assessed by the rate of flash. The mechanism that operates it is rather complex, and there is no need to describe it here; but I should mention that it is very sensitive to the rate of climb and descent and will indicate it however small. It also eliminates the time lag of the ordinary variometer, and this is particularly valuable when trying to 'centre' in a weak thermal. If you refer to the section on thermal flying in Chapter III you will readily appreciate this point.

THE ALTIMETER

The altimeter is akin to the variometer, but instead of having to measure the *rate* of change in atmospheric pressure, it merely has to indicate the change. I conclude that people who have a barometer in their house realize that this instrument actually indicates the changes of pressure in the room or hall where it hangs. These changes of pressure, of course, tell us what kind of weather we may expect. I have a little pocket barometer which is very sensitive. In addition to the usual 'Rain—Change—Fair', it is marked off to register height in feet, and if I carry it upstairs to my bedroom it actually records this small ascent. In other words the air pressure in my bedroom is less, measurably less, than that in my sitting-room downstairs. The altimeter in an aircraft is built on the same principle as the common domestic barometer, and it records changes of pressure in the air. If you put your glider away in the hangar on a nice fine, sunny evening, with the altimeter reading 0 feet, and then the next morning turns out to be cloudy and wet, you will find that according to your altimeter the hangar has gone up 250 feet during the night! It is another proof of the fact that weather and atmospheric pressure are interdependent.

From the foregoing the reader will deduce that an altimeter cannot give a definite and correct reading of, say, the height of your house above sea-level; it all depends on the air pressure at that spot at that moment. On a wet day your house may be, apparently, as much as 2,000 feet higher than on a fine day. To find out the actual height of your house above sea-level you would need to know the exact pressure of the air at sea-level at that particular moment, then look at your altimeter, and then make a little calculation. All this is not necessary, however, when you are flying a glider or an aeroplane. You are not interested in the height of your aerodrome above sea-level, at least not at the moment; what you want to know is the height of your aircraft above your aerodrome after you have been flying for a few minutes. To make this easy, and to do away with any calculations, your altimeter is fitted with a little knob by means of which you can set the hand to 0 feet while you are still on the ground. It will now record your correct height above your home aerodrome. But there is a snag. In fact there are two snags: (1) While you are flying the weather may change, or in other words the pressure of the atmosphere may change; (2) If you make a flight to another aerodrome it probably will not be the same height above sea-level as your home aerodrome. When your altimeter reads 1,000 feet you may, in fact, be only 700 feet above the ground at this aerodrome.

Neither of these snags causes any serious worry to the glider pilot, as he should be quite good at judging his height at anything up to 1,000 feet; he will probably have spent many hours 'stooging' about below 1,000 feet during his early stages of training, and later when questing for thermals. If he is planning to land at a different aerodrome it is a simple matter to look at a map and see how the height of it compares with his own. But to the pilot of an air-liner who may be flying over mountainous country at night it is a very different matter. He could conceivably be flying near mountain peaks rising to 8,000 feet with his altimeter registering a safe 10,000 feet, when in actual fact he was only at 7,500 feet; a very unhealthy position. However, all necessary information can be obtained 'en route' by wireless, and it is the navigator's job to sort out this information, make any calculations required regarding height and position, and pass the results on to his pilot.

The actual instrument that indicates these pressure changes, the altimeter, is quite a simple device. It consists of a little air-tight metal drum, with a partial vacuum inside it; that is to say some of the air has been extracted so that its internal pressure is below normal atmospheric pressure. Consequently it is very sensitive to pressure changes in the air, and the thin metal that forms the two heads of the drum bulges out, or caves in, according to that pressure. A system of levers connected to a hand indicates this on a dial which is marked off to show height in feet.

The Air Speed Indicator

So far our instruments have depended on air pressure. The air speed indicator, which in future I shall refer to as the A.S.I., also depends on air pressure, but in a different way. It has to record the air pressure that is caused by the forward movement of the aircraft. The most common type in use today consists of a tube outside the cockpit, with an open end facing forwards, which 'collects', so to speak, the air as the aircraft flies along. The tube is led to an instrument with a sensitive diaphragm that records the pressure of air in the tube; the faster the aircraft flies the harder the air is pressed into the tube. The diaphragm is connected by a system of levers to a hand, like the altimeter just described, and this hand indicates on a dial marked off in miles per hour.

The Turn-and-bank Indicator

This instrument enables the pilot to fly inside a cloud. Possibly the reader will wonder why a special instrument should be necessary. I can say, here and now, that it is, and shall explain why in the chapter on Clouds and Cloud Flying. The instrument tells the pilot whether he is flying straight ahead or turning, and if turning whether he is applying the correct amount of 'bank'.

Incorrect banking causes the aircraft either to slip inwards or skid outwards, and the instrument indicates the amount of slip or skid; for this reason it would probably be more correct to call it a Turn-and-slip Indicator. The part that indicates slip and skid is quite a simple device, and worked by a pendulum, but the turn indicator is much more intricate. It is coupled to a gyroscope which is driven by an electric motor. The current is supplied by dry batteries, and these need only be switched on if the pilot intends to enter cloud.

The Artificial Horizon

This is another aid to the pilot when flying in cloud, but instead of the needles to show whether the aeroplane is turning, slipping or skidding, there is a little aeroplane mounted in the centre of the dial. Behind it there is a white line to represent the horizon, and this tips to the left or right, or moves up and down, exactly like the real horizon would do if you could see it; all you have to do is to 'fly' the little aeroplane and keep it in correct relation to the white line. This instrument is much easier to use than the Turn-and-bank Indicator, but rather delicate in operation, and can be put out of order by incorrect handling. Some sailplanes have both types fitted, so that if one goes wrong there is another to fall back on. If you have only the one and it fails when you are in a cloud the situation can become quite dangerous, as I shall explain in Chapter VI.

The Compass

Everybody knows what a compass is, but everybody does not know how to use one. Navigation as a whole is quite a big subject, and my knowledge of it is pretty sketchy; however, I had to learn something about it in order to fly an aeroplane on cross-country journeys, and there are always some questions on navigation in the exam when you qualify for a Private Pilot's Licence. Navigation in a glider, however, is quite a different story to navigation in a powered aircraft. In the latter, you can rule a line across your map, direct to the place where you want to go (does this make the motorist jealous?) and follow it like the proverbial crow. You find the angle of this line, allow for wind strength and direction, and by means of a little calculation work out the compass bearing on which you must fly. When you start the flight you can set your compass on this bearing and forget about degrees, and courses, like S.W. and E.N.E., and all that nonsense; all you have to do is to keep the needle of the compass parallel with two white lines on the compass bowl and Bob's your Uncle. Perhaps I have made it sound rather easy; it does take a bit of practice to be able actually to arrive at the place you are aiming at!

Photograph by Donald Greig

▲

"The magnificent view, which stretches away to the far horizon"

PLATE VII

"You can choose yourself a nice spot."

Photograph by Teddy Proll, Midland Gliding Club

Photographs by the author, Surrey Gliding Club. Taken at Camphill, the site of the Derbyshire and Lancashire Gliding Club

Gliders hill-soaring, and waiting for the cumulus cloud to come across the valley

The cloud arrives, and five gliders go up in the same thermal; a sixth is about to join them

PLATE VIII

A modern sailplane; note the very clean lines

In a glider you cannot do anything so straightforward. You spend so much of your time darting hither and thither in search of the elusive lift, and then, having found it, twirling yourself round and round like a top in order to stay in it, that it makes complete nonsense of a compass. And think of the poor compass; it is all right if it starts its life in a glider, but I am sure any compass which has spent its early life sedately in a powered aircraft, and then gets transferred to a glider, would very soon be saying about its new owner, "This man's a fool." Do not imagine, however, that a glider pilot does not use his compass; he does, but in a different way from that in which it is normally used, and rather as a supplement to a map. For flying in cloud it is most important, because having climbed inside a cloud to a good height you may want to leave it and set off towards a goal. Unless the cloud is sufficiently thin to get a bearing on the sun you would not have the least idea in which direction to fly, without reference to the compass. You have got to be pretty good with a map too; you must be able to pick out features on the ground and then find them on your map. There are no signposts in the air, no milestones, and you cannot stop and ask a passer-by, "Excuse me, am I going the right way for Leicester?" And if you are *not* going the right way for Leicester you are going the wrong way at some 40 m.p.h. and that's that. It is quite easy to get completely lost in the air; even towns that you know quite well can be unrecognizable from above until you have learnt the knack of 'reading' them. I remember on one occasion, flying a powered aircraft, I got off my course somehow and it was a day of poor visibility. There was a little town below me on a railway, but it did not fit in with any town I should be flying over on my correct course, and my map was full of little towns on railways. There was only one thing for it: put the map away, fly right down over the station, and *look at the board* giving the name of the town. I do not like flying low in strange places, so I did a 'dummy run' at about 200 feet to weigh up the positions of factory chimneys, church steeples, and similar obstacles, when I suddenly noticed a little tunnel near the station, and then the line terminated. Here was a clue, so up I went again to a safe height and got out my map. I soon found it; it was the small town of Cheadle, in Staffordshire.

A Thermal Finder

Before concluding this description of the instruments to be found on the instrument board of a sailplane I must make brief mention of the very latest. At the time of writing it is still in the experimental stage, and so far as I am aware has not yet even been given a name; I shall therefore call it a 'thermal finder'. I have taken care to point out that the variometer will not help you to find a thermal, it will only tell you *when* you have found it; this instrument definitely helps you to find it, and by the following ingenious method: an instrument called a thermopile is mounted in each wing-tip which records temperature by producing an electric current. The two instruments are interconnected so that they record the difference in temperature between the two wing-tips, and a needle on a dial in the cockpit points to the warmer wing. You will realize the significance of this if you remember that a thermal is a column of rising *warm air*; it has been found that there is usually a slight rise in temperature round a thermal spreading out to a radius of several hundred yards. When the pilot gets an indication he makes a 45° turn towards the warmer wing; he now knows he is approaching a thermal. When he gets a second indication he makes another 45° turn towards the warmer wing and this usually takes him into the thermal. If at any time the pilot is flying straight towards a thermal he would presumably get no indication at all, but in such a case why worry?

The Barograph

Now we come to an instrument which does not appear at all on the instrument board; it is stowed away in a little cupboard behind the pilot's seat. Nevertheless it is an important instrument, although not for flying, as the pilot is unable to see it from his cockpit. It records on a piece of special 'graph paper' what has happened during a flight. Fig. 12 shows a barograph recording of a cross-country flight. The instrument is really an altimeter, but instead of showing the height on a dial it is equipped with a pen and records it on graph paper. This paper is fixed to a cylinder which revolves very slowly, by clockwork, and at a definite speed; so it not only records the height at which the glider has been flying, but also the time at which the different climbs and descents were made.

It is essential to carry a barograph if you want to qualify for any of the special awards granted by the Fédération Aéronautique Internationale, or to claim a new record. Furthermore, in such a case, the instrument has to be sealed and must only be opened by an official Royal Aero Club Observer. He examines it, and if it is all in order he signs it, and posts it to the British Gliding Association.

The Oxygen Cylinder

As far as I am concerned, carrying an oxygen supply in a sailplane is a bit of a 'line-shoot'. The kind of clouds that I like to choose for my modest climbs do not go to such dizzy heights. On a certain occasion I once coaxed a powered aircraft, a Gypsy Moth, up to 17,500 feet, but neither myself nor my passenger felt the need of oxygen. On the other hand I have been climbing on rock and ice at 14,000 feet and felt the need very much, because the hard physical exertion requires a good supply. Some people, of course, may feel the need of oxygen at less heights than others, and it is always a wise precaution to use it when above about 12,000 feet, because oxygen *lack* works rather like alcohol *excess*: you feel fine and all the time you are half tight.

Many glider flights have been made, of course, during which oxygen was absolutely essential; the World's Height Record, for instance, is over 44,000 feet. It is even considered likely that a sailplane with a pressure cabin would be able to beat the height record for powered aircraft.

The Safety Harness

Anyone who has travelled by airliner will be familiar with the instruction, 'Fasten safety belts. No smoking.' They are precautions that are always insisted upon for take-off and landing. For the benefit of those who have never been in an aircraft I should explain that the type of belt used is a large webbing strap that goes across your lap, and is often referred to as a 'lap-strap'. As far as gliding is concerned, or aerobatics, this type is about as much good as its namesake the 'lap-dog'. A strong downdraught, or a turbulent cloud, could throw you right off your seat if you were not held firmly down, and this type of belt would be quite inadequate. The safety harness used in gliders, and any type of aircraft that is used for aerobatics, has four straps. Two of these come over your shoulders and the other two come up from below, and all four meet in a central clip at about the height of your chest. You can fix these straps very tightly, so that all you can do is to move your arms and legs; for this firm grip you may be very thankful; of which more anon in Chapter VIII. All four straps can be immediately released in case of emergency by pulling out a pin. This type of safety harness is sometimes known by the name of Sutton harness, and some modern versions are tested to stand 25g. I hope, having read my remarks about g at the beginning of this chapter, you will know what that means.

The Parachute

A parachute is part of the normal equipment of a sailplane pilot, but fortunately he rarely has any need to use it. There have been occasions when part of a sailplane has failed in the air, and the pilot has been saved by his parachute, but it is a most unusual occurrence.

If a pilot has to use his parachute while flying in a cumulo-nimbus cloud (thundercloud), which may contain very powerful upcurrents, it is dangerous to jump out and pull the rip-cord while still in the cloud as you may *continue to go up!* This happened on one occasion in Germany and the poor pilot was almost frozen to death before he finally got down. The rule is to do a free drop until you come out of the bottom of the cloud.

The major portion of the time spent in the air in gliders is probably at too low an altitude for a parachute to be of any use, and they are not even part of the standard equipment in training gliders. But there is no need for the reader to be alarmed by this fact; I consider that if you spend an hour or two gliding during the week-end it is a much safer pastime than driving your car on the road.

Radio Communication

It is possible to have your sailplane equipped with 'talkie' radio communication for sending and receiving, so that you can keep in touch with your retrieving crew when making cross-country flights. Their towing car, which pulls the trailer that takes your glider home, also has a two-way radio set. It is, of course, rather expensive, and also adds to the weight of your glider, but for competition work it will pay handsome dividends.

It is certainly most intriguing, after waiting for some time in silence for news, to hear the pilot say, for instance, "I have contacted a wave, and am flying above cloud at 6,000 feet, a little to the south of Sheffield; proceed to Derby." By this means your trailer and crew can follow closely on your heels, and be ready to join you almost as soon as you land. The glider can then be de-rigged and returned to the starting point with the minimum loss of time. Indeed, on more than one occasion a suitable field has been found by the ground crew, and the news is then sent up to the pilot. He spots the car and trailer from above, and when he lands all is ready for immediate de-rigging.

The Controls

The main controls in a glider are identical with those in an aeroplane, but instead of the engine controls such as the throttle lever, petrol tap, ignition switch, etc., the glider has some special 'knobs' of its own:

(1) The tow-line release knob.
(2) The undercarriage release knob.
(3) The dive-brake lever.

The Tow-line Release Knob

Yes, the tow-line release actually is a knob; a yellow knob on the end of a cable, which you pull. The undercarriage release, when this luxury is fitted, is also a knob, and as there is often a knob, or even two knobs, to release the cockpit cover, the inside of the cockpit appears to bristle with knobs at times, which can become a little confusing. Sometimes an effort is made to help the pilot select the right one by giving them different colours, but personally I have always found them confusing and I heave a sigh of relief when the knob-pulling session is over. It all takes place during the first minute or so of your flight, with the exception of the cockpit cover knobs, and these must be left severely alone until you are back on the ground. Only in the last emergency, that is to say before 'bailing out' with your parachute, do you pull these knobs while still airborne. Pilots have been known to make mistakes. One of the best gliding stories I know concerns the World Gliding Champion of 1952, who once Pulled the Wrong Knob. The result of this slip was far-reaching. I would like to tell you the story now, but I should hate to infringe on his copyright, and he tells the story so well, against himself, in his recent book, *On Being a Bird.*

There is one good thing about the tow-line release knob: if you forget to pull it, or leave the pulling a bit late, it releases itself. It is quite an ingenious mechanism. The wire does not just drop off the hook, like the bunjie tow-line already described, for it is a closed hook; but if the glider flies on beyond the winch or the towing car before releasing, the backward pull on the mechanism causes it to open, and the line drops off.

