MOTORLESS FLIGHT

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EDITED BY

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CHAPTER I

THE ENGLISH GLIDING MOVEMENT

By the Editor

MUCH has been written of the pioneer work in England of Sir George Cayley, Percy Pilcher, Jose Weiss and others, but for the purpose of this chapter it will be sufficient to deal only with post-war development. In 1922 a large international gliding competition was organized by the *Daily Mail* at Itford Hill, near Lewes, in Sussex, where many interesting machines appeared, the outstanding performance of this meeting was that of Maneyrol, who remained in the air for three hours and twenty minutes, and completed the flight with a landing after dark. The result of this meeting was that everyone began to point out what could have been accomplished if such machines had been fitted with a small engine. In consequence of this the *Daily Mail* offered a similar prize for really light aeroplanes, and from this competition grew the present day light aeroplane movement. For some years nothing more was done, and gliding was assumed to have died out completely.

However towards the end of 1929, various articles appeared in the Aeronautical Press of this country, describing the wonderful progress and achievements which had been accomplished in Germany, where a subsidized light aeroplane movement was an impossibility owing to the ban of the Versailles Treaty. In consequence of which motorless flight had been developed on an elaborate scale. The immediate result of these accounts was that many people began to enquire as to where it was possible to glide in England. In December, 1929, at the suggestion of an interested reader, Mr. C. G. Grey, editor of the *Aeroplane*, organized a lunch in London, to which all interested in gliding were invited to attend. An attendance of about twenty was expected, but nearly sixty persons arrived. At this lunch a committee was appointed to investigate the best possible ways and means of providing gliding facilities in England. This committee became what is now known as the British Association, and whilst this body was getting its house in order, some of its London members founded the London Gliding Club. About the same time Mr. Lowe-Wylde, now a prominent figure in the gliding movement, and a contributor to this book, founded the Kent Gliding Club; here a small body of enthusiasts designed, built and successfully flew their first glider within the short time of five weeks. A fortnight later—now in early March—the London Gliding Club held its first trials at Guildford, starting off with two machines, one of English and one of German construction. From this date progress was fast and furious, although no really up-to-date gliding experience was available. Within a month no less than fifteen gliding clubs had been formed in different parts of the country, and the first three Royal Aero Club's Glider Pilot's Certificates in accordance with the regulations of the Fédération Aéronautique Intérnationale had been claimed (Class A). Then just as real difficulties and obstacles were looming large on the horizon, and the lack of really expert advice was becoming a source of genuine danger to the whole movement, the British Gliding Association made the welcome announcement that a very generous donation of one thousand guineas from Lord Wakefield (then Sir Charles) had enabled them to secure the services of Herr Robert Kronfeld, the world's most famous glider pilot, who had been engaged to give a series of lectures and demonstrations in the various centres where interest in gliding had been aroused.

It was announced that the first of these demonstrations would take place at Itford Hill near Lewes (the site of the 1922 Gliding Competitions) and that by courtesy of the *Daily Express* a second expert pilot, Herr Maggersuppe, would also be present with a machine. Clubs were invited to bring their own machines and to take instruction from the recognized experts. Conditions were almost ideal for the opening week-end (Whitsuntide), and many thousands of spectators turned up to witness the demonstrations. After both pilots had astounded all present by the ease and gracefulness of their soaring flights, Captain Needham was launched in the intermediate type machine of the London Gliding Club, which had just arrived from Germany, and to the surprise of all, including the pilot himself, succeeded in staying aloft for over an hour, which, of course, easily qualified him for his " C " Royal Aero Club Glider Pilot's Certificate, the first to be issued to an Englishman. His flight was quickly followed by Messrs. Manton and Buxton and Colonel the Master of Sempill, all of whom made flights of approximately a quarter of an hour, and made voluntary landings at the starting-point. Captain Needham then followed on by his remarkable record of twenty-seven minutes on the original British-built primary training machine which had made its first flight at the early Guildford trials.

In addition to the flights recorded above, a number of other flights were made qualifying their pilots for their " A " and " B " Royal Aero Club's Gliding Certificates. The Itford meeting was finally brought to a close by the remarkable flight of Herr Kronfeld on his machine, the "Wien," which he flew from Itford Hill along the South Downs, behind Brighton and Worthing, across the nine-mile-gap to the Portsdown Hills, and eventually landed, in failing light, close to the site of his next demonstration, near Havant, a distance of seventy-two miles. After Itford came a long series of meetings where Herr Kronfeld did valuable work instructing and nearly always managed to put up one of his highly-polished demonstrations, though very often under adverse weather conditions. Demonstrations were given at Weymouth, Portsmouth, Bradford, Ilkley, Scarborough, and elsewhere, whilst a private demonstration was given before H.R.H. the Prince of Wales and H.R.H. Prince George on the London Club ground at Dunstable. Before Herr Kronfeld's return to Germany, no less than thirty-seven gliding clubs had been formed in various parts of the country, and several others were under consideration.

Naturally this tremendous pace of expansion could not be kept up, and there followed an uneventful period in which slow but steady progress was being made, and a still greater number of persons became officially qualified glider pilots. The next development of interest was in the North of England, where Herr Maggersuppe, who had stayed on in England as official instructor to the Scarborough Club, made a number of fine flights of considerable duration, carrying passengers in a two-seater sailplane, returning to the starting-point with regularity to deposit his passengers. Shortly after this came the British Gliding Association Inter-Club Competitions which were held at Ditchling Beacon, near Brighton. These were, however, marred by thoroughly unsuitable weather conditions, and the longest flight of the meeting was only four and a half minutes, by Mr. Mathieson, a New Zealander, and a member of the London Gliding Club, who is now doing pioneer work building up a gliding movement in New Zealand. In spite of the unfortunate conditions, however, no less than twenty-nine successful qualifying flights were made for the junior classes of Royal Aero Club's Glider Pilot's Certificates.

The winter months did not bring about the anticipated decrease in gliding activity, in spite of unpleasant weather conditions and short hours of daylight. There was, in fact, a considerable burst of soaring flight, both at the Southdown Club at Ditchling (the site of the Inter-Club Competition) and at Dunstable, the site of the London Gliding Club. Several flights of over two hours were recorded, and the unofficial Englishmen's duration record increased and changed hands quickly. During this period the majority of the younger clubs were settling down steadily, and at the close of 1930 about fifty clubs were operating some hundred odd machines (most of which had only just come into service owing to the difficulties of obtaining delivery). Of these about ten per cent were of secondary or advanced type, and three were two-seaters. Two companies were manufacturing machines. The gliding movement continued to go steadily forward during the early months of 1931, and then in March came the interesting development introduced by Mr. Lowe-Wylde, who introduced gliding in a new form, that of auto-towing, in which the machine was launched from the ground like a kite by towing it with a motor-car at the end of a long cable. This development enabled flights of several minutes to be made off flat aerodromes, which had a favourable effect upon the gliding clubs by creating interest amongst the members of the light aeroplane clubs, a considerable number of whom joined their local gliding club in addition to their flying clubs. So great was the interest created that Mr. Lowe-Wylde produced a two-seater edition of his machine, and gave a considerable amount of instruction in gliding at well-known aerodromes.

Just before Whitsuntide, Major Petre of the London Gliding Club succeeded in recapturing the official English Duration Record, which up till then had still remained with Maneyrol. Major Petre soared for three hours and thirty-seven minutes at Dunstable in a German sailplane. He did not hold this record for very long, however, because, in July, Mr. Buxton flew a British-built and designed sailplane for six and a quarter hours also at Dunstable, and shortly afterwards from the same site made a flight of sixteen and a half miles, one of the first distance flights ever made by an Englishman. Gliding clubs still continued to grow, though a number of amalgamations were brought about owing to the difficulty of finding suitable soaring terrain. It had been hoped to send a machine to compete in the international soaring competitions held in Germany, but this was not possible for financial reasons, and will probably happen next year. In June the *Daily Mail* offered a prize of a thousand pounds for the first flight in a glider across the Channel; this was won by Herr Kronfeld, who accomplished this by having his machine, the "Wien" towed up to a considerable height by an aeroplane and casting loose after having gained his initial height. A demonstration of aeroplane-towing was then given by Herr Kronfeld, Mr. Lowe-Wylde, and Mr. Mole at Hanworth Aerodrome, and here Herr Kronfeld succeeded in demonstrating thermic soaring by making a flight of an hour and a half over Hanworth, which was the first demonstration of cloud soaring ever given in this country. By means of aeroplane-towing he also demonstrated his new sailplane, the "Austria," which has a cantilever wing with a span of ninety-nine feet. Three days later, quite unannounced, Kronfeld was towed by aeroplane up to about three thousand feet, and, making use of suitable cumulus clouds, he succeeded in flying across London and landed some hours later in a children's playground at Chatham; although not breaking any official record, this flight across London is probably the most interesting gliding feat yet accomplished in this country.

Shortly after Kronfeld's return to Germany, Magersuppe, flying a new British sailplane, the "Tern," made a flight of nearly nine miles flying in Yorkshire, and a considerable amount of soaring was done by various pilots flying on the South Downs. The first week of October was marked by the holding of the first conference of the International Commission for the Study of Motorless Flight in London. This was opened by Lord Amulree, the Minister for Air, and twelve different nations were represented, including Germany, France, Greece, Belgium, Holland, and America. At the conclusion of the Conference the delegates moved to Brighton to witness the second British Gliding Association's Inter-Club Competitions, which, like the first, were marred by bad weather, this time by fog on the second day, but not before a considerable number of good flights had been made, and the number and quality of machines which arrived was adequate proof of the progress which had been made during the previous twelve months. Since these competitions, the number of soaring or Royal Aero Club "C" Certificates which have been granted is ample proof of the steady if uneventful progress which is being made by clubs. Several promising designs are under construction, and at present it would appear that the year 1932 is likely to be eventful.