The Undercarriage Release Knob

The detachable undercarriage, if fitted, consists of a pair of small wheels on an axle, and they are spaced just wide enough to straddle the skid. The height at which they should be released is critical, and not generally agreed upon. There is a danger, if you release them the moment you are airborne, that they may bounce up and damage the underneath of the fuselage. This is no imaginary danger and I have seen a nasty hole knocked in the bottom panel of the fuselage through an early release. It avails nothing to say, "But a ball can't bounce back to the height it is dropped from." The wheels dropping from a sailplane are also travelling forwards, and they may hit a bump. If you have ever played ski-ball in a fun-fair you will know exactly how the wheels may jump to a greater height than that from which they are dropped. I have also seen the axle of the undercarriage badly bent through being dropped too late, and falling about 30 feet. I think 10 feet is generally considered to be a safe height. If the pilot forgets to release them until he is above 20 or 30 feet it is usually best to leave them where they are. The glider will not fly so well, and he will have to remember they are there and make a suitable allowance when landing.

The Dive-brakes

The dive-brakes are an interesting feature of the sailplane. You can see them in the 'out' position in Plate I. There are various types of dive-brakes, but they all have the same purpose: to spoil some of the 'lift' of the wing and offer more resistance to the air, so that the sailplane will *descend* more quickly without gathering forward speed. They are not to be confused with flaps on a powered aircraft; indeed, a pilot guilty of this confusion might well come to grief. The flaps on an aeroplane *reduce* the stalling speed; in other words an aeroplane that normally becomes uncontrollable and liable to stall at 50 m.p.h. will still be flying properly and under control at, say, 40 m.p.h. with the flaps in action. The dive-brakes on a sailplane have exactly the opposite effect; they *increase* the stalling speed. In other words, if you could normally fly your sailplane safely and under control at 40 m.p.h., you would have to *increase* your speed to fly safely with your dive-brakes in action. I can now hear my reader saying to himself, "Well, that's a crazy set of brakes." I must admit it all sounds a bit odd, but I shall try to explain it.

The whole thing is really a question of gliding angles, and consequently rates of descent. Let us suppose a pilot wants to put his sailplane down in a small field; the field is a quarter of a mile ahead, and he is flying at a height of 500 feet. At a normal gliding angle, say 1 in 25, in order to lose that 500 feet he has got to fly a distance of 500 × 25 feet = 12,500 feet, which is about two miles. All the time he is busy 'flying off' the two miles he must keep the field well in view, and not behind him, and not very far away. It is not easy. He must resist the temptation to put his nose down and fly straight in, because if he did he would arrive at about 80 m.p.h., sweep across the field at 70 m.p.h., and arrive at the hedge on the far side still doing about 40 m.p.h., and still flying. A nice kettle of fish. But this is where the dive-brakes come in; with the brakes out, that is to say in action, the pilot can put his nose down and aim at the spot he wants to land on. Instead of arriving at about 80 m.p.h. he will arrive at a modest 55 or 60, and, what is more, the moment he flattens out to land the speed will rapidly drop to stalling point, and he will touch down in the next 20 or 30 yards. So you will see (I hope) that the brakes on a sailplane are not to make you fly *slower*; no aircraft can fly slower than its stalling speed. They are there to enable you to descend much more steeply *without flying a lot faster*, and then in the last few seconds, as you flatten out to land, they cut your speed down very rapidly to stalling point. By means of the lever in the cockpit the amount of braking surface presented to the air is variable from nothing to 'full on', so with practice a pilot can adjust his angle of approach, his speed, and consequently his rate of descent, to any requirements.

There is also another and quite different reason for fitting dive-brakes to sailplanes, and this has to do with getting out of control when flying in a cloud. Details will be found in Chapter VI.

CHAPTER VI

CLOUDS AND CLOUD FLYING

I

A WHOLE book could be written about the weather, the clouds, and kindred subjects, and as several such books exist I recommend anyone interested in a serious study of meteorology to purchase one of these. I am going to talk about clouds from two points of view: the ordinary man looking up at the clouds from below, and the glider pilot who flies in them. But let me point out here and now that I am not an expert on blind-flying; that is to say flying in a cloud where you cannot see. Even if I was it would be an impossible task to teach anyone to fly in cloud by the written word, or give a really adequate impression of the peculiar sensations involved. However, let us get back to the beginning: the ordinary man looking up at the clouds from below.

It is quite extraordinary how most people go through life without ever learning anything about the clouds, and yet there they are passing overhead, all shapes and sizes, almost every day of your life. In fact in this country I think one could safely omit the word 'almost'. One learns about the flowers, and trees, and animals, and if sufficiently hard-pressed could probably put names to the more common ones. The reader may object to this suggestion, and say indignantly that he or she could name most of the animals, and a great many flowers and trees. I reply that they would only be skimming the surface. The different kinds of trees and flowers are bad enough, but when it comes to the animal kingdom the mind just boggles at the immensity of the problem. Taking insects alone, there are more different kinds of these creatures than all the rest of the animal kingdom put together. And yet the poor humble clouds, passing daily overhead, boast only of ten principal types, and we are content to lump the whole lot together under the one word 'cloud'; and this in spite of the fact that they have a considerable influence on our daily lives. So much so that you do not even pass your friend or acquaintance in the street without making some reference to it. "Going to be a nice day," "Bit cloudy this morning." The standard topic of conversation of the Englishman, and yet if someone were to answer, "Yes, what kind of clouds are they?" he would be nonplussed. Mackerel sky; thunder-clouds; this would be about the limit of his vocabulary. So while the weather is the most universal topic of conversation for the opening remark, most people remain blissfully ignorant about the clouds, why they form, why they disappear, and what they are made of.

Now let us have a look at the clouds and see what we can find out. If you get yourself a nice little book on meteorology and turn to the chapter on clouds, you will not have to read very far before you come to a sentence something like the following: "If the lapse-rate is much greater than the saturated adiabatic for a considerable range of height, the cloud will tower up to a great height." What on earth does that mean? The dictionary is no help. Assuming that you are a novice, tentatively questing for knowledge of meteorology, you are now faced with two alternatives: (1) To put the book away on a shelf and forget it; (2) To turn back to the beginning, arm yourself with a paper and pencil, and quietly work at each chapter in turn until you really understand what the author is trying to tell you. If you have an interest in scientific subjects I strongly advise course No. 2. Every day and all day the sky and the weather will provide first-hand illustrations of what you are studying.

A cloud, a patch of fog, or a layer of mist are all the same thing; they are given different names because they are caused by different sets of conditions, and therefore appear in slightly different forms. It is enough for our purposes, for the moment, to know that they are all caused by condensation of water vapour, so that tiny particles of moisture hang suspended in the air. When they form a cloud in the sky they are nice clean droplets of water, but when they form a fog over a big city they are dirty, polluted droplets, full of the impurities of industrial and domestic life.

What, then, is the primary cause of cloud formation? I have already mentioned this briefly in Chapter III, but now we will study it a little more carefully. Clouds are formed by a mass of air moving upwards. Under normal conditions the atmosphere is colder at 1,000 feet altitude than at ground level, and colder at 2,000 feet than it is at 1,000 feet, and in fact scientists have discovered that it *usually* gets colder the higher you go, according to a definite plan, and the plan is approximately 3°F. for every 1,000 feet. A certain gentleman, Sir Napier Shaw, suggested that this fall in temperature be called 'lapse', and so the rate at which it happens is called the 'lapse rate'. Now let us return for a moment to the sailplane pilot's Magic Carpet, the mass of air moving upward. Scientists have made the surprising discovery that this air usually cools down *at a faster rate than the air through which it climbs.* "Why?" I was afraid you would ask me that. Well, air does some funny things when you compress it, or decompress it. If a mass of air rises from ground level to 3,000 feet, where the atmospheric pressure is less, it is going to be decompressed, it is going to expand. Have you ever blown up a bicycle tyre? I hope so, because if not my next remarks will not be so convincing. The pump connector gets hot, doesn't it? If you thought this was caused by the friction of the air being forced through a small hole, you were wrong; it is caused by the air being *compressed.* If you remove the valve centre and let the air come rushing out, it feels very cold against your hand, doesn't it? If you thought this was because the air was 'blowing' against your hand, like blowing your soup to cool it, you were wrong again; it is caused by the air being *decompressed.* So will you now keep these two facts in mind; (1) If you compress air, it gets hotter; (2) If you let it expand it gets cooler. "Why?" Ah, you've got me there, pal! The explanation of the reason for these changes of temperature with pressure involves a study of the atomic structure of gases, and I am certainly not qualified to go into this. So you must take it for granted: if you compress air it gets hot; if you release the pressure it gets cool.

So to return once more to our thermal: the mass of air moving upwards. It goes up to a region where the air pressure is less, so it is going to be decompressed; it is going to expand, therefore it is going to get cooler. Now we already know that if you take moist, warm air, and cool it down, the moisture condenses. If you breathe on a cold window-pane, the moisture in your breath causes a cloud to form on the glass. So a mass of air moving upwards will soon become cold enough to cause condensation of the contained moisture, and cause a cloud to form in the sky. I mentioned just now that air moving upwards usually cools down faster than the air through which it climbs; that is to say it has a faster 'lapse rate'. Actually this is about 5½°F. per 1,000 feet, but it varies according to the amount of moisture contained in it. This special lapse rate of ascending masses of air has been given the name 'adiabatic lapse rate'. I am going to explain the meaning of this rather carefully, because it is very important, and important to you personally, whether you fly or not; you will see why in a moment. Adiabatic is a Greek word, meaning 'impassable', or 'not passing'. In this case it refers to heat. Normally you would say that to get anything hot you must heat it, for instance in front of a fire; in other words you would *pass heat into it.* To cool an object down you would put it in a cold place, and so *take heat out of it.* But adiabatic means 'not passing'; in other words these masses of rising or falling air do not get hotter or colder because they are being heated or cooled by the surrounding air; they do it of their own volition, as it were, because *something is happening inside them.* This meteorological phenomenon is certainly mainly responsible for the appearance and disappearance of clouds, and therefore must fairly and squarely take the blame for our rainfall.

If we examine the situation now, knowing that the adiabatic lapse rate can be as much as 5½°F. per 1,000 feet, even though the lapse rate of the surrounding air is only 3°F., another strange state of affairs will come to light, and we shall discover what the weather experts mean when they say conditions are stable, or unstable. We will suppose that a warm bubble of air has developed over a ploughed field, and that its temperature has reached 52°F., whereas the surrounding air is only 50°F. (*see* Fig. 15, Section 1). It now breaks free from the ground and starts to rise as a thermal, and reaches nearly 1,000 feet. It does not quite get to 1,000 feet because if it did it would be ½° colder than the surrounding air, as shown by the 'dotted line' thermal in Section 2. If it were *colder* it would be *heavier*, so it would remain somewhere about 900 feet, as shown in Section 3. This is a poor do for the sailplane pilot; a feeble thermal petering out at less than 1,000 feet. He puts his sailplane away and retires to the club bar. The 'back-room boys' are already in session there, and they declare that conditions are 'Stable'. But fortunately the lapse rate is not always as low as 3°F. per 1,000 feet; it might be 5°. So now if a thermal rises to 1,000 feet and loses 5½°F. it will still be 1½° *warmer* than the surrounding air, and if it is warmer then it must be *lighter*, so it goes on climbing upwards. See Fig. 16, Section 2. Now have a look at it when it gets to 2,000 feet; still 1° warmer as shown in Section 3. Finally, in Section 5 you will see that it has become the same temperature as the surrounding air, so this is as high as it will go. However, it has made a nice little climb of 4,000 feet; just the job for the sailplane pilot, and you will not find the back-room boys in the bar. They will be out flying, and their verdict on the prevailing conditions will be 'Unstable'.

I am sure if any meteorologists see my diagrams they will be horrified, because they make the whole thing too simple; in real life lapse rates and adiabatic lapse rates do not just go on at the same rate all the way up, like the 'tamed' ones in my diagrams. Their rates are affected by various things such as the moisture content, and the latent heat of condensation, which I hope to tell you about shortly. The little 'hot air balloons' that I have drawn to represent a rising thermal are also very much simplified; actually they would be more likely to develop into columns of rising air, with different lapse rates in different

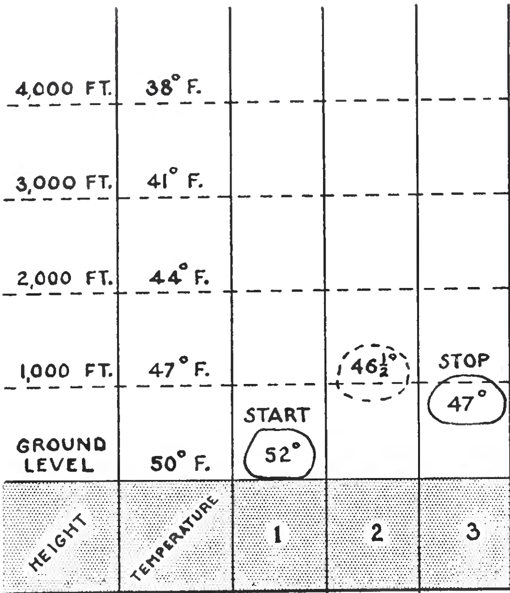


FIG. 15

Stable Conditions

The lapse rate is 3° F. (See temperature column.) The adiabatic lapse rate is 5½° F. (See figures in the thermal.) Compare these at various levels

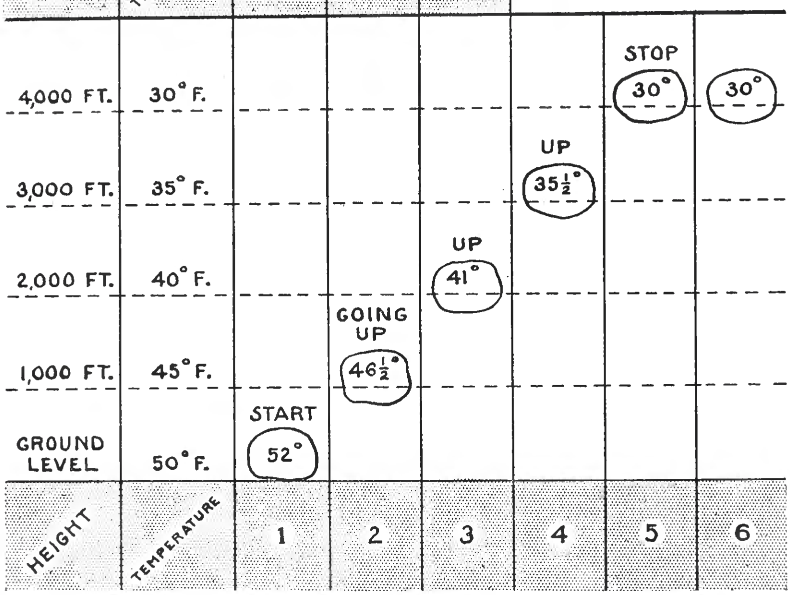


FIG. 16

Unstable Conditions

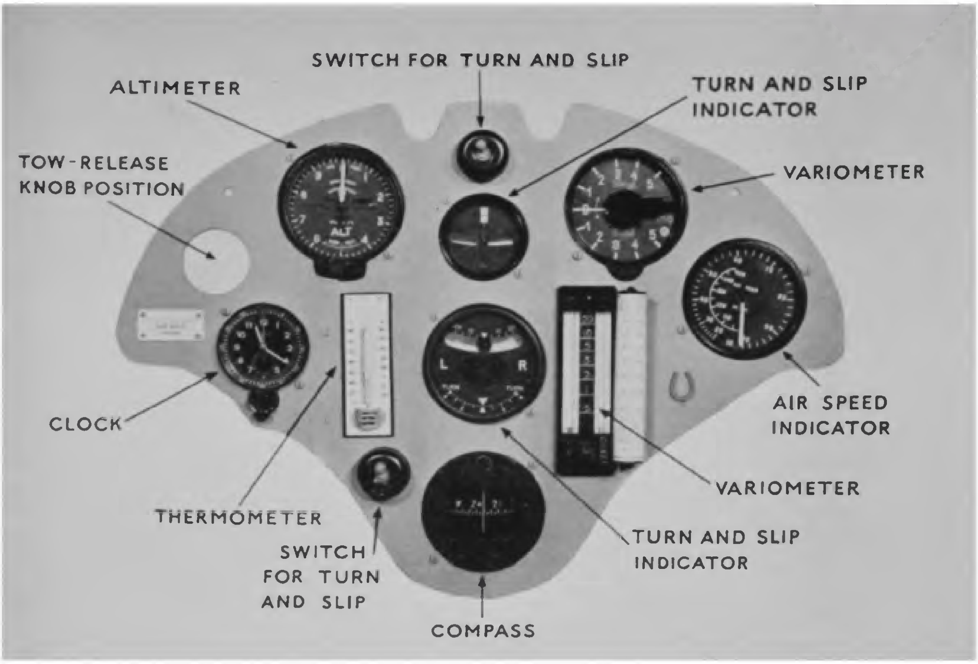
The lapse rate is now 5° F. (See temperature column.) The adiabatic lapse rate is 5½° F. (See figures in the thermal.) Compare these again and you will see that the thermal is always slightly warmer until it reaches a height of 4,000 feet parts of the same thermal. But they help me to understand lapse rates and the difference between stable and unstable conditions, so I hope they will also help the reader.

So now, if you have read Chapter I, you will have some idea of the kind of things that may start a thermal off from the ground, and also what sort of conditions will make it continue to climb, or slow down and stop. The conditions are not difficult to recognize if you take the trouble to look up at the clouds. If it is overcast with greyish flat-looking cloud, and little or no blue sky showing through, then the conditions are stable. This type of cloud is called 'stratus'. A thermal that may get 'triggered off', for one reason or another, will soon slow down in its ascent. If any condensation takes place the resulting cloud will join up with the existing layer, and help to make an even bigger, thicker cloud, that blots out the sun. The thermal, as such, has ceased to exist. If, on the other hand, there is a fair amount of blue sky, and there are nice white, woolly-looking clouds, the conditions are unstable. These clouds are called 'cumulus'. The lapse rate is high. Up there at 3,000 to 4,000 feet it is pretty cold. A thermal that starts off from the ground now is in for a big climb; at 3,000 feet it will still find itself warmer than the surrounding air, and therefore lighter, so it will continue to climb. At a certain height, of course, it will have cooled down sufficiently to start condensation, but this does not mean that it will stop climbing; it may, in fact, increase its upward speed. As the cloud forms, a new factor comes into play: when moisture in the air condenses a certain amount of heat is set free; it is only a small amount but it has quite an important effect. The scientists call this the 'latent heat of condensation'. If you look up the word latent in the dictionary you will find it means 'hidden'. Where was this heat hidden and how did it get there?

Something rather special happens when a gas turns to a liquid (e.g. water vapour condensing to become water), or a liquid turns to a solid (e.g. water freezing to become ice) and also when the reverse operation takes place. In these operations there seems to be a sort of barrier to be overcome. For instance, it requires a definite amount of heat to raise the temperature of a bucket of water 1 °C. but it requires about *eighty times* that amount to raise the temperature of a bucket of ice 1 °C. so that it becomes water. In the same way it requires a great deal of extra heat to convert water into water vapour. This heat seems to be stored up in some way and then released when the change occurs in the opposite direction, so that when water vapour in the air condenses to form a cloud the heat is released. Now referring again to the thermal which is beginning to form a cloud; it has risen to its present height, the condensation level, because it is warmer and therefore lighter than the surrounding air. It is cooling down all the time, as it rises, but not so quickly that it becomes as cold as the surrounding air. This is the point at which the latent heat of condensation takes a hand; it is not enough to make the thermal warmer; but it slows down the rate of cooling, and causes a greater difference between the temperature of the thermal and the cool air through which it is climbing. This is what makes it climb faster, and therefore the sailplane pilot often finds his rate of climb increases when he enters the cloud that is capping his thermal.

You will probably have noticed, on a suitable day when there are big cumulus clouds about, how they tower up into the sky. If you watch carefully you will be able to see the tops building up, and this is because of the very strong currents that climb up through the centre. They may reach vertical speeds of 35 or 40 feet per second, that is to say about 25 m.p.h., and carry the tops of the clouds to a height of 30,000 feet or even more.

Broadly speaking, clouds can be divided into two main groups, namely Heap Clouds and Layer Clouds. These are subdivided again according to the heights at which they generally occur. I am going to give a short description of some of those most commonly seen, with a few notes on how they affect the sailplane pilot; with the help of the photographs the reader should be able to recognize them. (*see* Plates XI and XII.)



The instrument board *Photograph by Charles E. Brown*

PLATE IX

A cloud street *Photograph by Dr. R. S. Scorer*

Photograph—Illustrated

"The problem of leaning over on corners" (*See* Chap. IX)

"There is no sensation of leaning or falling." (The girl in the centre is trying a bit of blind flying)

Photograph—Sunday Pictorial

PLATE X

NIMBO-STRATUS

This is a good name for a cloud, because if you look up the words in your Latin dictionary you will find they mean cloud-cover, or cloud-layer. This type is a dark shapeless mass, often bringing rain or snow, the base of which is usually very close to the ground. It is no good to the sailplane pilot. I have not included a photograph of this cloud because it makes a dull, uninteresting picture.

STRATUS

A layer of cloud almost uniform in density, not so dark as the nimbo-stratus, and often obscuring the whole sky; a typical dull day, with probably no sunshine, and sometimes rain or a fine drizzle. Like the nimbo-stratus it is no use to the sailplane pilot. The cloud may lie at any height from about 400 to 4,000 feet, and sometimes the layer is of considerable thickness. It is rather like an immense fog that does not reach down to ground level, but it may well cover high ground and is therefore dangerous for aircraft to fly in. Gliders launched on this sort of day often disappear into cloud while still on the launching wire. Airliners, equipped with all the latest aids to navigation, think nothing of taking off and flying up through this layer of cloud. It is a wonderful experience to embark at the airport on a miserable dull day, and soon after take-off, having possibly had a rather bumpy journey through the cloud, to break through the cloud-top into glorious sunshine. Here it is smooth flying, and a vast sea of brilliant white cloud stretches away as far as the eye can see; you will need your dark glasses. Even in England every day is a lovely day if you go high enough!

CUMULUS

The familiar 'woolpack' clouds seen in fair weather. The bases appear to be all about the same level, which may be anything from about 2,000 to 5,000 feet, and the tops sometimes reach a considerable height, towering up to 10,000 or 15,000 feet; there is blue sky between individual clouds. This is the day for the sailplane pilot, for those towering white clouds are his signposts. They mark the tops of the invisible magic carpets, as already explained in Chapter III. The word cumulus is Latin for heap, and is therefore quite descriptive of this type of cloud (*see* Plate VI).

Cirrus

These 'wispy' looking clouds are sometimes called Mare's Tails, and have the appearance of being very high. They are—perhaps 30,000 feet—and consist of ice crystals, so they are really a form of snow suspended in the sky. They are of no special interest to the glider pilot except as an indication of what kind of weather to expect. Unfortunately, though appearing in a blue sky, they often indicate the approach of dull and rainy weather. Cirrus means a tendril, or curled filament.

Cumulo-nimbus

Amongst the flying fraternity this ominous-looking cloud is popularly called a 'cu-nim' (pronounced cue-nim). It is like a cumulus cloud to look at except that it is usually darker, bigger, and extends to a greater height. In fact it may be difficult to decide when a cloud ceases to be a cumulus and becomes a cumulo-nimbus, and to a certain extent this applies to all types of cloud. Sometimes you may look up at the sky and find it a bit of a mixture, with one type merging into another, and you will be at a loss as to how to classify them.

The genuine 'cu-nim' has exciting entertainments for the sailplane pilot, such as snow, hail, ice formation on the wings and other parts, and thunderstorms. The layman calls it a thundercloud. It is rough and turbulent inside, and the up-currents reach very high vertical speeds, probably in the neighbourhood of 50 m.p.h.

Anvil Cloud

Sometimes the top of a 'cu-nim' takes the shape of a blacksmith's anvil. It is an interesting phenomenon, and probably caused by what is known as an inversion. This means that the normal temperature lapse is inverted; it gets warmer with increasing height and a layer of warm air is formed. This effectively puts a stop to any upcurrents, because rising air will not climb through air that is warmer than itself. Consequently the strong upcurrents at the top of a cu-nim suddenly find themselves up against a sort of ceiling, and they have to spread out to make room for the rising air which continues to come up from below. More details about what goes on inside a cumulo-nimbus cloud will be found in Part II of this chapter.

Lenticular

This is the wave-cloud which I have already mentioned in connection with wave-lift. The word means lens or lentil-shaped, but they are often elongated and look more like huge cigars. One is formed at the crest of each wave, so there may be several all lying parallel to each other, as in Plate XI. For further details see Chapter III, and Figs. 4 and 9.

Cirro-cumulus

This is the name the scientists have given to our old friend 'Mackerel Sky'. As the name implies, it is cirrus cloud in cumulus form. It is of no special interest to the glider pilot but I have included it here because it is fairly well known by its familiar name, and I had cause to mention it earlier in this chapter.

II.

Some of my readers may have been puzzled by the expression 'blind-flying' used in Chapter V. It is a term frequently used in the flying world to indicate flying in cloud, or flying at night when it is very dark, and there is nothing to be seen outside the aircraft. I can assure you that it is quite an apt expression, for when in a thick cloud the pilot might just as well be blind for all that he can see outside. There is no horizon by which he can judge his attitude; the only way he can tell whether he is flying straight, or turning, and whether he has the correct amount of bank for the turn, and the correct gliding angle, is by watching his instruments. This may well be difficult to believe for anyone who has never flown in a cloud, but I will attempt to explain it.

Suppose you sit blindfolded in an ordinary chair, and get a friend to tip the chair in various directions. In spite of the fact that you cannot see you will be able to tell quite easily which way the chair is being tipped, and if you had a control-stick like that in an aircraft there would be no doubt in your mind about which way to move it to correct the tipping of the chair. In view of this, why is it that in an aircraft, in a cloud where you cannot see, you do not know which way you are being tipped? I have a nasty suspicion that in setting myself this question to answer I may have bitten off more than I can chew. Even if I give the correct answer I am afraid it may not sound very convincing. But in the interests of science, or rather in the interests of explaining a scientific fact to my readers, I must make the attempt.

The fundamental difference between the chair in your sitting-room at home and the seat in the cockpit of an aircraft is that the chair is stationary and the seat in the aircraft is not. The moment that the chair is tipped you know what is happening, because gravity exerts its pull and you feel that you are going to slide off, to one side or the other, or forwards, or else your weight will be taken by the back of the chair. But in an aircraft there is another force to be taken into account, and that is the force caused by the movement of the aircraft itself. Whether you like to call this centrifugal force, or centripetal acceleration, or 'g' does not really matter; it is a force which can exert its pull in *any direction*, up, down or sideways, like the force acting on the water in the bucket that I talked about in Chapter V. This force, which acts upon a moving aircraft, can make complete nonsense of your normal reactions which would tell you what is happening to the chair in your sitting-room at home.

I think I could illustrate this point by considering for a moment that contrivance seen at fun-fairs and known as 'The

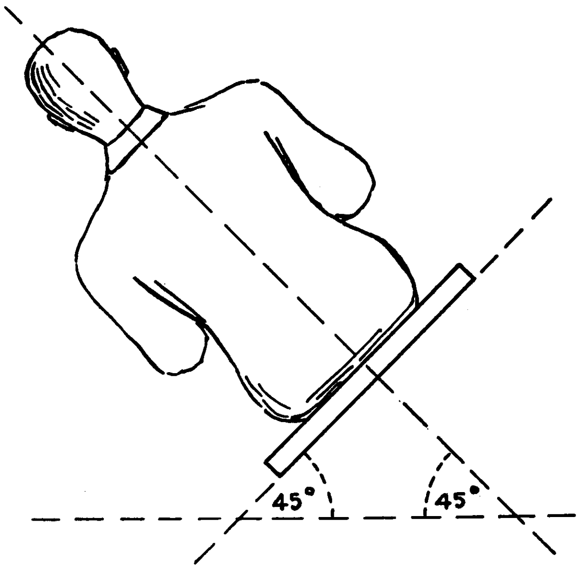


FIG. 17
The Chair-o-Planes
There is no sensation of leaning

Chair-o-planes'. (*See* Plate X). Certainly the name is apt if nothing else, and seems to combine a chair and an aeroplane in a most convenient manner. Sitting in one of these 'chairs', and being swung out to an angle of at least 45°, there is no feeling that you are going to fall out of your chair, nor even any tendency to slide down against the arm of the chair on the lower side. This means that there is no sensation of 'leaning' or 'falling', in spite of the fact that you are actually sitting on a chair that is inclined at an angle of 45°, and your body is also inclined at an angle of 45° in the other direction (*see* Fig. 17). In other words, if you were blindfolded, *you would not know that you were leaning over sideways.* Further, you would not know whether you were being swung round to the right or to the left; in fact you might think you were not turning in either direction.

This is the problem that faces the pilot of an aircraft in a cloud, and this is why it is called blind-flying. For the sailplane pilot life is even more complicated, because he goes into the cloud to gain height, and to gain height he must fly round and round in circles; in fact just as though he were sitting in the chair-o-planes! Furthermore the cloud is likely to be rough and turbulent, and it may be very rough; consequently the sailplane is continuously being thrown into peculiar attitudes, and this must be known and corrected by the pilot. There are at least three instruments on the dashboard that must be watched, and their information digested and acted upon, in order to make a successful climb in a cloud. And even these instruments are not such a gift from the gods as you might imagine; it takes a lot of practice to use them properly, and they frequently tell you things that are very hard to believe. Something gives you the impression that your left wing is low, and you instinctively want to correct this with your control-stick, but your instruments tell you that your right wing is low, and you have to *make* yourself do exactly the opposite to what your instinctive feelings suggest you ought to do. It is mentally quite tiring, and some pilots find that five or ten minutes of it is enough. If you choose your cloud with discretion, which is the better part of valour, it will be possible to stop circling and set a straight course and be out of the cloud in a couple of minutes. You can then have a short rest, and if your recent sojourn in the cloud has been successful and has not frightened you too much, you will almost certainly be tempted to fly in again and have another go.

I remember on one occasion I was flying nicely out of a cloud (as I thought), and when I burst out into the sunshine, looking eagerly for the horizon ahead of me, it was not there; only blue sky. I had committed the unpardonable sin of not watching the Air Speed Indicator, and I had come out of the cloud with the nose of my machine well up in the air, and on the point of stalling. Before I had time to get the nose down we stalled, and then the nose came down with a vengeance, and I plunged straight back into the cloud that I thought I had so successfully flown out of. However, it was only an outcrop of the main cloud, and as soon as I had flattened out again I emerged on an even keel and with a sigh of relief.

A pilot who has not had a good deal of experience of blind-flying, and who is rash enough to enter a big cloud and successfully climb some way up inside it, may get into quite serious difficulty. Even experienced pilots find that in a turbulent cloud they sometimes get a feeling of vertigo and perhaps nausea, and an inability to respond to their instruments which is caused by this and mental fatigue. I have no hesitation in admitting that I do not fly into these big clouds myself; the small fry give me quite enough fun, and often a modest measure of excitement.

If a pilot who is inside a cloud does get into difficulties, and his sailplane gets out of control and dives, he may well cause undue stress on the structure by mishandling the controls in trying to extricate himself. Sailplanes have been known to break up in the air, and for this reason a parachute is an essential part of the equipment. Modern sailplanes, however, have a sort of 'safety valve' in the form of dive-brakes. If you are in a cloud and get into difficulties, all you need do is to put out your dive-brakes, *let go of the controls*, and wait. (You will have time to offer a silent prayer!) The sailplane will bring itself out of the cloud quite comfortably. It cannot exceed a safe speed because the dive-brakes are designed partly for this purpose; there cannot be undue stresses imposed on the airframe through mishandling the controls because you do not touch them. It is advisable, however, to be sure that your cloud is not sitting on the top of a hill.

Recently I had an opportunity to try out this technique in an Olympia sailplane, as a deliberate experiment, when not in cloud. I say 'opportunity' because it is not often that a glider pilot is prepared to chuck away, so to speak, hard-earned height by putting out his dive-brakes unnecessarily. On this occasion, however, I was at about 3,500 feet and had been in the air for an hour; this was an agreed 'time ration' because other pilots were waiting to fly the aircraft, so now I *had* to get down.