At the present time the future of the English gliding movement is extremely difficult to forecast, for although it is certain to progress, the present financial crisis has affected gliding like everything else, and at present gliding in almost every country is passing through hard times. In England the vital need at present is the establishment of a central gliding school and research institute, where it must be possible, as in Germany, for the real enthusiast, who finds himself forging ahead, to be helped still farther forward, and not have to wait until his own local club, which cannot for financial reasons do this, can come up to his own standards. After a period at such a national school, the enthusiast would be able to return to his club and would then be in a position to be of real assistance in guiding it along the lines which it should follow. It is also the writer's personal opinion that the best English gliding sites have not been found, and that when better sites are available that the present talent, as yet working under extremely difficult conditions, will progress with really startling rapidity, and much very interesting data will be made available.

CHAPTER II

GENERAL CONSIDERATIONS

By the Editor

FOR presentation purposes motorless flight has been divided into two parts, "gliding" and "soaring." The former is the part of the subject which concerns flights which commence at a high point and descend to a lower point along a track which is dependent upon the design of the machine. The latter covers the part in which the loss of height is slowed down or prevented completely by the use of air currents. At the present time the term "soaring" is itself being further classified, first "static soaring" where flying is prolonged by the use of deflection or rising air currents, and "dynamic soaring," where the internal relative movements of the air itself are used. In the actual flight it is not possible to separate these branches absolutely, a normal flight may quite possibly combine a little of each, and is almost certain to combine gliding and static soaring.

The new-comer to gliding is almost always extremely puzzled as to how he is ever going to be able to learn how to make use of the vital but invisible air currents. He need not be disheartened however, for it has been found that, like in most, things there are certain basic principles and laws which can be applied. Of these more will be found in a later chapter, but it will not be out of place to forewarn him that he can learn a great deal, even right at the start, by watching other pilots' flights; this applies both to learning how to control a glider, and also to learning how to find suitable air currents. Every gliding site has its own particular good and bad sections, which, for obvious reasons, vary according to wind strength and direction, and the beginner will soon learn much of these peculiarities if he is a regular attendant at his club, and watches the varying tactics of the more experienced pilots.

The Object of Gliding.

In these days when almost everything is valued in the mind of the layman simply by the measure of its utility, it will perhaps be wise to consider the value of being able to make a simple hop from a high point to a low one, or even a prolonged soaring flight. When one considers the highly specialized types of terrain and weather which are necessary at present, the assessment of value is likely to be very low. The reason for this is that at present all new forms of transport are at once compared to such old types of conveyance as the train or steamship. On this basis they are at once assessed in terms of speed, economy, and safety, and unless comparing favourably are at once disregarded and slandered. Yet surely there are other measures of practicability? The small sailing boat or the tobaggon are both useless considered on this basis, but to the person who uses either, or the manufacturer, or the suppliers of materials, both of them are thoroughly sound.

Admittedly above all else gliding is a sport. The best sports are those in which personal skill, judgment, and endurance are foremost, whilst a sport which demands good team work, and a spirit of competition is even better. Gliding fulfils all these functions, obviously skill and judgment are absolutely essential, whilst undoubtedly he who sticks at it and refuses to be put off by early difficulties or bad conditions, but turns out regularly in the hope that things will improve, will soon find his level and start to go ahead. Further, good team work is absolutely necessary. In competitions, for instance, the best pilot will be selected to fly for his club. If conditions are difficult and he fails to soar, the team which rushes the machine back to the launching ground in order that he may try again is the team which has the best chance. On such occasions there is no room for the man who knows (out loud) that he could have done it better. From the soaring pilot who is flying silently along, a sense of constant alertness is demanded if he is going to make the best use of each up-current which he finds, he must always be looking ahead, thinking where he is likely to find the next, and deciding whether or not he has sufficient height to reach it. Even the rawest pupil benefits from the competitive spirit; he is always trying to outdo the other pupils. In brief, gliding is one of the finest teamwork sports imaginable, and is worthy of much greater attention than it is at present receiving from schools and sports clubs, where real enthusiasm abounds.

There is also no doubt that the glider is an excellent medium for flying training, whilst it has the added advantages of comparative cheapness and safety. A well-known flying instructor remarked recently that with the majority of his pupils one-third of the instructional period was spent not in teaching, but in building up confidence. What finer medium for building up confidence is there than the glider? From the start every flight is "solo," the pupil knows that whatever he knows he has learnt by experience. One of the greatest worries of the aeroplane pilot about to make his first solo flight after a considerable period of dual instruction, is almost invariably as to how much of the flying he has done has actually been accomplished by himself, and how much has been made possible by the kindly hand of his instructor. The glider pilot has no such fears. The theory is often advanced by aeroplane pilots that glider training is little or no use because of the extremely short flying time which the glider pilot has experienced; they are apt to overlook, however, that on each flight, however short, the pupil has had to go through all the motions for taking off, flying, and landing. Another point which is commonly overlooked is that the glider pilot has learnt to fly "by feel," for the training type machines are not fitted with instruments. How many of the minor crashes on landing an aeroplane are attributed to "having struck a bump coming in"; to the glider pilot "a bump" is something much more; it is a particular form of air current, and in many cases he will be able to anticipate it, and occasionally even make use of it. In the case of engine failure he may well be able to prolong his glide by knowing how to make use of the terrain where he is forced to land. It is, however, interesting to note that although it is an accepted fact that good glider pilots make good aeroplane pilots, the converse of this statement is by no means the case; in both Germany and England experience has shown that a number of famous aeroplane pilots have failed miserably in their attempts at soaring flight.

Another practical application of the glider is for full-scale aeronautical research purposes. It is interesting to note in this connection that the highly successful Lippisch-Koehl tailless machine, which has been most successfully demonstrated in Germany, was developed from the model stage through a series of no less than five tailless gliders to the present power-driven edition, and in all at a cost of considerably less than the cost of building two power-driven machines. A considerable number of the Gottingen wing sections have also been developed with the assistance of gliders.

On the Safety of Gliding.

So clean is the record of this particular branch of aviation that there is very little to be recorded. In Germany, where gliding has been developing on a considerable scale for about twelve years, the records show that fatal accidents average slightly less than one per year, and even this figure is deceptive because approximately sixty-five per cent. of these accidents occurred in the first five years, and happened to pioneers doing experimental work. There has only been one fatal accident to a pupil within the last four years. In America the record is not so good, but here again figures are deceptive, as no less than sixty per cent. of the fatal accidents which have happened as a result of gliding, have occurred to professional aeroplane pilots attempting foolhardy stunts. In England during the three years in which the gliding movement as it is to-day has been in existence there have been three fatal accidents, one of which happened to a well-known pilot doing experimental work, and three cases of serious injury, none of which have resulted in permanent disablement. To appreciate this to the full it should be remembered that there are over eighty gliding clubs in active operation, and a number of them with little operating or maintenance experience. Surely a wonderful record, and adequate assurance for anyone who has fears or doubts on this point.

The Cost of Gliding.

There are many thousands of people in England who are keenly interested in aviation, and have been unable to participate actively owing to the high cost of such participation. In gliding it is possible for them to obtain most of the fun of sporting aviation at a cost which is within the reach of almost everyone. The average club charges an annual subscription of about three guineas a year, on top of which there is usually a nominal entrance fee varying from ten shillings to a guinea. Contrary to most clubs this is not just the beginning of the expense, but is usually the major portion. In addition, it is customary to charge a small fee for joining an instructional group, here the normal fee is half-a-crown per day, though some clubs charge a higher subscription and make no additional charge for flying.

During the summer months some clubs organize week-end camps, or camps for longer periods on such occasions as public holidays. For these camps it is customary to charge an inclusive fee for the period of the camp, but here again the fees are usually kept extremely low and well within the reach of almost everyone. The beginner would be well advised to make a point of attending one of these camps, as apart from being very enjoyable, the continuity of instruction which is made possible on such occasions is usually very beneficial, and considerably accelerates the normal rate of progress. Although clubs vary considerably it should be possible for anyone to take up gliding and fly every week-end for the sum of about ten guineas a year, which sum includes subscription, entrance fee, flying charges, and at least two week-end camps.

For the ambitious enthusiast who wishes to own his own machine, two courses are open; either to build or buy his own machine. If it is decided to build a machine, excellent drawings and instructions of a successfully proved and tested machine can be purchased from the British Gliding Association for a fee of six guineas, whilst material should not cost more than an additional thirty pounds. If the constructor has doubts concerning his constructional abilities he would be well advised to buy a set of completed parts from one of the glider manufacturing companies; in this case it is only necessary to assemble the completed parts in accordance with the drawings provided, and very few tools are necessary for this purpose. This would probably increase the cost in the case of a good intermediate type machine to about fifty-five pounds. If it is intended to purchase the complete machine, it is possible to pay anything from about seventy-five pounds to about two hundred pounds, though it is possible to purchase an excellent all-round machine, capable of soaring flights in low winds, for about one hundred and ten pounds. The costs of operation of such a machine vary considerably according to use and location. Storage of such a machine, dismantled, should not exceed fifteen pounds a year, whilst in addition it will be necessary to take out a "third party" insurance policy which would probably cost about another four to five pounds.

There are now quite a number of privately owned glider and sailplanes in the country, but very few are owned by individuals; most of them are owned by a small syndicate of from three to five persons, usually members of the same club, who buy the machine and operate it amongst themselves, using a club gliding ground, storing it in the club hangars, and contracting with their club to maintain the machine.

CHAPTER III

THE A B C OF GLIDING

BY M. D. MANTON

The Early Stages.

FEW people are able to mount a bicycle and ride it at the first attempt; however with a little practice a sense of balance is obtained and riding thenceforward becomes instinctive.