First of all I pulled the dive-brakes right out, let go of the stick, and took my feet off the rudder bar. The nose went down a little and the speed increased to about 45 m.p.h.; we came down in a big, fairly flat spiral, turning gently to the right. It was a most harmless and unspectacular descent. I put the brakes in, corrected the attitude to a normal glide, and then tried the experiment again. This time we descended in a similar spiral but turning to the left. Now I wanted to see what would happen if the brakes were put out while the aircraft was diving. I put the nose down into a dive of about 80 m.p.h. and then eased the brakes out; I held it in the dive for a moment and then let go of all controls as before. The nose came up immediately and we settled down once more into the old, gentle, spiral descent. I regard this as a most convincing and reassuring experiment, and a remarkable testimony to the aerodynamic qualities of the sailplane and its dive-brakes.

Sailplane pilots do not fly in clouds just because they like it; it is because, having selected a suitable cloud, they are fairly certain to find good lift there, and, what is more, lift that will probably continue for some thousands of feet, according to the size of the cloud. An ordinary white cumulus cloud may be fairly smooth and steady inside, and provide quite a pleasant climb, though not particularly fast. A cumulo-nimbus, on the other hand, is quite a different story. I will remind you again that a cumulo-nimbus cloud is a thunder-cloud. It may contain electric storms and other unpleasant features such as snow and hail. An intrepid sailplane pilot is prepared to face these dangers, in the same way that a mountaineer is prepared to face danger, provided the pilot has the proper blind-flying instruments and knows how to use them, because the lift is much stronger than in an ordinary cumulus cloud. But it might be very turbulent and gusty, and therefore very difficult to keep the aircraft in a proper flying attitude.

There is no doubt some strange things go on inside a 'cu-nim', and more often than not it is the sailplane pilot who experiences them at first hand. With the exception of service aircraft, pilots of powered planes tend to avoid these clouds because they are very bumpy and unpleasant, and most passengers in an airliner would certainly be air-sick. They would probably all be frightened. Scientists know about some of these things by observation and deduction, but they are not all in agreement as to their cause and effect. For instance, it rains *upwards* in a thunder-cloud. The ascending currents may be so strong, possibly in the region of 50 m.p.h., that they carry the raindrops up with them. As the drops are carried up they collect more moisture and get bigger and bigger, but there is a limit to their size and the speed at which these large drops can climb. If the upward current exceeds 27 m.p.h. they become top-heavy, as it were, and break up into smaller drops which continue upwards; and this is where the thunderstorm steps in. Scientists believe that when the drops break up they become charged with positive electricity, and as the process continues the electric charge gets bigger and bigger, so that the cloud becomes a sort of positive plate of a gigantic accumulator. The negative plate is another part of the cloud, or a different cloud, or the earth. When the charge reaches a certain magnitude it overcomes the resistance of the air and leaps across the gap, with the result that is familiar to all.

Now we will go back for a moment and have another look at our 'upward rain'. The terrific gusts that carry the rain up through a cloud are not continuous; they have bursts of activity and then die away. If the lull comes when the upward travelling raindrops are a fair size, and if it lasts long enough, these drops will fall out through the bottom of the cloud and we get that very heavy rain that often accompanies a thunderstorm. But sometimes the upward gust renews its vigour before the raindrops have had time to fall out of the cloud, and they get carried up again. They may reach a level where it is freezing, and become little balls of ice, so now we have the makings of a perfectly good hailstorm. It is unlikely, however, that they will be allowed to drop out of their parent cloud at the first time of asking. Having fallen a bit and collected a coating of water, or possibly even snow, on the way down, they will be caught by another upward gust, and get carried up to the freezing level again, and their newly acquired coating of water or snow turns to ice. They are getting bigger. In fact this up and down process may happen several times, and each time it happens they acquire an additional coating of ice, so getting bigger and bigger. This is how the very big hailstones that sometimes fall are formed, and if you cut one of these in half you may be able to see the different layers, which tell the story of its journeys up and down.

Snow is formed when conditions are such that condensation takes place at freezing level, and the tiny particles of water form into ice crystals, which cling together in clusters and thus make the familiar snowflakes. It is by no means certain, however, that they will fall to the ground in this form. They may be destined to help build up some hailstones, or, unromantic thought, they may thaw out on their downward journey and reach the ground as common or garden drops of rain.

CHAPTER VII

FLYING WITH AN ENGINE

CONSIDERING that I owe my original interest in flying to powered aircraft this book would certainly not be complete without some mention of it. I suppose it all began in the year 1910, when I was nine years old, and we were staying in Dover. It was the year that the Hon. Charles Rolls flew across the English Channel and back without landing in France, and my father and I walked up on to the cliffs of Dover to watch him land on his return.

It was during this same holiday that I learnt to swim, and ever since then swimming and diving have been among my favourite sports. Recently I have been trying 'goggle fishing', with breathing apparatus and frogman's feet, and I must take this opportunity to recommend this sport to the reader if he or she is keen on swimming. Strange as it may seem, this sport and gliding have something very much in common: they both open up an entirely new world, and it is a world of three dimensions. The underwater swimmer, like the glider pilot, can go up or down at will, in addition to being able to turn left or right. The poor old landlubber, trudging about on his flat feet, is only able to turn left or right. In other directions he is completely dependent upon the contours of the ground; if he wants to go up he must find a mountain, and if he wants to go down he must find a hole in the ground. This limitation has bred two special types, and presumably types who have grown tired of a flat existence; they are called, respectively, Mountaineers and Speleologists (Pot-holers may sound more familiar). I hasten to add that I have had a go at both these sports and thoroughly enjoyed them. People who tend to scoff at unusual and so-called useless hobbies often pick on mountaineering and rock climbing, and I am sure they would attack pot-holing too, but they probably have never heard of it.

But to return for a moment to goggle fishing (and then, I suppose, to return to flying!), my underwater 'fishing' does not involve the use of a harpoon gun. The beauty of the underwater world, and the fish that live there, is such that I should be loth to desecrate it with death and destruction. The extraordinary thing about the goggles that are worn for swimming under water is that they enable you to see everything perfectly clearly, which reveals a new and undreamt-of world of extreme beauty and amazing colour. It is the special reward of the underwater swimmer, in the same way that the unending beauty and fascination of flight is the special reward of the pilot.

My childhood interest in flying was again roused in 1911, when I watched aircraft fly past that were taking part in the Round-England Air Race; and later during the 1914–18 War, when one of my elder brothers joined the Royal Flying Corps, as it was called in those days. I still have in my possession letters which he wrote to me from France, when I was a boy at school, with sketches to show the names of all the various parts and controls of an aeroplane. I recollect very clearly that he told me that he and some of his colleagues in the Squadron had succeeded in flying their aircraft upside-down, without our modern equipment of safety harness, by wedging their shoulders under the fairing at the back of the cockpit! On the strength of these letters, which were most informative, I gave lectures to the school Scientific Society about flying and the theory of flight.

Like many another air-minded enthusiast of about that time I had my first flight in an Avro 504 K, which was giving joy-rides near my home. It cost only 2*s*. 6*d*. for a short flight, and 7*s*. 6*d*. for a flight with aerobatics; 'Stunts' they were called in those days. We were taken up two at a time, and having been up with a friend on a 2*s*. 6*d*. trip we immediately booked for a 'stunt flight'. I shall never forget it; we were not strapped in but were told to 'hang on', and shown what we could 'hang on' to. Actually the pilot did not do any 'stunts' that were likely to throw us out of the plane, which was just as well because most of the time we were helpless with laughter. I could not tell you now what we actually did, but certainly loops and spins, and the earth cavorted up and around us in all directions. I lost my glasses but gained an overwhelming desire to learn to fly.

This must have been about the year 1920, but it was not until ten years later that I joined the Lancashire Aero Club, then operating at Woodford Aerodrome, Cheshire, and had my first lessons in flying. I was so impressed by the experience that I immediately wrote to my brother and told him all about it, and said that I found flying was a fascinating game. I shall always remember his opening remark in the letter which I received in reply: "You are right, flying is a fascinating game, first, last, and always." How true.

In those days flying clubs received a subsidy from the Government, so flying was much cheaper than it is now, and there were more people taking part. The clubs were altogether more 'alive', both from a flying and a social point of view. Nowadays when I go to my own club, or visit any others, I get the impression that almost nothing is going on, and I can only describe them as 'dead'. I would not like to say that all flying clubs are like this, but it certainly is so in my experience. I think there are two main reasons why this state of affairs has come about: first the very high cost of hiring club planes, which is usually around £3 an hour; and secondly the fantastic amount of regulations which you come up against if you want to own a light aeroplane yourself, or build one. A powered aircraft must, by law, have what is known as a Certificate of Airworthiness; usually referred to as a C. of A. It must be renewed every year. This may not sound very terrible, but I should explain that the gentleman who comes along to see that everything is done according to plan may decide that the wings and fuselage need to be stripped and covered with new fabric. If the makers of your aeroplane have brought out some modifications for their later models, he may insist that these be incorporated in your own aircraft before he will grant the C. of A. The whole job might well cost £150 to £200. You can buy a second-hand aeroplane for less than this, and no wonder; you need to have a small fortune to be able to fly it.

All these regulations, presumably, have been imposed to ensure the safety of the pilot and his passenger, and people on the ground who might be hit by a crashing aircraft. From this point of view they have been a howling success because they have practically eliminated private aeroplanes altogether. No one would quarrel with these very strict precautions where they are concerned with aircraft carrying fare-paying passengers; but to make them apply to every Tom, Dick, and Harry who wants to buy or build himself a small aeroplane seems to me unnecessary. A cargo- or passenger-carrying ship has to have, by law, a water-line mark round its hull known as the Plimsoll Line, to prevent dangerous overloading. This is a good law, and it is estimated that it has saved the lives of about 3,000 sailors per year; but imagine what it would be like if every privately owned yacht, dinghy, motor-boat or rowing-boat had to have a Plimsoll Line. Consider also that the line would have to be measured up and painted on by an expert, charging the owner of the boat for his services; and when it was done the Government would send along another expert to see if the line was painted on correctly.

Gliders and sailplanes have managed to escape from the tentacles of this death-dealing octopus, thanks to the British Gliding Association. They have undertaken to see that all gliders are airworthy, and have authorized certain properly qualified 'ground engineers', who in many cases are themselves members of gliding clubs, to see that a thorough inspection is carried out once a year; all necessary renovations and modifications for a C. of A. are then put in hand. In addition to this there is a daily inspection, carried out by qualified club members, before a glider is allowed to be flown.

Apart from the very high cost, I consider there are two snags about power flying: firstly the noise and clatter of the engine, and secondly the worry that this noise may suddenly stop. The noise in a small aeroplane is much worse than that experienced in an airliner. If it is a cabin machine you have to shout in order to take part in a conversation with your passenger, and if it has open cockpits you have to use speaking tubes and earphones; therefore normal conversation is ruled out. There may be quiet light aeroplanes in existence, but I have never come across one, and I have flown a good many different types. The trouble is that if you fit a really efficient silencer you lose some power, but apart from this it is doubtful if an air-cooled engine, which is the normal for a small aeroplane, can ever be as quiet as the water-cooled type.

This continual noise can be very tiring, especially on a long trip. While in Uganda, East Africa, in 1952, where I was working as a cotton buyer, I sometimes flew with my friend Mr. Margach, a keen amateur pilot who owned a Piper Cruiser. Incidentally he was also my 'boss' in the cotton business. On one occasion we flew from Entebbe in Uganda to Nairobi in Kenya. It was a magnificent flight, right across the famous Rift Valley, but we were in the air for four hours, and of course during this time the noise of the engine never stopped (thank goodness!). What a relief, on arriving at Nairobi, to be able to shut off the engine and step out into a world of silence! This must have been the longest trip I have ever done in a powered aircraft; it is strange to think that my longest trip in an aircraft *without* an engine exceeds this by one and a half hours.

And then there is the worry that the engine may suddenly stop. A pilot flying a single-engined aeroplane away from his home aerodrome is always faced with the possibility that he may get engine failure, and have to make a forced landing. The glider pilot, having no engine at all, is quite used to putting his aircraft down at any moment and in any convenient—or possibly inconvenient—spot. But this is a very different proposition. A glider is light compared with an aeroplane, and by using the dive-brakes can be put down in quite a small space, and will quickly come to rest. An aeroplane, with its heavy engine, and coming in to land at 50 or 60 m.p.h., will run some distance along the ground even after it has touched down. Over-enthusiastic use of the wheel-brakes will tip it on to its nose.

I made a number of trips in East Africa with Mr. Margach in his Piper Cruiser in connection with the cotton business, and we frequently flew over the Lake Albert area and down the Nile Valley to Northern Uganda. This was fascinating country to fly over, with its wild scenery and big game, but very ugly for a forced landing. One route took us slap across the Mgombo Forest; I do not know what the technique is if your engine fails here. You would almost certainly finish up perched in the tree-tops, but how to get down to the ground would present quite a tricky problem. Having reached the ground, life would still be complicated by wild animals, lack of food, and a difficult trek back to civilization. Equally unpleasant to contemplate was the Nile Valley itself, with miles and miles of papyrus swamps. It is not possible to walk in these swamps because the water is often quite deep, and you certainly could not swim because of the papyrus grass, which grows to a height of seven or eight feet, and is very thick. I think a better choice would be to land in the Nile itself, where you could at least swim. They say that crocodiles will not attack you in deep water; it would certainly be a chance to test the truth of this theory.

We used to do a good deal of 'forced landing practice' at the Lancashire Aero Club. This was quite an amusing pastime and not without its excitements. I would go up with the instructor, who at that time was Mr. George F. Yuill, in a dual-controlled plane and we would take it in turns to fly. The one who was not flying would suddenly, and without warning, close the throttle. It would be quite possible, of course, for the pilot to open it again, but the game was to pretend that this was engine failure. You had to pick a suitable field, get properly into wind, and glide in to land. On crossing the boundary hedge it was possible to tell whether you had made a good approach or 'muffed it', and you were then allowed to open the throttle again and fly away, without having actually touched the ground. At this point the 'observer' was allowed to make rude remarks about his opponent's performance. Needless to say George Yuill had more scope for such remarks than I did.

On two occasions I have had engine failure while flying across country, and therefore have reason to be thankful for

PLATE XI

1. Stratus

2. Cirrus

3. Cirro-cumulus

4. Lenticular

Photographs by permission of the Royal Meteorological Society

Photograph by Aero-films Ltd.

Photograph by John Simpson, London Gliding Club

A cumulo-nimbus producing rain and electricity

and this remarkable phenomenon—the anvil

Photograph by permission of Dolan, Davis Whitcombe & Stewart Ltd., and the Gloster Aircraft Co.

PLATE XII

those early days of forced landing practice. On the first occasion I was returning to Woodford Aerodrome after a trip to Norwich, with my brother as passenger. This was not the brother who had been a pilot during the 1914–18 War, I am glad to say; he would have been a far more critical judge of my performance. We had been deceived by a faulty petrol gauge, which had stuck at fifteen gallons; it was carelessness on my part because I should have known that there could not possibly be that amount of petrol left. I realized the state of affairs just before we were due to cross the Pennines, and so we decided to look for a suitable field near a garage. Unfortunately large fields in that part of the world are few and far between, and all the fields are surrounded by nasty stone walls. After stooging around a small village for several minutes at a very low altitude, I said to my brother over the speaking tube, "I don't like the look of anything here." I pushed open the throttle to climb away but there was no response; the engine only choked and spluttered! There was no time to argue the point now. I put the nose down and made straight for the field that had originally looked like a possibility. Luckily I was already on the leeward side of it, which meant that I could land upwind in the normal way. I was a bit high, so I had to do a long side-slip right down to the corner of the field. We straightened up and touched down quite comfortably, and judicious use of the wheel-brakes brought us to a stop in front of a line of trees at the opposite corner of the field. This corner was at a road junction in the middle of the village of Little Longstone; a pub stood exactly opposite. There was no need for discussion, no need for consultation; we climbed out, scaled the low wall, and disappeared through the door labelled 'Bar'.

The villagers, of course, knowing that people who fly are somewhat crazy anyhow, and that people who fly for pleasure are beyond hope, thought that we had just 'dropped in for a drink'. However, help was forthcoming on all sides, as it always is, and we soon had petrol aboard and were ready for take-off. By this time we had decided that a downwind take-off in a small field was not going to be clever with two up, so my brother was to be left behind. Actually the diagonal run was about 275 yards; there were two trees at the opposite corner, but there was room to fly between them if necessary. The aircraft we were flying in was an Avro Cadet, a gentleman among aeroplanes, and powered with a 140 h.p. Armstrong-Siddeley Genet Major. We got it tucked well under the trees to give as long a run as possible, and away I went. It was a roughish field, and after about two bounces I was airborne; by the time I reached the two trees I was fifty feet above them.