The same applies to gliding; but possibly the latter is a little more difficult owing to the fact that balance has to be provided both laterally and longitudinally. Fortunately the glider has no tendency, if properly rigged, to flop about and fall out of the air, and only the actions of the pilot or the effects of atmospheric disturbance will put the machine off its even keel.

To glide, therefore, all one has to do is to launch the machine from a suitable hill-top, and so manipulate the controls so that the machine will assume a normal gliding angle, and to steer it towards a suitable place on which to alight.

All this sounds extraordinarily easy, and so it is when you know how.

It is not proposed to describe what a glider is or how it is constructed, since that is the subject of other articles in this book; so given a glider, a launching rope, and a team, we will start on the gliding business right away.

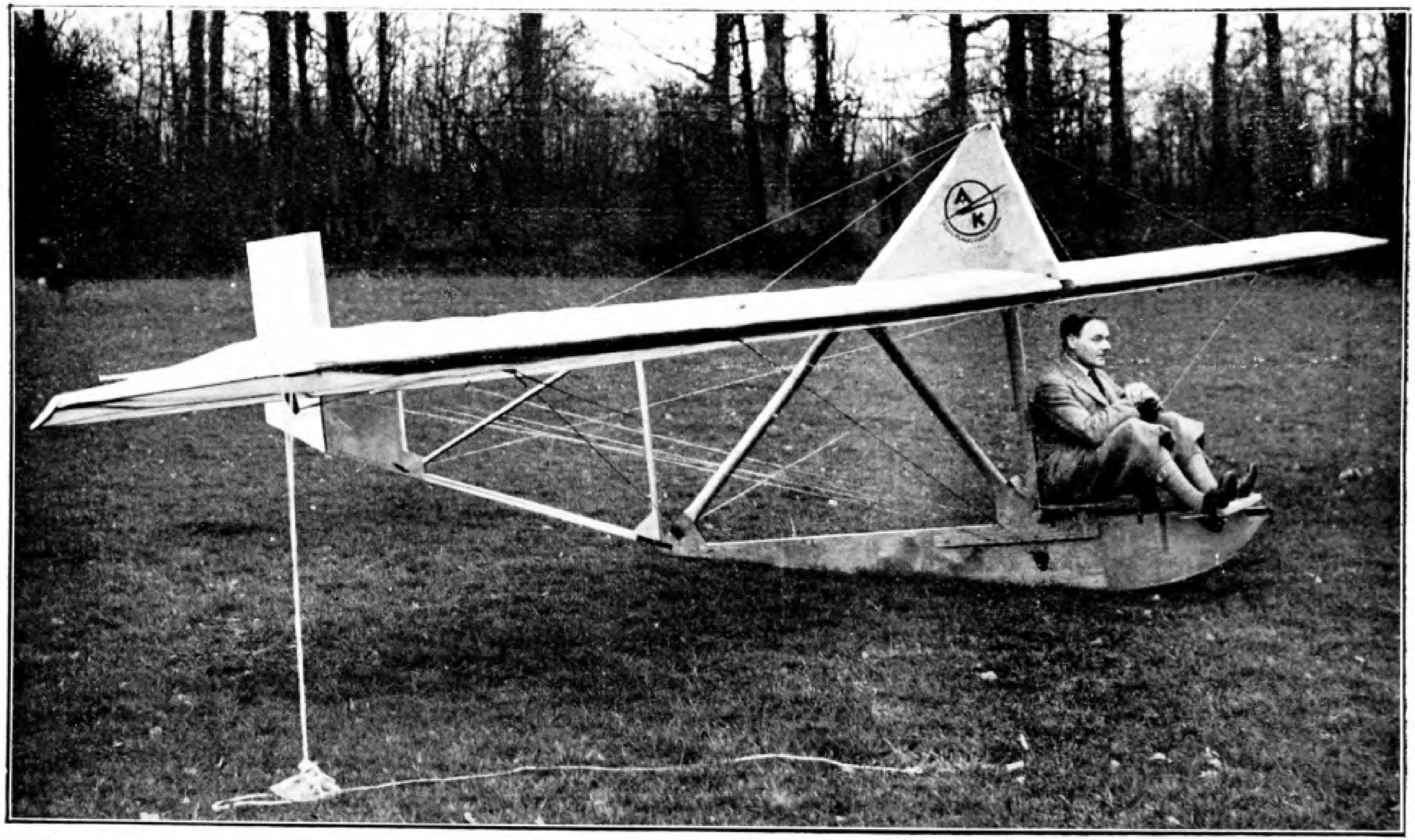
Take your seat in the machine and make yourself comfortable; just a minute, you have forgotten to fasten your safety belt; that's better, you will now feel part and parcel of the machine and not, it is hoped, feel the same desire to clutch the stick (control column) for support.

Put your feet on the rudder bar and hold the control column in your right hand, now just listen to me for a moment.

Steering is done by the feet; to turn to the left, press on the left-hand end of the rudder bar; that is, push your left-foot forward; to steer to the right, push your right foot forward—remember left, left foot; right, right foot.

The stick controls the elevator and the ailerons, by means of which the machine is balanced fore and aft and laterally; if you push the stick forward the nose of the machine will dip, pull the stick back towards you and the machine will climb. A side to side movement of the same control column (stick) controls the ailerons which are responsible for lateral balance, if the left wing drops pull it up by moving the stick to the right, should the right wing drop then push the stick to the left.

Before we launch you just demonstrate to us



Planet News, Ltd.

A PRIMARY MACHINE WITH MARCUS MANTON, AUTHOR OF "THE A B C OF GLIDING," AT THE CONTROLS

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what you would do if you found the machine turning to the left. Well, if you do that you will turn farther to the left; you should have pushed the other foot forward; to check a left turn you must use right rudder and for right rudder you must push the right foot forward. Please remember, right turn right foot; left turn left foot. Just forget about riding a bicycle, the steering being just the opposite.

You think you can remember that? Now we will give you a gentle launch; just a slide on the ground in front of you, which is almost level; we will only give you a small launching team so there will not be much acceleration and shock to you for the first launch. Do not get off the ground this time, but concentrate on keeping a straight course; hold the stick in this position, which is neutral, and the machine will not rise, but in case you accidentally pull the stick back and get off the ground, do not hold it there, but ease the stick forward gently; gently remember, or you may overdo it and land on the front of the skid, nose down.

Two on each rope please, one on the tail, you are not quite into wind, turn the tail round to the left a little please.

The V is not quite straight, left-hand team in a bit, right-hand team move out a bit; that's enough; don't forget to run straight.

Are you all ready? Walk—— Run—— Release.

Well, that's that; how did you feel? Pretty good for a first effort; you put on wrong rudder at first and were not quick enough in correcting the mistake, and you finished up on a turn instead of straight; now don't forget that rudder business left turn, left foot forward; right turn, right foot forward. You push the foot forward in the direction which you want to go, just think about that for a bit and try to do better next time. You might give a hand on the rope.

Who is next?

We'll have the machine back here.

Go on, hop in. You have done a couple of good slides, so we will try to get you off this time; no altitude records, just try to make a steady level flight a couple of feet off the ground, as the machine gathers speed ease the stick back slightly and take off, then gently push the stick until the machine is level and hold it there, and as you are about to touch the ground bring the stick back towards you just a trifle. Don't pump-handle; remember, quickly and gently does it.

If your wing drops pull it up; that is the same as pushing the stick towards the wing which is high. If the machine heels over, your body goes with it, and if you move the stick the same way as you move your body in order to sit straight up, you will make the correct movement, which is, of course, quite instinctive.

Don't forget about your rudder, to turn right, right foot forward, and left, left foot forward: left, left; right, right.

Three on each rope please, one on the tail; take up the slack, please.

All set? Walk—— Run—— Release.

Stick forward! FORWARD!

That was a pretty grim effort; surely you realized that you were climbing too steeply. You were told to ease the stick back slightly, not to heave it right back into your stomach. Please remember that a machine can only fly when it has sufficient air speed, and that if it has too little speed it will stall. Stalling is due to flying too slowly, whether it be due to climbing too steeply or gliding too flat. Next time be more gentle and only pull the stick back about quarter the amount you did last time and you will get on much better.

What is that? Did you say you were quite sure you had seen other people pull the machine up just as steeply? That is true, if you are referring to a beginner; he was making just the same mistake as yourself; if you are thinking of a more experienced person or, say, an instructor who you think should know better, he actually does know better, but you are forgetting that he may have had a stronger launch than you had, and also that he has had more experience and knows by the feel of the machine when to stop climbing, and does so before reaching stalling point.

The next fellow is getting the hang of it very well; if you watch him you may pick up a point or two. Quite a lot can be learnt by watching the others in between your flights.

You are next Brown. Would you like a strong pull this time? You would? All right, we will see what we can do.