When nicely clear I turned and set course across the Pennines. It was then that I realized my troubles were not yet over; by now it was late evening, getting dark, and rather cloudy, and I could only just see to read the compass. Another ten minutes and I should not be able to see it at all. There was a little break in the clouds ahead showing a red glow where the sun was setting, so I took a bearing on this. I reckoned I should be home in twenty minutes, but with the gathering darkness it might be difficult to find the aerodrome. Perhaps my friends at the Club would put out some flares for me, as I had 'phoned George Yuill to say that I should be late. Sure enough, after about ten minutes I could see a bright fire away to the left in the far distance; I was 'off course'. I was annoyed about this because I reckoned I was correctly 'on course', but I turned and made for the flare. I did not like the look of it; the landmarks, what could be seen of them, were not familiar; and then I suddenly saw that this was no flare; this was some silly clot with a bonfire in his back garden. So I had not been 'off course'. Things were just beginning to look a bit ugly when I spotted the Cheadle Hulme–Macclesfield railway; now I knew where I was, this was as good as home. I came low and followed the railway north; some pilots call this 'flying by Bradshaw'. It was a good thing I knew this particular bit of the line well, because I still could not see the aerodrome when I was due to leave the line and turn west. But now I knew every tree, every haystack; this was my flying 'nursery', this was the country over which I had spent hours learning to fly, and doing forced landing practice with George. There was just enough light to get down safely, but I was a little peeved to think that nobody had bothered to put out a flare for me; where were my friends of the Lancashire Aero Club? Where do you think? In the bar.

On the occasion of my second forced landing I was taking up a girl friend on her very first flight. It was from Portsmouth Aerodrome, and we were just crossing the South Downs. The engine did not stop altogether, but suddenly started misfiring, making the most alarming and expensive noises and shaking as though it would drop out of the aircraft. I throttled back. We had plenty of height. "We shall have to come down in a field somewhere," I shouted over the speaking tube; "the engine's not behaving properly." It is difficult to sound casual when you have to shout, particularly if you do not actually feel casual, but the reply came back quite unconcerned: "That's all right, don't worry about me."

The engine continued to tick over, albeit rather more noisily than usual. Even if you switch off completely the engine will continue to turn, as the forward movement of the aircraft turns the propeller; a short burst of engine might save a crash landing, and would probably not do any more harm than had already been done. I picked a nice field, got correctly into the wind, and started to glide in. Then I saw cows, masses of them, in the far corner; but there was plenty of room, and it was too late to change the plan now, so I landed.

I do not know why cows seem to like aircraft; they certainly do not seem to be frightened of them. They came across the field the moment we touched down, and then stood round in the usual enquiring circle. This time my passenger was able to keep guard while I walked down to the nearest telephone. Later it transpired that a valve head had broken off and was dancing about inside the cylinder. When the piston happened to catch it edgeways, so that there was not room for it to make its full stroke, the situation became very ugly; the top of the piston suffered accordingly.

In 1935 the Club purchased an autogyro, and George Yuill attended a course to learn all about it, so that he could teach us to fly this monster. We had a lot of fun with it, but it was not my idea of a pleasant machine to fly. I always had the feeling that I was flying a traction engine. The take-off procedure was novel in the extreme: first you had to couple the engine to the rotor by means of a special clutch with a hand lever, and then 'rev' the rotor up to 200 r.p.m. This was quite an alarming procedure in itself, with those enormous blades flailing round above your head; the whole contraption shook as though it had a fit of the ague. Then you declutched, and rather quickly, before the rotor had time to slow down, you grabbed the control-stick and opened the throttle. The control-stick came down from above, which gave you the impression that you were grasping the handle of an enormous, crazy, whirling umbrella. Now came the masterstroke of take-off technique: you were instructed to count three, and then pull the stick back. I shall never forget the moment when George first explained to me this staggering plan, this pearl of procedure. Of course, I laughed, and so did George, but there it was; that was how he was taught to take off and that was how we learnt. Count three. How fast do I count? I really do not believe it mattered much, provided the thing was *moving along the ground.* In any case you never achieved a proper take-off speed; having counted your 'three', you pulled the umbrella handle back and the whole contrivance then lumbered into the air. Once in the air life became a little more normal, and there was the comforting thought that engine failure did not matter. It is impossible (so we were told) to stop the rotor whether you glide or whether you let the thing come almost vertically down like a parachute. With practice the landing run was as little as two or three feet. I can only repeat it was fun, but it was not my idea of flying.

Before leaving the subject of autogyros I should explain that they were not helicopters, but they were the forerunners of the helicopter as we know it today. The invention of the auto-rotating blades by the Spanish engineer Señor de Cierva was what made helicopters a practical proposition. Previously they just dropped out of the sky like a stone if they had engine failure, but now they can descend safely because of the auto-rotating blades. The autogyro, of course, was not able to remain stationary in the air or take off vertically, because the rotor blades were not driven by the engine except for the preliminary 'run-up'.

My next adventure into the air by unorthodox means was in a little power-driven glider called The Drone. This aircraft was designed and built by Mr. Lowe-Wylde, and later taken over by Mr. Robert Kronfeld and constructed by the British Aircraft Company. It was originally a glider pure and simple, but experiments were being made with a flat-twin Douglas motor-cycle engine, probably developing about 15 brake horse-power, which was mounted on the top of the wing.

At the time the aircraft was at Hanworth Aerodrome, London, and while on a visit there I was given the opportunity to fly it. In those days I knew nothing about gliding, and like many other misguided people I looked on the idea of trying to fly without an engine as a hare-brained scheme. But this thing had an engine, and I understood that. I was a little worried by the size of the engine; all my previous experience had been with engines of about 100 h.p. or more, and to expect this thing to get into the air on 15 h.p. I thought was a bit much. However, I accepted the offer and before long found myself installed in the small cockpit. It being a solo machine I was given a good 'briefing', and then they started up the engine. Doubts again assailed me; it sounded exactly like a motor-bike engine, which indeed it was. However, I had let myself in for it now, so after a short wait to let the engine warm up they signalled me away, and I opened the throttle. Apart from a lot of noise nothing much happened. Then we started to trundle forward slowly, but I am sure we never achieved a speed of more than about 25 m.p.h., and just as I was beginning to wonder how on earth we could take off at that speed I realized we were airborne. I suppose there was a wind of 10 or 15 m.p.h. which gave an airspeed of 35 to 40 m.p.h. and this was enough. I do not remember the official cruising speed now, but it cannot have been more than about 45 m.p.h.

I had been warned that when I shut the engine off to come in to land I might not come down. This struck me as a fantastic suggestion, but I was shortly to learn how near it was to the truth. I turned in from the circuit at about the normal height for a powered aircraft, around 600 feet, and throttled back. It soon became obvious that I was going to overshoot, so I did some 'S' turns to lose height, but 'overshoot' turned out to be a mild way of putting it. I was now over the aerodrome boundary and still at 550 feet. I can remember thinking to myself, "We seem to be floating about the sky." In those days I had never heard of such a thing as a thermal, but I feel sure now that I must have struck one or two small upcurrents and got what glider pilots call 'delayed sink'. The thing did eventually float down to earth and I came in for a fair amount of leg-pulling from my friends on the ground, who had been watching my efforts to get down.

More recently I have flown the Motor Tutor. This is an ordinary Slingsby two-seater Tutor Glider, with a J.A.P. flat-twin of about 36 b.h.p. mounted in front where the passenger would normally sit. It looks like a baby Auster. I must say it was quite fun to fly, but these gliders with an engine strike me as falling between two stools. They are too slow to be useful as a means of getting from A to B, like an aeroplane, and as you cannot stop and start the engine while flying, it is not possible to soar them like you can a glider. I am sure there is scope for a glider with an auxiliary engine, which can be retracted into the fuselage, and stopped and started in the air. Many diehard gliding enthusiasts would of course be horrified at this idea, but I can well remember the time when sailing enthusiasts felt just the same about having an auxiliary engine in a sailing-boat. Nowadays, in most sailing-boats, except the very small ones, these are taken for granted. Think of the scope with a glider so equipped! You could keep it in a field near your home; you could fly to your gliding club site instead of having to struggle there by car; if the weather were suitable you would of course retract your engine and 'sail' there. You would not require complicated and expensive launching apparatus; you would not require a trailer and crew chasing after you on the ground every time you wanted to do a cross-country flight. This is a fantastically cumbersome plan when you come to think of it. Suppose a yacht had to have a motor-boat, *and another boat trailing behind that*, to come and fetch it every time it put out to sea! To set against it, of course, there is the weight factor and the expense, and anyhow I am not sure that I like the idea after all. Perhaps I am a diehard.

Recently I had a trip to Spain in the Vickers Viscount, the first turbo-prop airliner in the world to go into regular service. This is truly a magnificent aircraft, powered by four Rolls-Royce Dart turbo-prop engines, of which more anon. It is quiet in the cabin, and there is no vibration; I was able to balance a penny on its edge on the table in front of me, and there it stayed until we flew through a slight 'bump'. On the return journey we climbed to 26,000 feet, to get above the clouds, where the air is usually still and calm. A very lucky break in the clouds revealed the Pyrenees, snow-covered, far, far below. They rise to a height of 10,000 feet but how small they looked; it was an unforgettable sight. I could not help thinking of the Everest climbers, who reached, *on foot*, a height 3,000 feet higher than we were. Later during the trip it began to get a little chilly, and the Captain took his customary stroll through the cabin to have a chat with the passengers. "I'm sorry it's rather cold," he said apologetically. "The heating is full on, but there is 110° of frost outside."

Here are some extracts from the Flight Log:

Vickers Viscount G-AMOO.
"John Oxenham."
Air speed: 305 m.p.h.
Ground speed (corrected for wind): 335 m.p.h.
Altitude: 26,000 feet.
Cabin altitude: 6,000 feet.

So you will see that we had a following wind of 30 m.p.h., or possibly more, but not directly behind us. It is interesting to note that the cabin was kept at a 'theoretical' altitude of 6,000 feet, in spite of our actual altitude of 26,000 feet.

Before leaving the subject of powered aircraft I want to say a word about jets and propeller-turbines (more commonly known as turbo-prop or prop-jet). These are the engines of the future. First of all let us be quite clear in our minds about the principle on which a jet works. It does *not* derive its propelling effect by the jet impinging on the air. This is a very common misconception, and it is even found among people in the

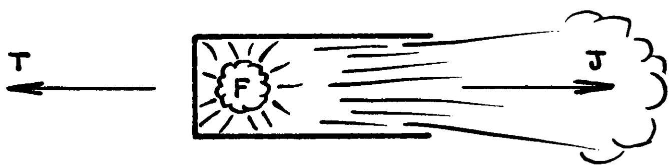


FIG. 18

The jet engine

aeronautical world who should know better. To explain it I must refer you to Fig. 18, which shows the simplest form of jet that one can imagine. It is just a tube, closed at one end and open at the other. At the point F we are going to introduce some inflammable gas and then set fire to it. When this happens the gases from the fire go roaring out through the open end of the tube. But they did not all go in that direction from choice; they wanted to go roaring away from the centre of the firing point in all directions, but that was their only escape route open. Whatever force the fire had that pushed these gases out through the open end of the tube, let us suppose 10 lb., it must also have pushed gases against the closed end of the tube with a force of 10 lb. So the tube was given a thrust of 10 lb. in the direction of the arrow T, and the gases roared out—this is the jet—with a thrust of 10 lb. in the direction of the arrow J. Sir Isaac Newton had some ideas about this, as long ago as the seventeenth century; he said, "To every force there is an equal and opposite reaction." It is as simple as that. If you fire a gun from your shoulder it gives it a kick, it pushes it in the opposite direction to the bullet; if you fire a jet from an aeroplane it gives it a kick, it pushes it in the opposite direction to the jet. "Ah!" says the reader. "But what about all the gases that pushed with a force of 10 lb. all round the wall of the tube itself, what happened to them?" Well, of course they pushed like blazes too, but the tube is made strongly enough to stand that, and as the force is the same in all directions they did not have any effect on the tube. They say there is nothing new under the sun; I am not sure that I agree with that, but I do know that the jet engine was in use before the dawn of history. The squid, a small type of fish, shoots out a jet of water when in danger, and thus retires rapidly in the opposite direction.

As regards giving a thrust, a driving force, the jet engine would work perfectly well in a vacuum, but of course there would be no air to make a combustible mixture. It does work well, however, in a rarefied atmosphere, and drives an aircraft much faster because there is less resistance to overcome, and therefore a jet works well at very high altitudes. What is more, the faster it goes the more power it delivers, because the air that it needs for burning in the jet is scooped in at a faster rate. It needs quite a bit of air; somewhere in the region of 60 tons per minute at a speed of 600 m.p.h. "Well, that doesn't mean much to me," says the reader. "What is 60 tons of air?" To give you an idea, it would be the amount of air contained in about two hundred and forty medium-sized houses.

Now what about the 'prop-jet'—in other words a jet engine with a propeller stuck on the front? First of all I must explain to you that jet engines have a gas turbine inside them; it is rather an ingenious plan. The jet drives the turbine, the turbine drives an air compressor, and the air compressor supplies air to the jet. This sort of 'inner circle' builds up extra power, and it also supplies a rotating shaft which can be used to drive a propeller, although of course it is not used for this purpose in a pure jet aircraft. The shaft has to be geared down a lot because turbines turn very fast; up to 20,000 r.p.m. Propellers do not like this speed, they are most efficient at about 2,000 r.p.m. Even then the tips of the blades travel pretty fast; they have been breaking the sound barrier for years.

But why go back to the old-fashioned propeller when you have already got, in the form of a perfectly good jet, the most modern system of power for aircraft? For two quite simple reasons: (*a*) A jet is not efficient at low speeds, so for take-off, just the the time when you want the *most* power, you have got the *least.* This means very big jets for a safe take-off and therefore heavy fuel consumption; (*b*) A jet is not efficient at low altitudes, it likes to get up to about 35,000 feet, for the reason already explained in a previous paragraph. Quite obviously, therefore, a pure jet airliner is not an economical proposition for short-stage flights, which require frequent take-offs, and there is not enough time before the next stop to attain a good height. "All right," the reader will say, "I understand that, but why not use the good old petrol engine to turn your propeller; well tried, reliable, and economical?" I can immediately think of several reasons, and I have no doubt engine designers would know of a lot more. (1) In the jet engine there are no reciprocating parts, like pistons and valves; it absorbs a lot of power to stop and start a piston, and this has to be done some thousands of times per minute. The jet engine is therefore a more efficient unit. (2) For the same reason there is less vibration, and therefore less wear and tear. (3) Also, because there are not continual explosions taking place, there is less noise. (4) The fuel, kerosene, is much less volatile than petrol, and therefore safer.

There are also some snags, of course, but they do not seem to outweigh the advantages, and they are gradually being eliminated.

CHAPTER VIII

AEROBATICS

WHY is it that an apparently normal, sane, and level-headed sort of bloke, when taught to fly an aeroplane or a glider, always reaches a stage when he wants to turn it over and fly it upside down? Most aircraft are not designed and built to be flown upside down but they nearly all can be. This, I suppose, is the root cause of the trouble; pilots know that they *can* be flown upside down, and therefore they are not satisfied until they have tried it. It is a sort of challenge. I am reminded of the reason I heard given recently as to why anyone should want to climb Mount Everest: it is because it is there. The Americans have discovered that you can roll a saloon car over on to its back without hurting the driver (much). Now they have combined this form of amusement with car racing. The cars are, needless to say, old ones, and they have heavy bumper bars fitted and 'roll bars' to take the weight when they turn over. Racing, as we know it, seems to take second place, the main idea being to bash into your nearest rival and roll him off the track; rather like the rugger match when one of the spectators was heard to call out, "Never mind the ball, get on with the game."

This sport, which they call 'Stock Car Racing', has been introduced to this country, and has found plenty of willing drivers, including a number of women. According to a report which I read they do it "without seriously damaging the drivers". I suppose it all boils down to a craving which many people have, thank goodness, for adventure and excitement. It certainly can be exciting to perform aerobatics in an aircraft, particularly when you are learning.