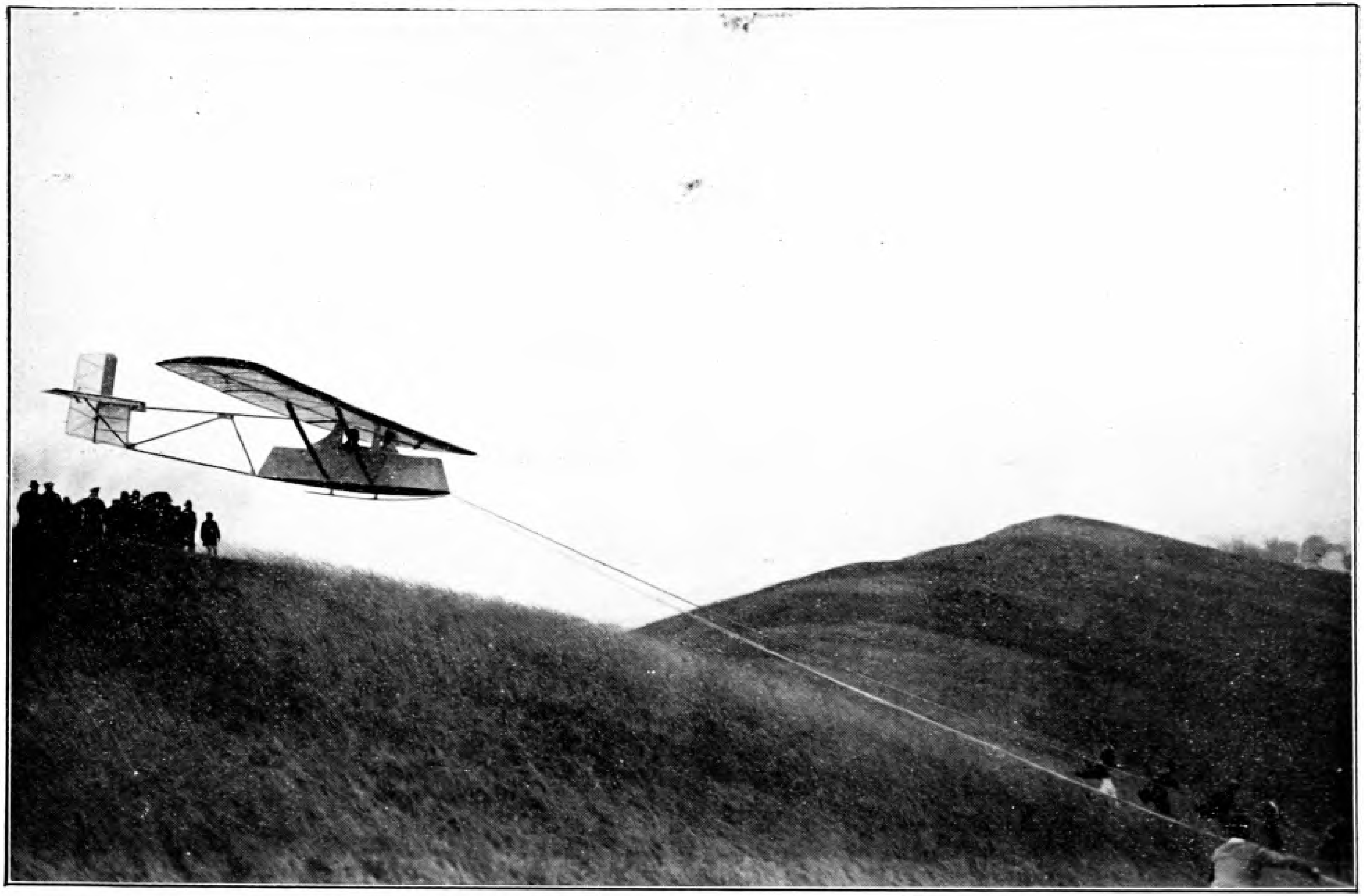
Three on each rope please, take up the slack, both sides in a little; that's enough. Ready? Walk—— Run—— Release, keep on running.

That was very good, you flattened out just a fraction too soon and you landed a little heavier than you would otherwise have done; you can go farther up the slope next time.

Next please; the wind has shifted round a bit; we will have the machine over there. Tail this way a little; that will do nicely.

One on the tail, three on each rope. Just a minute—you have got your safety belt done up round the aileron wires: you must watch for that, as it might make the lateral control feel stiff. What are you trying to do? Don't clutch the stick so tightly; it has not done you any harm so don't wring its neck. Hold it gently and comfortably, thus.

You have got your elevators up? Stick forward a little—a bit more; that's enough, hold it there and you should take off, fly and land with



Pacific and Atlantic Photos, Ltd.

THE LAUNCHING OF A TWO-SEATER

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hardly any movement of the stick, but remember if you are climbing too steeply, just put the stick forward a little.

Ready ? Walk—— Run—— Release.

Look out !

That was fair, but don't chase your launching crew and make them duck or fall on the ground whilst you pass over them. Why did it turn ? Because you had your rudder over of course. Oh yes you had ; we not only saw you put on rudder, but you did not take it off until you were slithering round after you landed. You must pick an object ahead of you and steer for it ; don't let your eyes wander round the landscape or your feet may start following your eyes. Choose an object ahead, but don't let it be the launching crew, as they don't like it. Let me have a look over the machine and see whether you have strained anything.

You have not done any harm, but those landings on the turn put a strain on the skid ; the machine will stand a lot of banging about providing that it hits the ground square and straight, but landing with side drift or on the turn may very easily put the machine out of commission.

We will have the machine about a third the way up the hill this time.

Take your seat and have a look round ; you see that tree in the distance, the one just above that dark patch on the ground, aim for that. It is much better to go off with the fixed intention of doing something definite, rather than shooting off in a haphazard manner not knowing where you are going or what you intend to do.

Soon after you take off you will find that you are forty or fifty feet above the ground at the bottom, but do not let that worry you; keep your eyes on the horizon; when the rope falls off push the stick a little forward and glide gently to the ground, but don't try to stretch the flight by gliding too flat; you will feel the rush of air against your face as one indication of speed. The machine will be rather soggy on its controls if you are gliding too slowly, in which case put the nose down a bit. Don't forget, keep your eyes on the horizon and that will give you a very good idea of position of the machine.

Are you ready? Walk—— Run—— Let go.

When he lands, bring the machine back to the foot of the hill for another ground slide.

That was very good indeed; no mistakes; it was a very safe flight; actually you can glide flatter than you did, as you will find out for yourself when you have had one or two more flights, but it is far better to err on the side of a bit too much speed than too little. You got one or two bumps from gusts and corrected them immediately. You may go off next time from half way up the hill if you wish, but don't rush into it if you don't feel like it; you can just as easily be launched from the same place as last time if you prefer it.

The foregoing remarks are intended to show how the beginner goes through the early stages, and to avoid repetition it should be realized that each stage is practised until the pupil improves sufficiently to be passed on to the next. Progress is not so slow as might be imagined, for although each trip only amounts to a few seconds, a good deal can be learnt by watching others and summing up their good points and their errors.

A word or two about beginners' mistakes might not be out of place. The most common one is the use of wrong rudder; this is the one control which is not instinctive, and is not like steering a car or cycle or even driving a horse, being in fact the reverse. It has often been said that it would be easier if the rudder were arranged to work in what appears to be the normal and instinctive manner. There are, however, two good reasons for this: one is that all aircraft controls have been standardized and the other is that it would not really simplify matters, apart from the very early stages, as the rudder and ailerons are worked in conjunction, and it would be much more difficult to co-ordinate these movements if the stick had to be pushed to the left as the rudder was pushed to the right.

Once the rudder control has been mastered, the pupil begins to realize how useful it is that the rudder control works the way it does, and will be inclined to think that it is fortunate that things have been arranged the way they are.

Another mistake is heavy-handedness; the pupil is apt to overdo all control movements by making use of jerky rather than a smooth movement, try to relax and hold the control column comfortably, it being quite unnecessary to grip it so tightly that the knuckles show white through the flesh.

Before leaving this chapter there is one very important rule which should be remembered by all, and that is never leave the seat of a glider or sailplane unless the wing tips are held by assistants. Machines are very easily blown over when relieved of the weight of the pilot, so on landing do not get out of the machine until help arrives.

The Hill-top.

The would-be pilot having been gradually worked up the slope on successive launches as he gains experience, the time comes when he arrives at the top and is launched for the first time from a considerable altitude.

The launch is normal and similar in all respects to previous launches, but within a second or two of being released the machine leaves the crest of the hill, and the pilot finds himself in the air several hundred feet above the flat or gentle slope at the bottom of the hill. Almost invariably the pilot pushes the stick forward, his one object in life apparently being to get back to earth in the shortest possible time.

From such a height it should, according to the conditions prevailing at the time, be possible to make a flight of between one or two minutes' duration, but few of these first flights from the top of the hill last longer than twenty to twenty-five seconds. Eyes stream and wires whistle and the pilot rapidly approaching the ground, pulls back the stick in order to flatten out the machine for landing. The machine flattens out; it does not touch ground, however, but continues its flight for another hundred yards or so, until the speed gained on the rapid descent is lost and the machine sinks to the ground.

The pilot, usually very pleased with himself after having accomplished his first flight from the hill-top, has found it exhilarating and has the satisfaction of knowing that he can bring the machine down safely from a considerable height.

He will also, if he has had time to think about it, have observed that the machine was exceedingly responsive to its controls, which answered immediately to all movements, even when made quite slowly and gently.

From this moment the "A" certificate is

within easy reach and after one or two further attempts, the pilot will overcome the tendency to gaze at the floor and dive to the ground, but will keep his eyes on the horizon, form a better idea of the inclination of the machine and will make longer flights by holding the machine on a steady glide.

It should here be mentioned once more that a machine is dependent for its support on air speed (that is the speed of air flow relative to the planes of the machine, e.g. in a calm a speed relative to the ground of 30 m.p.h. would be an air speed of 30 m.p.h. The air speed would still be 30 m.p.h. if the machine had a forward speed of 20 m.p.h. when flying against a breeze of 10 m.p.h.; and there is a certain speed below which the machine cannot fly. When a machine loses its flying speed it becomes what is known as stalled.

The pilot therefore must never stall the machine. Fortunately preliminary type training gliders are not vicious at the stall and do not rapidly go into a spin or dive, but give ample warning before the stall, and when stalled, if not too violently, will begin to sink on a practically even keel ; the controls will feel soggy and will be slow to function, the breeze against the face will be less as will the sound of the air in the ears.

Providing one has ample height, there is no great danger in stalling, and air speed will be regained almost immediately when the nose of the machine is dipped by easing the stick forward.

Stalling near the ground, however, is dangerous; the cure, it has been stated, is to dive to pick up the lost speed, and if there is not room to dive and flatten out again before hitting the ground, little can be done. Should this occur, however, it is usually advisable to centralize controls, not forgetting the rudder, and relax.