To start with we must divide aerobatics into two categories: (1) Those in which the stresses on the aircraft remain in the normal direction. (2) Those in which the stresses are reversed, and tend to throw the pilot out of his seat, or even right out of the aircraft. You will see how important this distinction is both for the aeroplane and its pilot. Sailplanes usually only perform aerobatics in the first group, which includes loops, spins, and stall turns. The barrel roll and the flick roll would also come in this category. They are seldom done in sailplanes, although I have seen a barrel roll done in the Slingsby Skylark. The second group consists of real upside-down flying. This is usually referred to as 'inverted flying', and includes the slow roll, and combinations of the various manœuvres such as half a loop and a half-roll off the top. In case the reader does not fully understand the difference between these two groups I am going to describe some of the more usual aerobatics in detail.

First of all then Group 1. Everybody knows what is meant by a loop. Not many years ago it was about the only aerobatic known to the general public. If you told your friends you could fly they nearly always asked you, "Have you ever looped?" This was the criterion by which to judge an airman. This was the hallmark of a real daredevil of the skies. But it is not difficult to do, and if properly executed there is no feeling of coming off your seat at the top. You stay there for the same reason that the water stays in the bucket, which I mentioned in Chapter V. As I was taught to loop in a powered aircraft, I confess to being a little anxious the first time I tried it in a glider. In an aeroplane you can open your throttle and get full power from the engine as you go up to the top, and this just helps you over nicely; in a glider you have got to depend entirely on your initial speed to carry you over. But there is no need to worry; a glider will loop without the slightest difficulty if you go into it at the right speed and perform the loop itself correctly. You have to dive down a bit first, until you are flying at about 80 m.p.h., but this is no faster than a light aeroplane goes into a loop. One of the reasons why a glider goes over so easily is *because* it has no engine; it has not got this great weight to be carried up with it. Also the type of glider that can be used for aerobatics, in other words a sailplane, is even more carefully streamlined than the average light aeroplane, and therefore offers less resistance to the air. Gliding experts would say it has 'better penetration'.

Now we come to the spin. There is no doubt that the spin has a bad name, and this is because in the early days of flying it was definitely a 'killer'. Pilots did not understand it, and once their aircraft had started to spin they could not stop them. Many aircraft hit the ground still spinning, so much so that a special name was used to describe it—to 'spin in'. "He spun in." The pilots were by no means always killed. I once saw an R.E.8 biplane 'spin in' during the 1914–18 War, and the pilot stepped out, calmly lit a cigarette, and walked away from the wrecked machine completely unhurt.

The original trouble lay in the fact that a spin develops from a stall, and while spinning the aeroplane is still in a stalled condition. The nose is well down, and so of course the pilot's instinctive reaction is to pull the stick back, to get the nose up again. It will not come up because the aeroplane is not actually flying, it is just dropping; holding the stick back, which lifts the elevator right up, turns the whole thing into a sort of enormous corkscrew, which keeps it spinning and prevents its gathering enough speed to fly again. It is necessary to apply full opposite rudder, pause, and then ease the stick forward until the spin stops; the aircraft will then go into a dive and can be pulled out of this in the normal way. Personally I do not like spinning; it is not a pretty manœuvre to watch, it is a nasty whirling sensation, the aircraft is not actually flying, and it requires little skill to get into it, to stay in it, or to come out of it. Even today aeroplanes and gliders will not always come out of a spin. Strictly speaking, I suppose, it should not be classed as aerobatics at all; it is usually done more as a 'test', either for the aircraft or the pilot.

How different from the stall turn! This is beautiful to watch, delightful to do, and requires considerable skill to be performed correctly and neatly. Reference to Fig. 19 will help the following description. As the name implies it is a turn, and

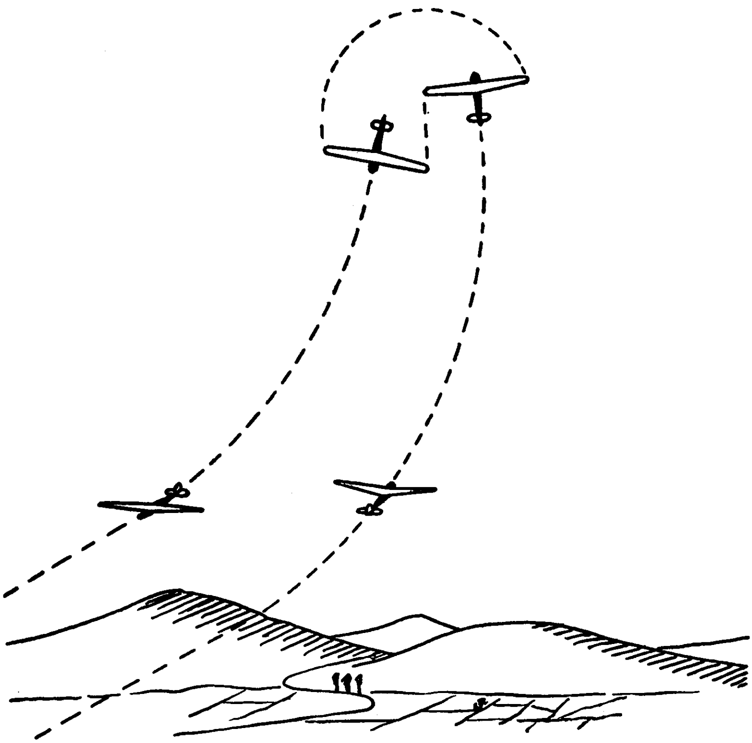


FIG. 19

The stall turn

a complete 'about turn', so that you come back roughly along the same flight path in the opposite direction.

To achieve this you pull the nose of the machine well up into an almost vertical climb. It would stall, of course, but just a moment before the stall you put on full rudder, left or right according to which way you want to make the turn. The aircraft now drops over sideways, let us suppose to the left, so in effect it is a sort of 'falling cartwheel' to the left; but now as you pull out of the resulting dive you will be facing in the opposite direction. It is not so easy as it looks, and if you get it wrong one or two quite surprising things can happen. If you allow the aircraft to stall when it is exactly vertical, or nearly vertical, it may go into a 'tail slide'; a most unpleasant sensation and it can also be dangerous. It drops back tail first, instead of cart-wheeling over, and therefore the airstream flows across the control surfaces the wrong way; it slaps them back against their hinges, like the wind catching a door and slamming it open against its hinges. I know of a case in which a glider had its rudder nearly torn off in this way; fortunately the pilot was able to land it without further mishap. In fact a true vertical stall turn is not recommended for gliders because of this risk.

I think if you are going to have anything go wrong with one of your controls in the air the rudder is the least dangerous. I was once practising approaches and landings in an Avro Avian in the early days, when I had not had much experience, and my rudder stuck. It would move to the right but not to the left. I quickly decided not to move it at all, in case it got stuck over to the right, which could have been ugly. I did a gentle wide sweep round to the downwind side of the aerodrome, using ailerons only, and got down quite safely. The trouble had been caused by the safety harness in the front cockpit, which had been left undone; one of the straps had fallen down and got caught in the rudder bar. It taught me a useful lesson—I should have examined the front cockpit before taking off. Luckily I had had it impressed on me how little you need to use the rudder on an aeroplane for normal flying; you just 'put on bank' and round you go. Have you ever realized how little you move the handlebars of your bicycle to turn a corner, once you get up any speed? You lean the bicycle over; in other words you 'put on bank', and round you go.

Now we come to the second Group: Inverted Flying. This is a very different kettle of fish. As I have already mentioned, in this the pilot tends to drop right out of his aircraft, as indeed he would if it were not for the Sutton Harness already described in Chapter V. It is as though the fellow swinging the bucket of water over his head were to stop at the top; if you are not clear about this you should take a bucket of water into the garden and try it.

The force now acting on the pilot and his aircraft is called 'negative g' (*see* Chapter V), and apart from any other considerations it causes a certain amount of physical discomfort. This aspect of inverted flying has never worried me, I suppose for the simple reason that for many years I have been a schoolmaster teaching mainly gymnastics. Right from my earliest days I have always been quite at home upside down, and in the school gymnasium this is a great asset. There is only one thing that schoolboys like better than being upside down and that is to see a schoolmaster upside down. Even the Ministry of Supply seem to have been affected now; one of their requirements for the Percival Provost Trainer for the R.A.F. is that it shall be capable of flying inverted for 90 seconds. This may not sound very long to anyone who has never tried it, but I can assure you that 90 seconds' continuous inversion is quite enough for most people, and it is doubtful if the Provost will often be called on to stay inverted for longer. Not many aeroplanes are able to use their engines at all when upside down, and can only glide; to meet this requirement the Provost has had to have a special modification made to the oil system. The fuel supply is not affected by negative g, as it is an injection system.

I shall never forget the first time my flying instructor, our old friend George Yuill again, turned me upside down *and stayed there.* To begin with, my safety harness was nothing like tight enough, so that I came off my seat and swung about in space in the most alarming fashion. It was an open cockpit, so there was nothing beneath me except the ground, 4,000 feet below. My feet came up off the floor, or rather *down* off the floor, so that my shins rested against the edge of the instrument board, and there they stayed. Dust and dirt and odd things that lay on the floor of the aircraft showered past my face. Without realizing what I was doing I grabbed the control-stick with both hands, like a strap-hanger clutching at a strap when the vehicle sways; but this vehicle did not just sway, *it was upside down.* Now George was worried too. "Let go of the bloody stick!" he screamed over the speaking-tube. "Turn the thing right way up!" I screamed back at him. He did. I dropped

Photographs by The Aeroplane

"An Avro Cadet, a gentleman among aeroplanes"

PLATE XIII

". . . so that he could teach us to fly this monster"

Photographs by The Aeroplane

"The thing did eventually float down to earth"

PLATE XIV

"It looks like a baby Auster"

back on to my seat, my feet returned to the floor, and I heaved a sigh of relief.

This 'introduction to inverted flying', as George called it, taught me one very important lesson; you have got to strap yourself down with your safety harness so tight that it almost chokes you. So I asked George to wait a moment while I tightened my harness; I did not want him trying any funny stuff while my straps were undone. When I had got myself tightened down so that I was half suffocated I told George to go ahead. I freely admit that I was not keen on trying this extraordinary manœuvre again, and as for ever being able to do it myself, this did not seem within the realms of possibility. But there was no line of retreat now; George had said to me that morning, "I think you should have some instruction on advanced aerobatics." Of course this appealed to my vanity, because it meant that he thought (*a*) I was a good enough pilot to be able to do it; (*b*) That I should be game to have a go. As regards (*b*) he was certainly right, but as regards (*a*) I was beginning to have my doubts. However, the last thing in the world I should do would be to admit to myself or to him that I was scared; incapable, perhaps, but not scared. George and I both loved the air, and all that it meant; we had a reverence for it, a deep respect, but we were not *frightened* by it. A lion-tamer must not be afraid of his lions; he must understand them and know their moods, he must respect their power, he must master them, but he must never be afraid of them. So it is with the air, and so up we went again for a second try.

It was not nearly so bad this time, because I knew what to expect. I stayed firmly on the seat and my feet remained on the floor; I was even able to have a look round and size up the situation. I reported to George that all was well, and the next time he let me fly it as soon as we were upside down. The aircraft we were flying was an Avro Cadet, in which you cannot use the engine when inverted, you can only glide. I soon got used to this strange attitude, and then came the big test: could I do the half-roll to put the thing on its back? I did one with George first, but of course he did most of it, and then I had a go without any help. The tricky part about the slow roll is that when you have done the first quarter turn your wings are in a *vertical* position, which means there is nothing to support you except the side of the fuselage. At this point, of course, the rudder is horizontal instead of vertical, and the elevator is vertical instead of horizontal. You have to use almost full rudder when you are a quarter of the way round, to keep the nose up, and this is called 'top rudder'. This all seemed quite logical to me, and I managed to get thus far quite successfully; but turning from there on to my back everything suddenly went haywire; the nose slewed round and we dropped into a headlong dive. I did not know quite what had happened, and I do not think George did either, because he was not able to say exactly where I went wrong. So up we went again for another try. Exactly the same thing happened again, but this time I was prepared for it and I watched carefully what happened. We were doing the roll to the right, and during the second quarter of the roll, when the aircraft was going from wings vertical position to upside down position, the nose swung violently to the right and down, which meant that I had taken the 'top rudder' (gradually becoming left rudder) off too soon. George confirmed my diagnosis, and up we went again. This time I got over quite successfully, glided upside down for a moment to collect my thoughts, and then continued the roll to come the right way up. To my surprise this final bit of the manœuvre came off without a hitch; it is much easier to roll from upside down to right way up than vice versa, I suppose because you are approaching a normal position and therefore your normal reactions make you do the right thing. When you are inverted the movements of the controls are far from normal; for instance, to keep the nose up you have to push the stick *forward.* Have you ever tried to ride a bicycle with your hands crossed over to the wrong sides? I advise you not to try it unless there is plenty of room to fall; that was why George took me up to 4,000 feet for my first attempt at inverted flying.

Once you have mastered the technique of rolling over on to your back and feel at home (more or less) flying upside down

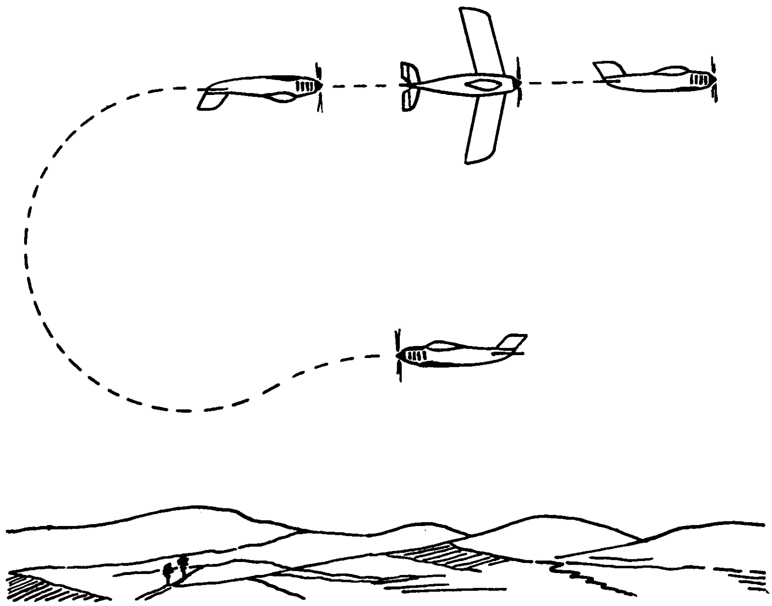


FIG. 20

The half-loop and roll off the top

you can have a go at the half-loop and roll off the top. The name really describes exactly what it is: at the top of the loop you push the stick well forward and hold the aircraft in the inverted position, and then immediately execute the second half —and the easiest half—of an ordinary slow roll. This brings you out facing where you came from, so it is really a turn, like the stall turn, but now your flight path is a little higher (*see* Fig. 20). It is not a difficult manœuvre once you have mastered the slow roll, and it is delightful to do and delightful to watch.

CHAPTER IX

WHAT MAKES AN AIRCRAFT FLY

I INCLUDE this chapter for the benefit of any of my readers who may have no knowledge of the subject; those who have, had better 'skip it', and for this reason I have put it at the end of the book.

Flying, of course, began with gliders. The Wright brothers, two Americans, built gliders and flew them before they installed an engine. In those days, about the year 1900, an engine was a real problem. There were some in existence, including internal combustion engines as used in cars and aeroplanes today, but they were big clumsy things, and confoundedly heavy. In the end they designed and built their own, a 4-cylinder water-cooled engine of about 12 h.p. On December 17th, 1903, the first flight ever to be made by man in a powered aircraft took place; the flight covered a distance of 260 yards! But it was a beginning, and considerable progress was made during the next few years.

How do aeroplanes get off the ground if they are heavier than air? The air itself is pretty heavy if you take enough of it; for instance, the total amount of air in a six-roomed house might weigh a quarter of a ton. It also exerts a pretty big force if it attacks you fast enough, as you know from struggling against the wind on a bicycle, and it exerts a big force if *you* attack *it* fast enough. This is what the aeroplane does: it attacks the air. But it does not just go mad-headed at it, like a bull at a gate, or even like a small boy running flat out in order to get his kite airborne. The wings of an aircraft are set to 'attack' the air at a certain angle, and they have a special shape; they are not just flat surfaces like a kite. They used to be in the very early days, and that was why they did not have much success; but men began to study the properties of moving air, and the effects of bodies moving through it. This special branch of science is called aerodynamics, which means 'air power'. It has given rise to a new word in our vocabulary, streamlined; now much used—and also misused—in everyday life. The latest I have heard is a 'streamlined kitchen'. It is a descriptive word, and obviously means that an object has smooth lines, which allow the air to flow over it in an unbroken stream. Streamlined kitchen indeed!