Whilst on this subject, a word of warning is given against stalling immediately after the launch; the machine will climb very rapidly into the wind with the velocity gained at the launch, but if you continue to climb, the speed will rapidly decrease. Do not be caught unawares, but be ready to ease the stick forward and bring the machine to its normal gliding angle.

At this point a word with reference to the launch will not be out of place.

At the command "Release," the machine will move forward and will quickly gather speed; it should not be pulled up steeply, or the ring will come off the inverted hook on the nose of the machine long before the rope has given up all its stretch. The elastic rope would be released with a "ping." This may give a jerk to the machine, the elastic, instead of falling to the ground, will shoot forward and possibly finish up by giving the back members of the crew a thrashing, possibly removing flesh or giving severe bruises.

Apart from the possibility of damaging the launching crew, much of the launching power is lost. If the machine is held down to a few feet above the ground until the ring falls off, the whole available power from the elastic will be transmitted to the machine and a much better launch will be the result. With the speed gained at the launch the machine may be climbed after the ring has fallen off, but it should be borne in mind that the climb can be only momentary and the machine must be flattened out and put on a normal glide before it loses speed and is in any danger of stalling.

The test for an " A " certificate consists of a straight glide of at least thirty seconds' duration, followed by a normal landing, and this should easily be accomplished on the second flight from the top of the hill, providing that the hill is of reasonable height; some sites used by clubs up and down the country are really only suitable for preliminary training and in some cases it is only just possible to make flights of over thirty seconds' duration by getting the utmost out of the machine at its best gliding angle.

The " A " test having been completed, the pilot then prepares for the next stage, which is known as the " B " test. This comprises a flight of at least sixty seconds' duration, followed by a normal landing, the flight path to be in the form of an "S", i.e. it must contain two curves, one to the left and one to the right.

Prior to being allowed to qualify for the "B" certificate, the regulations call for two preliminary flights of at least forty-five seconds' duration.

The pilot now sets out to make glides of forty-five seconds or longer; he may succeed at the first attempt or he may not, but instead of devoting the flights to straight glides, it is best at this stage to practise turns.

To turn is not difficult providing the pilot will make up his mind to do so, but cases have been known where pupils have made flight after flight always in a straight line without making any attempt to turn until one day, facing an obstruction, the rudder has been kicked over and the machine turned and has missed the obstacle.

On the first attempt at turning, just make gentle sweeps when the machine is gliding steadily, push the rudder bar gently forward in the direction in which the machine is to turn, and it will commence turning at once. Having turned gently, give opposite rudder to bring the machine on a straight course again and be ready to check the rudder movement as soon as it has done so.

On subsequent flights turns may be made first in one direction and then in the other, using bank on the turns and not holding off bank in an endeavour to keep the planes truly horizontal in relation to the ground (i.e. parallel with the horizon). A little bank is most helpful in making a turn and you will find that easy and graceful turns are accomplished when the machine is allowed to bank slightly.

The quicker the turn the more bank is required; turns of very large radius require very little bank. If the machine does not appear to answer the rudder as you would wish, try the effect of a little bank. There is, of course, a correct degree of bank for every turn.

The pupil will by this time have come to use the ailerons almost instinctively for balancing the machine laterally. He should therefore have little difficulty in combining this movement with the use of the rudder. Practise the simultaneous use of ailerons and rudder; to turn right, push the right foot forward, and the control column over to the right, and *vice versa.*

These movements require careful practice, as every beginner takes time to discover how much bank to apply for each type of turn, and it is most important therefore that only gentle turns should be attempted until this point has been mastered. Always try to apply rudder and bank in even quantities, as if too much bank is applied for the amount of rudder, the machine will start to sideslip. To come out of a turn, take off rudder and ease the control column slightly in the opposite direction, returning it to the neutral position as the machine returns to a straight course.

In order that the first turns particularly shall be perfectly safe, the following points are worth consideration. Do not climb on the turn by inadvertently pulling the stick back, but err in the other direction by increasing the speed slightly by easing the stick forward a little. Next apply rudder gently and await the effect. If not turning sufficiently apply a little more rudder and ease the stick over sideways in the direction in which you are turning.

Do not forget to straighten up before attempting to land; always land straight and where possible directly into the wind.

A word of warning. Do not turn close to the hillside on early attempts; wait until you are well out from the hill and then turn, and let the first turns be gentle ones. The reason for this is not far to seek, for you have taken off from the top of the hill into wind; if you turn too soon you will find yourself flying alongside the hill and with the wind, now on your beam, drifting you towards the hillside at the same time more than probably being bumped about by the eddies formed by the contour of the ground, and the position in which you find yourself will probably be disconcerting. The way out of the difficulty would be turn away from the hillside as quickly as possible by using opposite rudder and bank. An even worse position would be due to too sudden a turn after leaving the hill-top, sufficient rudder having been applied to turn the machine right round through 180 degrees ; you would then, with the wind on your tail, be charging back at the hillside at speed, and to avoid flying smack into it the only possible thing would be to try and land up the slope. The slope if steep, as it probably would be, would entail pulling the stick right back. If the machine was not completely written off and the pilot uninjured, it would be extremely fortunate.

The above remarks are not intended to scare the reader, but such things have been done and such happenings are usually the result of panic. Forewarned, however, is forearmed, and if you make haste slowly, you will not find yourself in any such predicament. Therefore, wait until you are well away from the hill before you turn and then turn gently and all will be well.

Having mastered easy turns the " B " test can be made.

Practise turns whenever possible, as it is the easy road to soaring flight.

Elementary Soaring.

There is no mystery about soaring flight ; soaring is nothing more than gliding downwards in a rising air current. Anyone who has mastered the handling of a glider can soar. If he happens to fly into a sufficiently strong up-current with a suitable machine it will soar, and so long as the strength and direction of the wind remain the same and the pilot remains in the ascending current, the machine will continue to soar.

There are types of soaring, however, which call for particular skill and experience, such as flying in the up-currents under clouds, cross-country flying on the rising air in front of a line squall, but this does not come under the head of elementary soaring.

A more suitable machine than the primary training type is required ; one with a low sinking speed is necessary for soaring, but for early work a high-performance machine is not required, nor is it desirable, as they are somewhat delicate and easily damaged, and take a good deal of bringing down in a confined space ; thus a secondary type of moderate performance is preferable for first attempts to soar.

On first flying a secondary type machine, the pilot should begin with ground hops on very gentle slopes in order to accustom himself to the difference in handling ; in fact these remarks apply equally when trying out any new type of machine.

The controls of the secondary type machine function in the same manner as those of the primary, but they are rather more sensitive; the pilot has also to accustom himself to sitting in a nacelle in place of the open cockpit of the primary types.

After one or two flights from the top of the hill, during which turns should be practised, the pilot will feel at home on his new craft.

When next the wind is of the right strength and blowing up the hillside the pilot may make his first attempt to soar. He will take off in the usual manner, but instead of flying right away from the hill, he will make a ninety-degree turn and fly along the face of the hill a short distance out from the crest. Instead of the machine sinking he will find that he is able to maintain level flight and even gain height. On reaching the other end of the ridge another turn is made, and the beat is retraced in the opposite direction.

Flying back and forth along the ridge the pilot is soaring.

A "C" certificate is granted for a flight of at least five minutes' duration at a height greater than that of the take-off point.

In a number of cases "C" tests have been accomplished on the pilot's first attempts at soaring flight, but, generally speaking, these flights are found to be rather exhausting at first, and the pilot becomes tired and decides to land. On other flights perhaps the pilot has turned too

A "PRUFLING" IN FLIGHT

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wide, and has got out of the up-current, the machine then being unable to maintain level flight, it has to descend in a normal glide to earth.

When one first attempts to soar there will be much to do : correct steering to keep in the up-current; quite a lot of work with the ailerons correcting the bumps which are sure to be present, due to gusts and the contour of the terrain; keeping air speed constant, etc., which may cause tension and nervous exhaustion. Should you feel the effects of this, do not attempt to carry on, but on the end of a beat instead of turning back again, turn out from the hill away from the rising current and glide down to land.

If the machine is fitted with an airspeed indicator, it will be a great comfort to the pilot, as he will be able to see at a glance whether he is flying too slowly and in danger of stalling or flying too fast in which case he may be descending quicker than the rising current can counterbalance and therefore he will lose height. Without an instrument one must rely entirely on the senses: feel, sound and sight.

There is no difficulty in knowing whether one wing is dipped if one keeps an eye on the skyline, and a sideways glance at the wing tip will show whether the machine is level, nose down or climbing from the angle formed by the end of the wing and the horizon.

The machine can be climbed on the gusts but must be dipped as they die away, as will be discovered as the pilot gains experience.

Before making the first attempt to soar, listen very carefully to what the instructor has to say. He will tell you the course to steer, how to avoid getting into the down-draughts by flying too far over the plateau on top of the hill; do not set out in doubt, but have your mind fully made up as to what you intend to do and try to follow the instructions to the letter.

The best course to steer is not an elongated figure eight, but a straight line with a circle at each end. Commence the turn by turning slightly towards the hill, so that the turn is completed within the area of rising current and not beyond it. Increase speed a little for the turns and be ready to check any tendency to overbank, remembering that the wind is blowing towards the hill and as you turn you will be presenting the outer and faster turning wing to the wind and the outer wing will thus have more lift.

When you have progressed this far, you will have got your "A," "B," and "C" and the A B C is the beginning of all learning.

CHAPTER IV

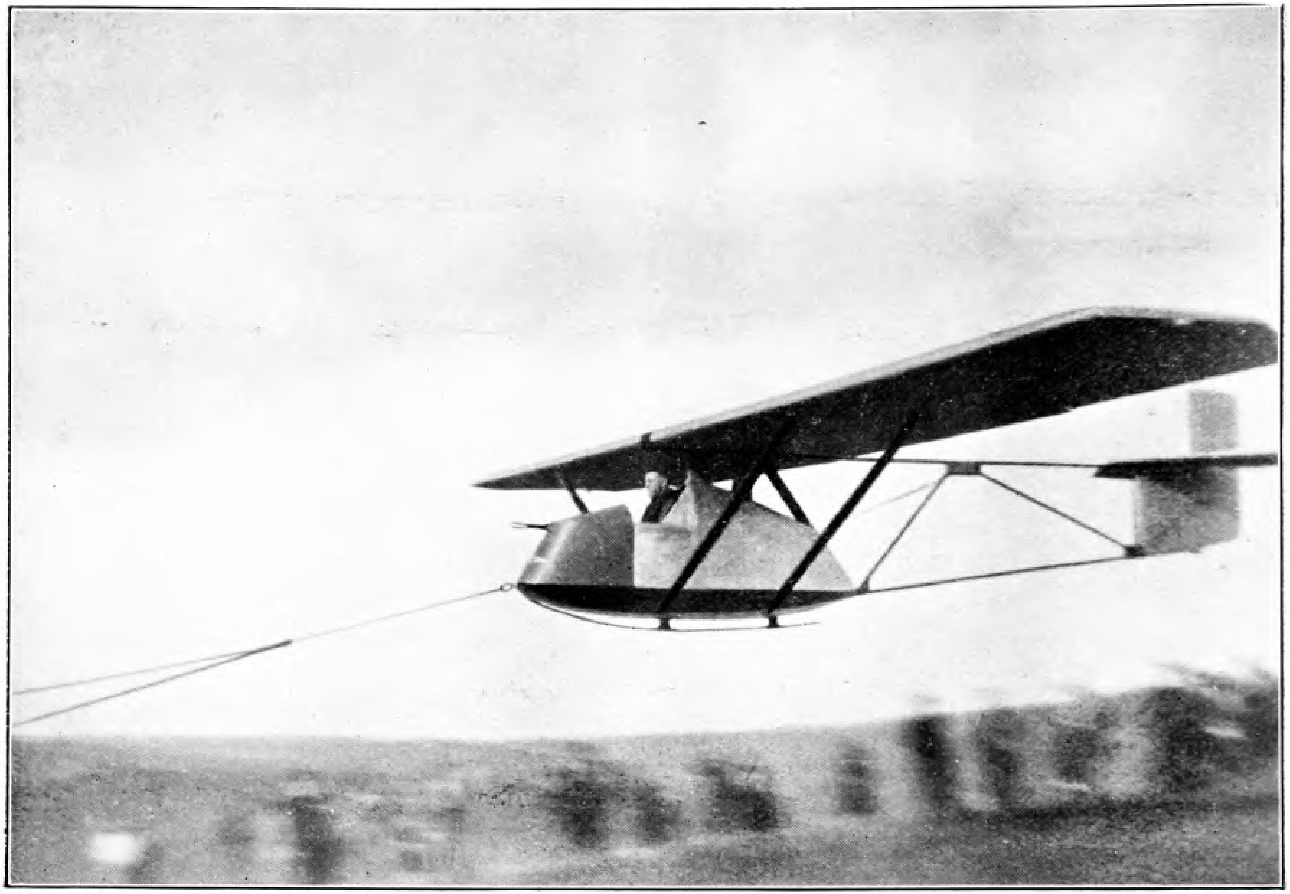
GLIDING AND SOARING FLIGHT TUITION

By H. A. Petre

THE most difficult period in the instruction of a glider pilot is at the very beginning, whilst the pupil is still reaching the stage at which he will be able to use the controls instinctively, and the greatest difficulty almost invariably occurs with the rudder. The vast majority of pupils seem to expect that the rudder control will function in the opposite way to that in which it actually does, in other words, that the movement of the rudder bar will produce results similar to the movement of the handle bar of a bicycle. New pupils should be advised to familiarize themselves with the use of the rudder by thinking about it constantly, even when not actually engaged in gliding. When sitting down in a chair at home it is simple to think it out and say to one self: "I am going to turn to the right," and push the right foot forward, or "I am going to turn to the left," and push the left foot forward. In this way the necessary instinct will soon be acquired. The use of the lateral control also presents certain difficulties. Although to move the control column to the right when it is desired to bank that way, or when it is necessary to take off left bank is as instinctive as any movement can well be, experience shows that the pupil seldom moves the control column *straight* across in such circumstances, particularly if he is holding the control column in his right hand when putting on right-hand bank, and *vice versa*. Almost invariably he imparts a backward as well as sideways movement. This is, of course, an extremely dangerous habit, which should be explained very carefully to every pupil, and checked whenever it occurs. Whilst still in the early stages it should be explained that every lateral movement of the control column must be accompanied by a slight forward movement so as to impart to the glider the increased speed necessary to overcome the resistance due to the use of the ailerons. The use of the elevator calls for little comment at this stage as the fore-and-aft movement of the control column is almost entirely instinctive. As soon as the pupil has begun to get a fair understanding of the use of the control system, it should be explained to him that the preliminary movement of the controls should be fairly generous, but should be reduced immediately the glider begins to respond, the control column being brought back to the neutral position a moment before the glider has taken up the desired new position. If this is not done the result will be violent over control.

When the actual tuition starts the pupil should be familiarized with the acceleration of the launch and to the handling of the glider without, in fact, leaving the ground. This is accomplished by keeping the speed of the launch below the actual flying speed of the glider. Level ground should be used, and a hand launch with not more than four people in all pulling on a single elastic catapult. For a normal launch it is usual for the team on the ropes to walk ten steps and then to run eight before the order to release is given. In the case of reduced launches for beginners, however, eight and six steps respectively will be sufficient. After four or five such launches the pupil should feel sufficiently at home in the machine to be allowed to leave the ground for a short distance by having the strength of his launch increased, and from this point on he has to learn almost at the same time to take off, to fly straight, and to land. It should be explained to him that the ideal to aim for is that the machine should leave the ground in a horizontal position, and not with the tail down as it normally rests on the ground. He should be shown the appropriate position of the control column to attain this, and it should be explained to him that as it is not intended that he should rise more than a few feet from the ground, he must not pull the control column back at all until the machine begins to sink again, when he should ease it back gently for the purpose of making a landing.

The next stage should, if possible, be carried out on gently sloping ground, and if possible against a light breeze. It should consist of launches increasing progressively in strength, with launching crews of six and then eight persons pulling on the ropes, or ultimately with auto-launching. The pupil should be instructed that he must still endeavour to leave the ground with the glider horizontal fore and aft, but as soon as he is clear of the ground he should ease the control column back gently and lift the machine into the air. It should also be emphasized that he must use the elevator to control his air-speed, and that he must endeavour to keep this constant at the best gliding speed of the machine. There are two ways of judging air-speed: one by an air-speed indicator and the other by the force of the resulting wind on one's face. During the earlier stages of instruction it is dangerous to provide a pupil with an air-speed indicator, as it diverts his attention from other more important things, and also an air-speed indicator does not register with sufficient rapidity to be anything but misleading during short flights. When judging the air speed by the wind on one's face, it is useful to remember



" TAKING OFF "

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that if the take-off has been made as it should be, with the glider horizontal, the speed at the moment of leaving the ground will be approximately the best flying speed of the machine. This speed should be maintained, as far as is possible, during the entire flight, and will result in the glider rising to its maximum height soon after the dropping of the launching ropes, and then descending at its best gliding angle. There is one exception, however, to the rule that the speed should be kept constant throughout the flight; should the launch be of exceptional strength, the speed should be allowed to rise above the speed of leaving the ground, until the launching ropes actually fall away, otherwise the climb will be very steep, and the pupil may get into difficulties, whilst in addition he will not attain the full benefits of such a launch. The importance of an accurate take-off cannot be too greatly emphasized.

Concurrently with the correct use of the elevator, the pupil must be taught to use the rudder and ailerons. Early flights should be straight, and the pupil should be advised to keep his eyes fixed on a pre-arranged point on the horizon, and keep the machine aimed at it during the whole of his flight. The instructor should watch the rudder to see if it is being used correctly, because it is at this stage that the pupil will get into difficulties if the rudder is not being used instinctively.

Landing has got to be learned at the same time, and this fortunately is very much easier with a glider than with an aeroplane. The pupil should still keep his eyes looking at a distant object, and he will find that he can judge his height from the ground by merely becoming aware of it below him. A landing cannot be made by looking straight down at the ground. The pupil must endeavour to bring the glider down until it skims along horizontally about a foot above the ground, and then pull the front of the machine up slowly as it loses speed. If this has been done correctly it will sink to the ground in the position in which it normally stands at rest. If the pulling up of the front of the machine causes it to gain height, it means that the speed is still too great to land, and the control column should be eased forward again, and the sinking continued a little longer. A pupil will find it easier to make a good landing if he increases his speed slightly during the last ten feet of the descent, and this particularly applies to the case of a landing made against an upward slope.

Whilst still operating on low slopes, the pupil should be taught to make turns using the rudder and aileron control, both to go into the turn and to straighten out before landing. As soon as the pupil can take off, turn in either direction, and land with reasonable proficiency, and feels at home in the machine, he can be launched from the top of the hill for his " A " Certificate. This should preferably be a straight flight, though as explained above, the pupil should be able to make turns before he is launched from any real height. If there is any possibility of his reaching any obstruction or danger point on the landing ground, it is most important that the pupil should be warned how to deal with it, as if left to himself he will watch it all the time, and instinctively turn towards it, until he finally hits it. He must instead choose another line, on which he can fly with safety, and keep his attention on that, preferably marking the direction by some distant object. He should be warned to concentrate on this point and ignore the danger point completely. A straight flight of half a minute's duration often represents something near the capacity of many gliding grounds, and for this and other reasons it is desirable that instruction in turns should be continued after the pupil has qualified for his " A " Certificate. Flights should still be made in calm air, or when the wind is only light, and the pupil should be told to fly straight out from the hill-top, till he is well clear of it, the distance varying according to the nature of the hill; he should then turn through about ninety degrees in one direction, following that by a similar turn in the opposite direction, and then land straight into wind. Such a flight as this is required to complete the " B " Certificate tests.