When it comes to getting lift from the air, however, a streamlined surface for the wings is not enough. After a good deal of study and experiment it was discovered that a surprisingly good result was obtained by putting a hump on the top surface of the wing. This hump is called 'camber', and is similar to the camber on a well-built road, though that is put there to make the water drain off.

The fundamental reason why a wing gives lift is because it deflects, or forces, air downwards. If it forces air downwards it must force itself upwards, by the principle of equal and opposite reaction which I have already spoken of in Chapter VII, in connection with jet engines. The whole question of lift, and wing shapes, is complex; if you ask scientists who study aerodynamics to explain it they will write down all kinds of mathematical formulae and talk about things and people you have never heard of. You can even get them to explain mathematically why a cricket ball or a tennis ball can be made to swerve in its flight; it does so because the 'spin' is deflecting air in one direction and this makes it swerve in the other direction. As I have already mentioned, the wing of an aircraft is set to meet the air at an angle; it is only a small angle, but in Fig. 21 I have exaggerated it a bit to make the explanation more clear. In the case of the flat plate, the under surface deflects the air down, but the upper surface upsets the smooth flow—in other words it is not streamlined—and causes turbulence and will not draw the air down. Now look at Fig. 22 which has a wing set at the same angle, but is streamlined with the special shape called camber. The air flows smoothly along the top and *down* the slope of the camber and joins the stream of air from underneath, so now all the air passing over the wing surface is being deflected *down.* This is a very simplified explanation of the effects of camber; for further details the reader should consult a book on aerodynamics.

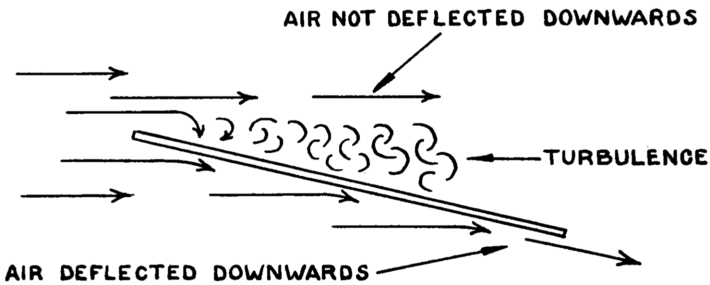


FIG. 21

The amount of lifting force derived can be altered by the pilot changing the attitude of the aircraft; if he pulls the nose up and increases the angle of attack the aircraft will climb. The lifting force will also be altered by the speed, a slower speed

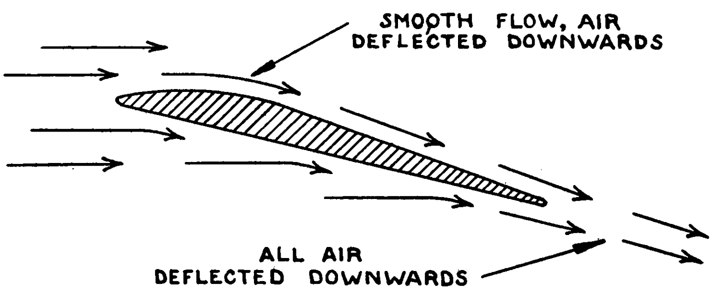


FIG. 22

obviously giving less lift. I do not suppose a boy with a kite would think of it in these terms, but he has learnt by experience that the faster he runs the better his kite will climb. So if an aircraft flies more slowly than normal, thus decreasing the lift, the pilot will have to increase the angle of attack to make up for it. There will come a time, however, if the aircraft continues to slow down, when the pilot will have increased the angle so much that even the special shape of the camber on the wings cannot keep the air flowing over them smoothly. When this happens the lift ceases, and the aircraft is said to 'stall'; it just drops. If the pilot has plenty of height this does not matter, in fact it is really rather fun, as described in the chapter on aerobatics; the aircraft will go into a dive and thus regain enough speed for the pilot to 'pull out', or 'flatten out' as it is sometimes called, and continue normal flying. But if he is near the ground then the position is very ugly. The only time you deliberately approach the stall near the ground is when you are landing; in fact in order to land you do very nearly stall; but the aircraft must be in the correct attitude, and *almost on the ground.* It requires a lot of judgment; landing correctly, to my mind, is the most difficult thing a pilot is called on to do, and needs endless practice to attain perfection.

Having found how to get lift from the air by attacking it, by moving a wing through it, some means must be found of moving the wing, and fairly fast too. Here are the three fundamental methods of getting an aircraft to move through the air:

(1) The force of gravity. (Gliding.)
(2) An engine turning a propeller.
(3) A jet or rocket.

All aircraft are able to use No. 1. Many use Nos. 1 and 2; some use 1 and 3; and a turbo-prop, which I described in Chapter VII, uses all three! Perhaps I ought to mention, *sotto voce*, that the turbo-prop does not get very much thrust from No. 3, its jet; nearly all the power goes into No. 2, its propeller. A glider, of course, uses various peculiar means to get itself into the air: a team of men pulling on an elastic rope, a motor-car, a power-driven winch, or a tow up from an aeroplane. But once a glider is launched, once it is in the air with a little spare height, it uses No. 1, and No. 1 only. I have already described this in Chapter II, and I have explained (?) the jet in Chapter VII, so it only remains now to say something about the propeller.

The airscrew or propeller, is, of course, just another wing, or rather two wings, travelling round and round instead of forwards. They are shaped like miniature wings, being set so as to attack the air at an angle, and they give a very good lift, but this 'lift' is now in a horizontal direction, and pulls the plane along. There are aeroplanes in existence today, of course, that actually have their *main* wings going round and round, and we call them helicopters—a Greek word meaning 'turn round wing'. The rotor of a helicopter is really a gigantic propeller; a sort of glorious mixture between a wing and a propeller.

A nice homely illustration of an aeroplane's propeller is an ordinary electric fan, or the fan under the bonnet of a car. You can see the 'angle of attack'; and, by the way, this is *not* the pitch. Pitch is measured, whether it be that of a propeller or an ordinary threaded bolt, as a distance, and not as an angle. For a bolt it is usually expressed as the number of threads per inch, and for a propeller the *theoretical* distance it will travel forward through the air for one revolution. But to get back to our fan; most fans even have a little 'camber', which is made by curving the metal blade. Its object, of course, is to push the air, and not itself, but aerodynamically the design is the same. If the fan is capable of pushing air with a thrust of 2 lb. it must also be pushing itself with a thrust of 2 lb. in the opposite direction. So we get back to our old friend Newton, "To every force there is an equal and opposite reaction."

Thus we have got the aeroplane moving forward, and we have shaped and set the wings to give some lift, and so it takes off; it becomes airborne. The next question is how to control it? A chap moving about in the air is faced with three quite new problems. Firstly he is in a world of three dimensions; that is to say he can go up and down, in addition to being able to turn right or left, and go backwards or forwards. Secondly he has got to start worrying about whether he is laterally level, whether he is on an even keel.

On the ground you never have to ask yourself: "Am I vertical, or am I leaning a bit to the right?" And the problem of 'leaning over' on corners: if you run fast round a corner you do in fact lean over, but it never comes into your calculations. Even on a bicycle, which can, and does, lean over to a considerable angle if travelling fast on corners, you never have to ask yourself, "Am I leaning over far enough?" It is something you learn, without ever being told, when you are a small child and learn to run. When you get a little older and learn to ride a bicycle, this lesson stands you in good stead, because at any given speed you lean over the same amount on a bicycle as you would if you were running. But in the air this lesson is of little avail. You do know that you will have to 'bank' your aircraft when turning, but you do not know how much. Even pilots with a lot of experience can get it wrong if they are careless, but nothing very awful happens if they do. When you lean over, that is to say 'put on bank', a little too much the aircraft will sideslip inwards; if you do not put on enough 'bank' it will skid outwards, that is all. But if you were to get it wrong on your push-bike you would come a cropper immediately.

Lastly there is the question of your actual height at any given moment; are you 1,000 feet above the ground or only 500 feet? What it amounts to, then, is that on the ground you have to worry about:

(1) The speed at which you are travelling.

(2) What direction you are taking.

In the air, in addition to the above, you have got to worry about:

(3) Whether you are going up or down.

(4) Whether you are laterally level, or if turning whether you are correctly banked.

(5) Your actual height above the ground.

Before I explain the various controls you should have a good look at Fig. 23 in order to become familiar with their names and positions.

(1) This is taken care of by the throttle, and is similar to a power-driven vehicle on the ground. It is always hand controlled because your feet are busy with the rudder.

(2) The rudder is attached to the fin, and swings from side to side, exactly like the rudder on a boat. Unlike a car on

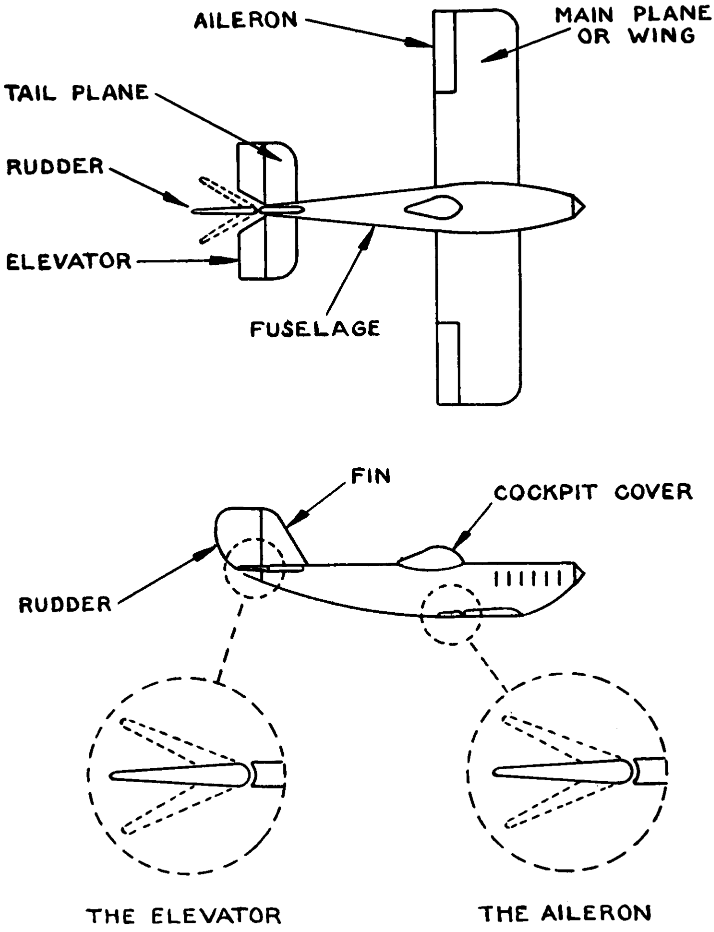
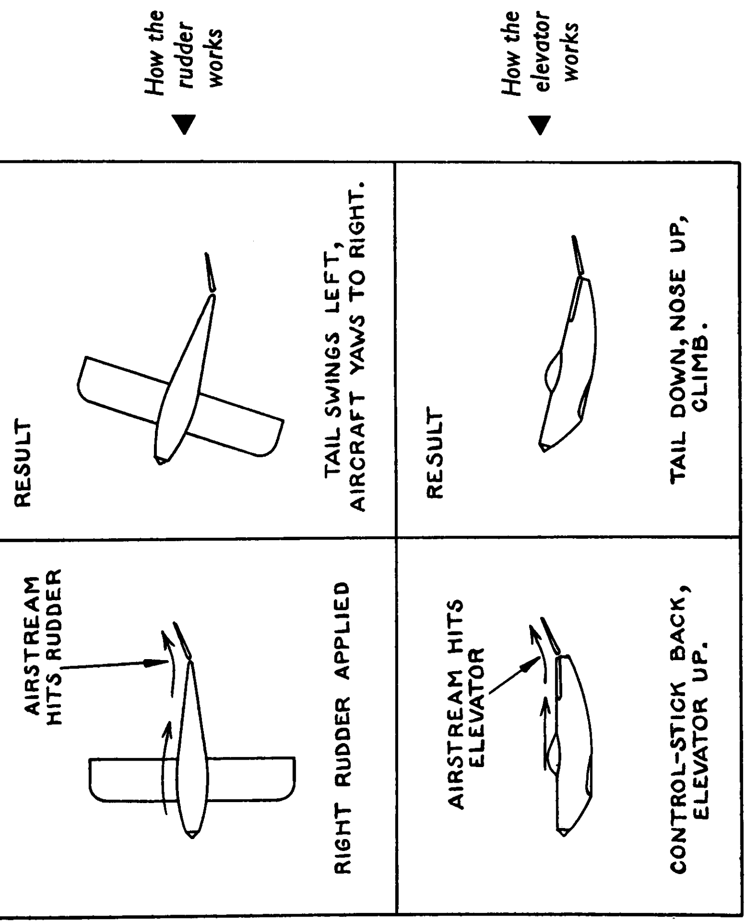


FIG. 23

The names of the principal parts of an aircraft which the wheels steer by swinging the front of the vehicle, a rudder steers by swinging the back. The rudder 'lines', which in a boat would be held by the coxswain, are fixed to a bar, known as the rudder bar, and this is controlled by the feet. But you must not imagine that it is like the handlebars on a bicycle, because it works exactly opposite. If you press with your right foot, so turning the bar to the left, you will yaw to the right. Fig. 24 will help to make this clear. Pressing the right foot pulls

FIG. 24



on the right rudder line, and so swings the rudder to the right; the airstream deflects the tail to the left, and thus causes the aircraft to yaw to the right.

(3) The elevator works on exactly the same principle, but is attached to the tailplane and moves up and down. This is a control that will be quite new to my non-flying reader. There is only one 'vehicle', apart from aircraft, that has this control, and that is the submarine. If my reader has been in, or is now in, the Submarine Service, then I take back my first remark. You will remember what I said about goggle fishing in Chapter VII, and that the frogman has a world of three dimensions; the airman and the underwater-man are the only people in the world who know anything about this from practical experience.

To work this new control an aircraft has what is called a control-column, or control-stick, usually known as 'the stick'. It is a most logical and easily understood control, and with it you literally push or pull the aircraft into the position that you want.

The elevator is coupled to it so that if you pull the stick back the elevator lifts up, so depressing the tail, and this makes the aircraft go up. So you *pull* the aircraft up. If you push the stick forward exactly the opposite happens: you *push* the aircraft down (*see* Fig. 24).

(4) The ailerons. Here we have another new control, and although the ailerons work on the same principle as the rudder and elevator they do a very different job. This is the control that enables you to keep level in straight flight or 'lean over' for taking corners. The ailerons are connected to the stick, the same stick that works the elevators, and this completes a very cunning arrangement. If you push the stick to the left it tips the aircraft to the left, and if you push the stick to the right it tips the aircraft to the right (*see* Fig. 25). Stick to the left causes the left aileron to move up, and the right aileron to move down, and the airflow against them tilts the aircraft over. So now we have got *two* different types of control both worked from *one* control-stick. The stick is free to move in any

direction, so if you push it diagonally forward and to the left you get a combination of two movements; it will put the nose of the aircraft down and at the same time put on 'left bank'. I had better not attempt to explain any further combinations of movements; you must go up in an aircraft and try it out for yourself. It will certainly be an experience you will always remember and cherish, and if it gives you the urge to learn to fly you will be entering on a world of new wonders and delights.