Up to this stage it has been assumed that a primary training machine has been used, and it is very desirable that this should be so, especially in the case of persons new to flying, as its slow speed and small rudder and aileron control prevent it from getting into dangerous situations and its great strength in comparison to its weight enables it to withstand many hard knocks without damage. Also the design is such that in a crash the pilot seldom gets hurt. After the pupil has qualified for his " B " licence, however, he should, if apt, be transferred to an intermediate type machine, starting in the first instance on flat ground or gentle slopes, to get himself thoroughly familiar with the different type. Special attention should be paid to landing, as the knowledge that he can make good landings gives the pupil much valuable confidence, and allows him, while in the air, to devote all his attention to the actual flying of the machine. The intermediate type will be found to skim much farther when about to land, than the primary type, and should be landed with the tail well down. As soon as the pupil is thoroughly at home in the secondary type he can be launched in it from the top of the hill, but preferably in calm weather, or in a very light wind, because he has now to acquire a new sense of judgment, viz. the landing approach, and this is more difficult under conditions when soaring flight is possible. Again unless the landing ground below the hill is very extensive indeed, the pupil should turn one way or the other as soon as he is well clear of the hill-top and fly more or less parallel to the contour of the hill for a short distance ; then turn again through an angle of about a hundred and eighty degrees, never turning towards the hill but always towards the landing ground, which he should approach in a series of one or more "S" turns. By this means he will be ready at any moment to turn in towards the landing ground when he judges that his altitude is sufficiently low to enable him to make a landing on it, and the difficulty of judging this correctly will be reduced to a minimum. While carrying out the manœuvres just described, it is of course essential to keep one eye on the hill to avoid getting dangerously close to it, and this is an additional reason why it should be first practised in calm weather, as there will not then be the additional risk of being blown against the hill. It goes without saying that if there is a wind blowing, pupils should not be launched from a hill, except from the slope up which the wind is blowing.

The next stage is soaring, which consists for all practical purposes of carrying out the manœuvres described in the last paragraph above the face of a steep ridge, up which a wind of from ten to twenty miles per hour is blowing. The launch should be made from the top of the main rise of the hill (which will usually be a little below its summit), straight into the wind, when the glider will be found to climb rapidly. As soon as the initial impetus of the launch has died away, and the glider has been brought back to its normal air speed or a little above it (usually about 35 m.p.h.), the pilot should turn and fly parallel with the crest of the hill, and over a line a little below the crest, on the windward side. It is here approximately that the maximum lift will be found, but the exact position will vary with the strength of the wind, moving farther out with a strong wind, and nearer in with a gentle wind. It should be specially noted however, that in no circumstances will any lift be found very close to the face of the hill, as here there is always a blanket of stationary air. This in a failing wind is extremely dangerous to fly into and is without the attendant compensation of any possible extra lift.

When the end of the ridge is reached, the pilot will, of course, turn back along it, and if well up, it usually pays to edge in a little above the brow of the hill just before turning, so as not to get too far away from the crest when completing the turn. Pupils should be specially warned that their turns must always be made into the wind and away from the hill. The speed of the machine should be slightly increased above the normal before starting the turn, so as to give plenty of control, and the bank applied should not be more than about twenty degrees, otherwise height will be lost. Any wind sufficiently strong to maintain soaring flight along the crest of the hill will naturally give the glider considerable lateral drift, with the result that the glider, instead of facing in the direction of flight, will face practically into wind at an angle increasing with the strength of the wind, until it reaches the point where the speed of the wind equalling the air speed of the glider, the latter remains stationary facing straight into wind. If the wind speed increases beyond this point it will be necessary to ease down the nose of the machine, and so gain extra speed to prevent being blown backwards. As this means loss of lift, it is obvious that the best soaring conditions will not be obtained in an excessive wind.

When flying along the crest of the hill, facing partially into the wind, and progressing at an angle of say thirty degrees to the line of flight (a normal condition of things in soaring flight), there is often a slight tendency to fly one wing low on the windward side. As in all gliders and sailplanes the pilot sits in front of the wings; this may easily continue unnoticed, but it is a habit which should be corrected, as it results in loss of lift. A quick glance round, first to one side and then to the other, will soon show whether the machine is in proper trim or not. The method of judging air speed by the feel of the wind on one's face has already been discussed, and although it is usual for sailplanes to be fitted with air-speed indicators, this method should still be used, the air-speed indicator being employed for checking up one's sensations. The recording of an air-speed indicator is unavoidably subject to such a big time lag that it is impossible to take advantage of favourable wind currents by its readings. The best method is to fly for a time with considerable care at the best gliding speed of the machine as shown by the air-speed indicator, noting and remembering the feel and sound of the wind for future use. Afterwards, while in soaring flight, this speed should be maintained at all times, except when extra speed is required for carrying out some manœuvre. A decrease in force of the upward current will first make itself known by a decrease in air speed, and this must be counteracted by diving till the speed is again normal, or stalling may result. In very rough weather the speed should be kept somewhat above normal the whole time, in case a sudden fluctuation in the wind should cause the machine to stall before the pilot has time to act, or the machine to respond to the controls.

The next matter for consideration is the method by which the soaring pilot is to judge at any given moment whether he is gaining or losing height. When at a fair altitude, this presents something of a problem, in the absence of special instruments, but the following method will be found applicable to many situations: When at a height above the ground it is approximately true to say that all objects that appear to lie at the same level as the horizon are at the same level as the observer; all objects that appear to lie below that horizon are below the observer; and that those appearing above the horizon are above the observer. This applies whether the horizon in question is a true horizon or a cloud horizon. Now in soaring country there will usually be other hills besides the one over which one is soaring at the moment, and if any point on such a hill appears to sink down to the level of the horizon, and pass below it, then the glider is rising and *vice versa*, and the nearer the hill is to the observer the more obvious will be the relative motion. This method is of course most easily applied when there is a hill available which actually cuts the horizon, but even if the observer is above the highest hill in the neighbourhood, or in fact has only got the far end of his own hill to judge by, it is not difficult to decide whether it appears to be sinking lower and lower below the horizon, or to be rising towards it. It must of course not be forgotten that motion towards the observed hill will also tend to make it increase its distance above or below the horizon, as the case may be, and motion away will have the opposite effect, so that if the hill is close this must be allowed for.

What has been said so far regarding soaring flight applies equally to intermediate type training machines and to sailplanes, but the following notes concerning landing apply more especially to sailplanes, and only in a modified degree to the intermediate type. Landing at the bottom of the gliding hill or at the top presents, particularly as regards approach, two rather different problems. Dealing first with landings at the bottom of the hill, the method of approach by making "S" turns has already been described and this in most cases is the best. As the long axis of the "S" or figure 8 will lie beyond the approach side of the landing ground, and as turns are always made towards the latter, the pilot will be in a position at any time to turn towards the landing ground and make his landing, the all-important question being to decide at what moment to do so. If there is no wind to land into, a large area will be required, because even if the approach is made at moderate speed, a sailplane floats or skims for a tremendous distance, before actually touching the ground. At least fifty yards should be allowed for this where the ground is level, and the final turn in to the landing ground must be fairly gradual as too much bank may cause a wing tip to touch the ground. The last of the "S" turns should be so placed that a gentle turn following it will bring the machine over the approach boundary of the landing ground at the lowest possible altitude.

It will be seen that the whole problem is one of getting the altitude right, and this can be greatly simplified by the use of the side slip. Here let it be said that under no circumstances when terminating the approach should any attempt be made to lose altitude by diving the machine. The result will be exactly the opposite to what is desired, as the machine will immediately gather so much speed that it will probably be impossible to stop it within the bounds of the landing ground. Side-slipping which is the safest way of losing altitude is carried out by putting the machine on a bank and preventing it from turning by putting on top rudder, that is to say by pushing forward the foot on the high side of the bank. The machine will then slip sideways without any gain in forward speed. A side slip is usually terminated by changing over the position of the rudder while maintaining the bank, and so putting the machine into a turn. It will at once be appreciated that this manœuvre can be very well applied while making any of the "S" turns; for if, instance, the pilot is a little too high on what was intended to be the last "S" turn, he can lose the excess altitude by side slipping; or if he is a little too low on what was intended to be the last turn but one, he can side slip down far enough to render further turns unnecessary.

If the wind is strong, the landing should, if possible, be made into wind, and a very big difference will be noted in the amount of space required, as even a comparatively light wind will steepen up the gliding angle relative to the ground very considerably. It is only necessary to remember that a sailplane with an air speed of 30 m.p.h. and a gliding angle of 20 to 1, will come down vertically in a wind of thirty miles per hour, but will have to travel forward one thousand feet to come down fifty feet if there is no wind, and that even to this more must be added for the final skim or float. It has been said above that the landing should be made into wind, but this is not always possible, and then the landing has to be made entirely or partially across the wind. Under these circumstances the glider will naturally be drifting to a certain extent sideways as it approaches the ground, but this drift can be entirely or partially counteracted by banking towards the windward direction, that is to say by dipping the wing on the windward side and raising that on the other side. In the case of a sailplane with a wide span, most of the bank should be taken off before the machine gets really close to the ground, otherwise it will touch with its lower wing tip first.