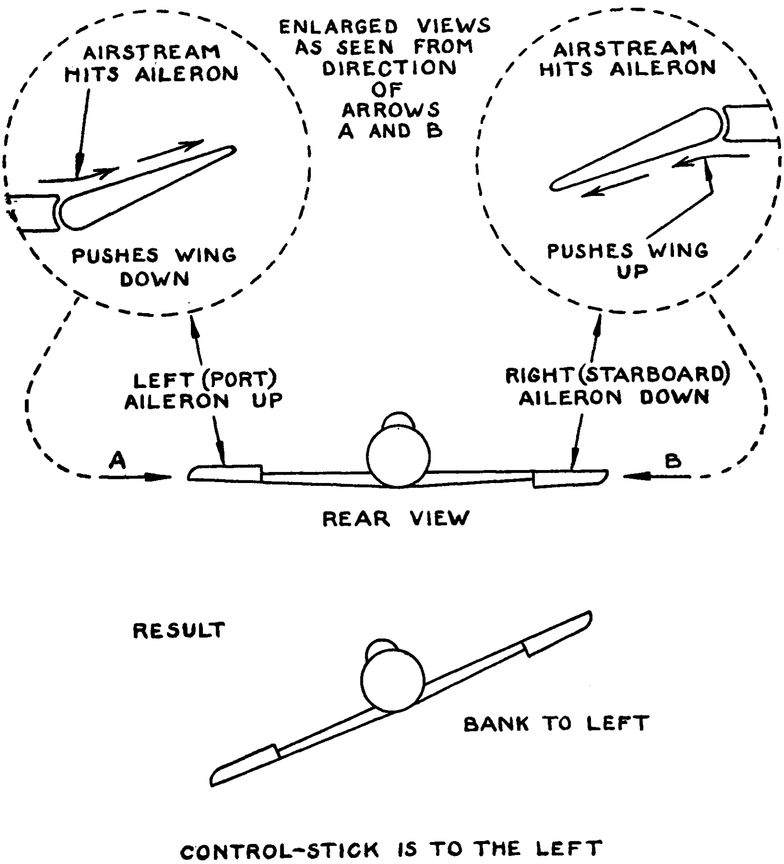


FIG. 25

How the ailerons work

CHAPTER X

GLIDING CLUBS

It is not actually necessary to join a gliding club or any other type of flying club in order to learn to fly. Courses are held during the summer months at several well-known gliding clubs which are chiefly for non-members, and instruction in power flying can be obtained at any time at various flying schools. The cost of power flying, however, is prohibitive for most people; it ranges from £2 10*s*. to £3 10*s*. an hour whether you join a club or not. The tests that must be passed to qualify for a Private Pilot's Licence are given in the Appendix. You have to do a minimum of forty hours' flying, so you can reckon the whole job will cost at least £120, although this can be reduced to thirty hours minimum if you attend one of the schools with special Ministry of Civil Aviation approval.

Gliding, on the other hand, is not nearly so expensive. If you attend one of the Summer Holiday Courses you will get six or seven days' board and lodging and all flying instruction included for about £12 to £15. I cannot predict how far you will progress while attending such a course, as this will depend upon your own aptitude and also your luck with the weather. If you attend a week's course, and have had no previous instruction, you must not expect to go solo. During a two-week course, however, you stand a good chance of getting away solo, and you will probably then get your 'B' Certificate.

I do, however, strongly recommend any of my readers who think they would like to try this sport to join a gliding club, and I include a list of these in Appendix I. The cost varies, but will probably be between four and six guineas annual subscription. You pay for your flying according to how much you do; it is usually about 3*s*. for a launch, and then if you are clever enough to stay in the air you pay according to time. Most clubs charge about 3*d*. per minute, so if you are able to stay up for an hour it will cost you fifteen shillings. I can assure you that if you do succeed in staying in the air for an hour you will be so pleased that this fifteen shillings will seem a mere nothing, and you will pay it gladly; it will represent an hour of concentrated skill, endeavour, and enjoyment.

While on the question of cost I must mention the tremendous help that the gliding movement has received from the Kemsley Flying Trust. This Trust was created in 1947 by Viscount Kemsley for the encouragement and development of private flying in Great Britain. It is probably true to say that most of the gliding clubs in Great Britain would not have been able to operate without it.

A Summer Course may teach you to fly, or perhaps I ought to say will teach you to get off the ground and back again in one piece, but it is only a beginning. You cannot become a sailplane pilot by attending a week's course once a year, and you will not get a proper impression of the fun and satisfaction that is to be had by being a member of a club; a club whose members are primarily concerned in *flying*. Joining in the many activities, the glider and vehicle maintenance and repair work, the improvement of club buildings and amenities, the organization of dances and other social functions, will bring you in contact with many friendly and interesting people. These are people who are not content to have as their spare-time interest something which only requires watching, instead of actually *doing*. They are not concerned as to whether you work at a bench in a factory or are a company director; they will not be worried about your 'old school tie' and whether you speak the Queen's English; their criteria will be: do you want to learn to fly, and are you prepared to take off your coat, roll up your sleeves, and help others to fly? These are the things upon which the British gliding movement has been built; not money (though I must admit that a certain amount is necessary), not influence, not Government support, but just those two things, enthusisam and hard work. There is much satisfaction, however, to be got from working and doing things that are contributing towards the progress and betterment of your club. But this is only by the way; the real reward comes as you begin to learn the lessons of the air, and to experience the joy of achievement in this new field; a field of adventure and hitherto unknown delights.

This is a scientific sport that requires a knowledge of mechanics, meteorology, and aerodynamics; things that you will learn in the most painless way. A social sport that calls for organizing ability, good comradeship, and the team spirit; a sport that requires a high degree of skill, lightness of touch, and superb judgment; an aesthetic experience that calls for an appreciation of the beauty of nature; a beauty that can only be found in the silent, solitary dominion of blue sky and cloud. Surely one can say, without fear of contradiction, that the glider pilot, more than any other kind of aviator, has found for himself a playground in the sky.

THE BRITISH GLIDING ASSOCIATION

(Affiliated to the Royal Aero Club)

LONDONDERRY HOUSE, 19 PARK LANE, LONDON, W.1.

Secretary : Mrs. J. R. Bonham. *Tel*: Hyde Park 3341

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4. CAMBRIDGE UNIVERSITY G.C., Marshall's Aerodrome. Tel: Cambridge 56291	D. Clayton, Manor Farm, Coton, Cambridge. Tel: Madingley 270
5. DERBYSHIRE & LANCASHIRE G.C., Camphill, Gt. Hucklow, Derby. Tel: Tideswell 207	R. Booth, 94 Arundel Street, Sheffield 2.
6. IMPERIAL COLLEGE G.C., Lasham Aerodrome, Nr. Alton, Hants. Tel: Herriard 270	The Secretary, Imperial College Union, Prince Consort Road, London S.W.7. Tel: Kensington 4861
7. LONDON GLIDING CLUB, Dunstable Downs, Beds. Tel: Dunstable 419	A. Sweet, F.C.A., 22 Half Moon Street, W.1. Asst. Sec.: G. W. Carter, Limbury Manor, Luton, Beds.
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10. OXFORD GLIDING CLUB, Kidlington Aerodrome.	Eric Stow, 19 Salisbury Cres., Oxford. Tel: Oxford 58747
11. SCOTTISH GLIDING UNION, Balado Airfield, Milnathort, Kinross-shire. Tel: Kinross 3268 Soaring Site: Bishophill.	David Hendry, Westermillig, Helensburgh, Dumbartonshire. Tel: Helensburgh 953
12. SOUTHDOWN GLIDING CLUB, Friston Aerodrome, Nr. Seaford, Sussex.	Mrs. L. S. Lycett, 64 Hayes Road, Bromley, Kent.
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*36. SOUTHEND MUNICIPAL AIR CENTRE AND FLYING SCHOOL, c/o The Town Clerk, Municipal Buildings, Southend-on-Sea, Essex.	Manager: Bernard F. Collins Telephone: Rochford 56204–5 Aerodrome: Southend (Rochford)
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APPENDIX III

TESTS FOR THE GLIDING CERTIFICATES AND BADGES

Issued by

THE BRITISH GLIDING ASSOCIATION

(Under Delegation of the Royal Aero Club of the United Kingdom)

STRAIGHT FLIGHT TEST

1. *National Certificates and Badges*

Certificate "A"

The candidate must carry out a free flight of not less than 30 seconds, followed by a normal landing.

Candidates must have made at least 12 slides or glides before attempting to qualify for this test.

Certificate "B" (Turns Test)

The candidate must carry out a free flight of not less than one minute, in the course of which he shall manœuvre the glider so that the flight path is in the form of a letter "S", i.e., one right-handed and one left-handed turn, followed by a normal landing. Before this flight is attempted, the candidate must have carried out not less than two flights each of a duration of at least 45 seconds.

Or as an alternative, the candidate must carry out two flights each of not less than one minute's duration, one of which must include a circuit to the right, and one of which must include a circuit to the left.

Certificate "C" (Soaring Test)

The candidate must carry out a free flight during which height is not lost over a continuous period of at least 5 minutes, followed by a normal landing. The candidate must pass an Oral Examination on the Syllabus issued by the British Gliding Association.

2. *The Fédération Aéronautique Internationale Tests for the Award of International Silver, Gold and Diamond Badges*

The Silver Badge

1. (Duration test.) A flight of not less than 5 hours.
2. (Distance test.) A flight of not less than 50 km. (31·07 miles)

made either: (i) in a straight line or (ii) round a triangular course, of which the shortest side must measure at least 15 km. (9·32 miles).

3. (Height test.) A flight with a gain of height of not less than 1,000 metres (3,281 eet).

The Gold Badge

1. (Duration test.) A flight of not less than 5 hours. Candidates holding the Silver Badge are exempt from this test.

2. (Distance test.) A flight of not less than 300 km. (186·42 miles) made either: (i) in a straight line or (ii) in a broken line of not more than three legs none of which may be less than 80 km. (49·7 miles) in length.

3. (Height test.) A flight with a gain of height of at least 3,000 metres (9,843 feet).

The Diamond Badges

The accomplishment of each of the following tests entitles the holder of a Gold Badge to add a diamond:

1. (Distance test.) A flight of not less than 500 km. (310·7 miles) made either: (i) in a straight line or (ii) in a broken line of not more than three legs none of which may be less than 80 km. (49·7 miles) in length.

2. (Goal flight test.) A flight to a previously declared place of a distance not less than 300 km. (186·42 miles) made either (i) in a straight line or (ii) in a broken line of not more than three legs none of which may be less than 80 km. (49·7 miles) in length.

3. (Height test.) A gain of height of not less than 5,000 metres (16,404 feet).

APPENDIX IV

THE PRIVATE PILOT'S LICENCE

The Air Navigation Order, 1954, provides for the issue of a Student Pilot's Licence and a Private Pilot's Licence. Applicants for either licence must have reached the age of 17 years, and will be required to pass a medical examination. For the grant of a Student Pilot's Licence, neither technical examination nor air experience is required. For the Private Pilot's Licence, however, applicants are required to satisfy the Ministry of Civil Aviation in respect of flying experience, flying skill and technical knowledge. All of these requirements must be completed within a period of six months.

A sixteen-page booklet, which may be obtained from Her Majesty's Stationery Office, price ninepence, gives the requirements in complete detail, but they may be summarized as follows:

A total of 40 hours' flying time as pilot, approximately 12 of which must be with a competent instructor in a dual control aircraft, and at least 15 hours as pilot-in-charge. The total time may be reduced to 30 hours if the training is done at one of the specially approved flying schools.

Three hours' cross-country flying, and one flight must include two intermediate stops, one of which must be at least 50 nautical miles from the home base.

Various flying tests must be taken, with an examiner on board, the main tests being as follows:

Pre-flight procedure.

Take-off, and engine failure after take-off.

Landing without power from a position and height selected by the examiner.

Turns of various degrees of bank with and without engine; climbing and descending turns.

Stalling and recovery.

Spinning and recovery.

In addition to the above there is a written and oral test on aviation law, navigation and meteorology, and airframes and engines.

The Student Pilot's Licence is an interim licence, and allows the student to fly solo, under the supervision of an instructor, while he is gaining experience for the tests required for the Private Pilot's Licence. The latter is issued for a period of two years for pilots under 35 years of age, and one year for pilots over that age. The applicant must undergo the full medical test again prior to each renewal, and must have flown at least 5 hours solo, or as pilot-in-charge, during the previous twelve months.

Gliding experience may be counted to make up the total time required for the initial tests, and also for renewal. The Ministry of Transport and Civil Aviation Circular No. 146/1954 gives the Regulations for this, but they may be summarized as follows:

Holders of "C" Gliding Certificates

The technical examination must be taken, and all the flying tests must be carried out including the cross-country flight. In addition to whatever gliding experience the applicant may have, he must do at least 10 hours' flying training under a competent instructor in a dual controlled aeroplane, and at least 10 hours' flying as pilot-in-charge of an aeroplane.

Holders of Dual Instructor's Category B2

The same as for "C" pilots except that the 10 hours' dual and 10 hours' solo in a powered aeroplane are not required.

Holders of the Silver "C" or Dual Instructor's Category A

The applicant need only pass the practical flying test and the technical examination.

N.B.—In all three cases there must be a total air experience of at least 40 hours.

Renewal of Private Pilot's Licence

All glider pilots may count two hours' solo gliding (or as pilot-in-charge of a glider), towards the 5 hours' total during the preceding 12 months, which is required for renewal.

So it will be seen that these concessions are very reasonable, and enable a glider pilot to obtain his Private Pilot's Licence at a considerably reduced cost.

Ultra-light Aircraft

Glider pilots are not permitted to fly ultra-light aircraft unless they hold a Student Pilot's Licence or a Private Pilot's Licence. At present gliders fitted with a small engine for launching purposes come in this category. If, however, this became a common method of launching gliders, these might well be classed in a separate category, and have their own regulations.

For glider pilots who wish to obtain their power flying experience for a Private Pilot's Licence by flying an ultra-light aircraft, exactly the same regulations are in force as for the ordinary light aeroplane.

APPENDIX V

RECENT MODIFICATIONS TO C. OF A. REGULATIONS JULY 1954

The Minister of Transport and Civil Aviation has now agreed to grant permits to fly to ultra-light aircraft without requiring them to undergo the full procedure of airworthiness certification, subject to the conditions set out below. The scheme will apply to aircraft not exceeding 1,200 lbs. all-up-weight with a maximum stalling speed (flaps up) of 45 m.p.h., and a maximum engine power of 75 h.p., which are to be used solely for private purposes.

The aircraft must have been built to a design approved by the Popular Flying Association and constructed under the supervision of that Association. The issue of permits will be subject to the advice of the Air Registration Board in each case. Under this scheme aircraft will be subject to the following conditions and limitations:

(*a*) They will be restricted to flight within the United Kingdom and may not be flown over populous areas or a concourse of people.
(*b*) They may be flown only by day, and in Visual Flight rule conditions.
(*c*) They may not be used for aerobatic flight.
(*d*) Third party insurance with a minimum limitation of liability of £10,000 will be required.

Provision has also been made for granting a Three-year Certificate of Airworthiness for private aeroplanes not exceeding a maximum total authorized weight of 3,500 lbs. The schedule consists of:

1. A quarterly Airframe Check.
2. An annual Airframe Check.
3. A complete overhaul of the Airframe every third year.
4. A ten flying hours' Engine Check. (Not certifiable.)
5. A minor Engine Check.
6. A major Engine Check.

Owners intending to use the scheme should notify the Board when they apply for the issue or renewal of their Certificates of Airworthiness. Flying Clubs and firms are approved by the Royal

Aero Club on the recommendation of the Air Registration Board to carry out work in accordance with the Schedule.

Full details of the Schedule, which is termed "Royal Aero Club Maintenance Schedule (R.Ae.C.3) for a Three-year Certificate of Airworthiness", may be obtained from The Royal Aero Club Aviation Centre, Londonderry House, 19 Park Lane, London, W.1.

APPENDIX VI

LIST OF BOOKS RECOMMENDED

Soaring Flight. Terence Horsley. (Eyre & Spottiswoode, 16/–.)

Gliding and Advanced Soaring. A. C. Douglas, P. A. Wills and A. E. Slater. (John Murray, 16/–.)

Meteorology for Aviators. R. C. Sutcliffe. (H.M. Stationery Office, 8/6.)

A First Book of Meteorology. A. J. Starr. (Geo. G. Harrap and Co. Ltd., 5/–.)

Cloud Reading for Pilots. A. C. Douglas. (John Murray, 6/–.)

On Being a Bird. P. A. Wills. (Max Parrish, 15/6.)

Elementary Gliding. Paul Blanchard. (Thermal Equipment Ltd., 5/–.)

Studies for Student Pilots. Michael Royce. (Pitman.)

Come Gliding With Me. Ann Welch. (Frederick Muller, 9/6.)

Icarus. An Anthology of the Poetry of Flight. (Macmillan & Co., Ltd., 5/–.)

Further Outlook. F. H. Ludlam & R. S. Scorer. (Allan Wingate, 15/–.)

The Soaring Pilot. A. & L. Welch & F. G. Irving. (John Murray. Now in course of preparation.)

PERIODICALS:

Gliding. (British Gliding Association, Londonderry House, 19, Park Lane, London, W.1. Quarterly, 2/6.)

Sailplane and Glider. (8 Lower Belgrave St., London, S.W.1. Published every second month, 2/–.)

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