For landing at the top of the hill, if this is a fair-sized plateau, the method of approach already detailed is applicable. This, however, is exceptional, as a good soaring hill is more often a ridge, and there is seldom room enough to land into wind when the wind is blowing across it. Also an approach from the down-wind side would probably involve getting too far out into the down-current at the back of the ridge for safety and overshooting would involve getting caught up again in the up-current on the front of the ridge. The best method is to approach straight along the line of the ridge, keeping back out of the up-current as long as it is desired to lose height, and coming forward into it if it is found that there is a risk of undershooting. The actual landing can then be made across wind neutralizing the drift by banking as described above.

CHAPTER V

THE CONSTRUCTION, REPAIR, AND MAINTENANCE OF SAILPLANES AND GLIDERS

By V. S. Gaunt, A.M.I.

Introductory Note.

When an individual or a club decides to build a machine, there are numerous little problems which arise and which cannot normally be settled by a reference to drawings. They are the small but important practical points the solution of which lies in the hands of those with previous experience. Each type of machine brings its particular problems and no detailed instructions can pretend to cover all points without reference to the particular design. Within the limited scope of this chapter the writer has attempted to offer hints and suggestions which it seems to him the lay reader may find of most assistance. Many of the points may be obvious and elementary to many readers; there are, however, so many newcomers to this scientific sport of gliding that it has been deemed best to deal with this section in a simple, elementary manner.

To this end there follows at the end of the chapter a glossary of those terms which are used in the article and the meaning of which is not immediately apparent to the lay reader.

Drawings.

BEFORE the construction of any machine is undertaken it is essential to observe the need for working only to approved drawings.

When building to an existing design approved by the British Gliding Association, approved working drawings can certainly be obtained, usually from the British Gliding Association. When working to a new or private design, the drawings should be submitted to the British Gliding Association Technical Committee for approval before work is commenced and arrangements should also be made for a British Gliding Association approved inspector to view the construction at various stages so that the complete machine may be certified as airworthy. These precautions may, to the uninitiated, appear irksome. It is a fact that if you wish you can ignore them, complete the machine, fly it and all may go well. BUT—all may not go well; you may in your enthusiasm have overlooked some small but important point, some aerodynamic condition, which under stress of exceptionally rough weather may produce a minor failure, which, going unobserved, may easily result in a major fracture and a crash. Moreover, the machine which has not been approved by the British Gliding Association in design and construction, cannot be entered in either National or International competitions—neither will it be acceptable for club use.

Enough has been said to show the need for compliance with British Gliding Association regulations which have the backing of the British Air Ministry.

Materials.

The next important point is to be sure that only approved and certified materials are used in the main constructional members. Where drawings do not clearly specify the quality—write to the British Gliding Association or use best aircraft quality timber if available.

In many places second-quality spruce or substitutes may be admitted—notably for fairings and in monocoque construction, where the skin carries most of the stress and the internal framework may be only serving as supporting formers. Let the designer or the British Gliding Association be your guide.

When selecting spruce for spars and struts and other important members, see that it is clean, straight grained, free from knots, snarls, and shakes, and note that the number of annual rings per inch is at least six. Beware of spiral grain.

If the lengths of plank available are not sufficient for your needs, do not assume that if you make an approved form of splice with a slope of one in twelve, you may do so with impunity. The position of the splice is all important; the point you choose may prove to be the position of maximum stress and repeated buffetings may in time induce a failure. Ask the designer and he will in most cases permit and indicate the position for a joint.

When choosing three-ply, it is not usually necessary to use "A" quality aircraft ply, as used on military machines—there is an excellent commercial quality as used on civil aircraft which is much cheaper.

The choice of metallic materials is all-important, for although many German designs allow for good commercial quality mild steel in most fittings, the desire for maximum strength in conjunction with lightness leads some designers to specify duralumin and high-tensile steels. To substitute lower-grade materials will lead to disaster. Most approved aircraft firms will be glad to supply small quantities of certified materials at a reasonable price.

Layouts and Jigs.

When setting out beware of scaling blue prints —they shrink—and unless the figured dimensions alone are worked to, assembly difficulties may occur.

The layout boards should be suitably battened to prevent warping and shrinkage, for it is well to remember you may need them again for repair work. When building ribs, it is well to mark on the layout the number of long ribs which reach right to the trailing edge and the number of short ribs which stop at or just abaft the rear spar. Also the scantlings of standard and compression ribs should be marked on the board or boards as thereby much time can be saved by dispensing with the drawings during actual construction and later when replacement ribs are needed for repair purposes. With the pencilled outline of the rib booms and bracings laid out, pairs of blocks are fixed at intervals to form a trough in which the different members can be laid. These blocks should be clear of the three-ply gusset outline to facilitate fixing the latter. A small hardwood cutting-off jig with a series of saw cuts across the trough at the correct angles for the different bracings is a workmanlike accessory to ensure good work.

In a fuselage layout the first consideration (except in monocoque construction) is to determine whether to lay out plan view and build top and bottom panels and then set up the two for assembly with verticals or whether to lay out and build sides and set up with cross members at the assembly stage. The decision depends entirely on the particular design under consideration, but the governing feature is usually the amount of curving in of the longerons. If the sides or top and bottom are nearly flat or have such a slight curve as to be negligible, they can be built flat on the simplest of layout boards and will conform to shape on assembly with cross struts or vertical struts respectively.

Naturally the bent portion of the longerons at the nose must be moulded in a jig, and a usual method of persuading the timber to conform to a double curve is to slit the longeron in the plane of the most severe curvature and insert thin strips of three-ply in the saw cuts with glue, the bending to be done whilst the glue is fresh so that on removing from the jig the bend is set. The number of saw cuts running along the grain of the member is usually one, two, or three for a cross-section of up to one inch square and the three-ply insertions need be no more than one-sixteenth inch thick, but must be wider than the member by a sufficient margin to allow of the double curvature of the finished member. These three-ply strips serve to permit the spruce, in which they are interleaved, to slide and so facilitate bending in the same way as a leaf spring is laminated to permit continuous flexing without fracture.

Construction.

During the actual construction it is imperative to ensure that the shed or hangar is reasonably dry. " Cold-water " glue is usually used and is convenient and excellent if made in accordance with the manufacturer's instructions. It should be freshly made daily in clean containers (the papier mâché type as used for cream are excellent). Unless the workshop is dry, the glue will go stale before it sets and a dangerous joint results. The oil-cooker type of stove can be brought into use to induce quicker drying, but it is better to build spars and ribs in a small, dry workshop and leave only the assembly processes to be carried out with improvised heating arrangements.

Most glider constructors apply all the three-ply with temporary brads, tacking-strips, clamps, etc., so that on removing the latter the glue alone remains to hold the joint. This is doubly useful, as firstly the weight of screws and brads is saved (this may amount to a few pounds on a machine), and the finishing off and repairing processes are easier to carry out and with less damage to tools when metal is absent. Again one must remember that a well-glued joint is strong enough in itself and it is of no avail to bolster up a badly glued joint with brads and screws as, if the glue fails, it will not be long before the flexing and wracking of the component will cause the fastenings to work in the timber and a loose joint results.

The use of clamping bars secured by bands of tape made taut by the simple expedient of a tourniquet should be remembered. Also, if the room be low enough, the ceiling can be made use of by springing ash or similar sticks between the surface of the clamp and the ceiling, whilst if a sufficiency of weights exists these plus quite a moderate number of cramps will suffice. Joints so made should remain undisturbed for at least twenty-four hours.

When building a fuselage, it is well to check the accuracy of alignment from time to time, as in most cases the work will be carried out in the evenings and week-ends and so will be spread over such a period that the jig framework or skeleton " set-up " may tend to move and it is far better to check and correct, if found necessary, than to discover on final inspection that a warp has set in. Especially should this interim check be made before applying the three-ply covering, which is the normal panel bracing. The check can readily be made by stretching thread lines above and below the centre line of the component and measurements can then be made by rule and checks for equality by trammels.

A spirit-level is almost essential and plumb-bobs are definitely required.

The simple " boning " strips should not be despised, i.e. by setting up straight edges at intervals along a component and sighting same for alignment with each other or with a known datum line the accuracy of the structure can be readily determined.

Whilst assembling main planes a taut line should always be kept along the centre line of the spars as when fitting ribs and diagonal bracings it is easy to impart a bow which cannot later be got rid of. It should also be obvious that frequent supports for the spars are essential—preferably a continuous beam as the spars will naturally deflect under their own weight.

Tramelling of the bays for squareness is the best method where parallel spars are used. With tapering wings datum cords and measurements therefrom must suffice.

One of the most important jobs on wing construction is the fixing of the three-ply nosing and much care should be taken to give adequate support and a sufficiency of clamping strips and bands to ensure a close, sound joint. Clamp blocks of one-inch deal with a female contour cut out to fit accurately the finished leading edge profile will be found of use if the formers, etc., have been built accurately to size. Otherwise, the more flexible tacking strips and canvas clamp bands must suffice.

In the writer's opinion, it is well worth while to protect the structure from the effects of damp by treating all woodwork with a coat of shellac—inside and out ; but remember to mark out on the ply nosing the position of spar, ribs and formers so that shellac is kept clear of glued joints.

When applying metal fittings to woodwork, remember that cold-water glue will corrode duralumin very quickly and that brass and duralumin in contact will quickly set up electrolytic corrosion. A good clear varnish or paint (not cellulose) is a good protection where lack of facilities, or reasons of expense, prevent plating or anodizing. A layer of varnished silk or fabric

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is an excellent intermediary between dissimilar metals or between metals and wood, as in seaplane work such protection is essential, using either a tung oil varnish or a bituminous paint which will remain plastic and defy the hidden workings of corrosion.

Externally, clear varnish for wood and fabric surface, and a good paint and enamel for the metal fittings will give the best protection.

In applying the fabric, cold-water glue is the best adhesive and the method to be recommended is to start by sticking the fabric to the root end rib and front spar inner end first, and then by stretching outwards and backwards the glue can be applied rib by rib and thin three-ply strips, already prepared with brads inserted at say two-inch intervals, are used to secure the fabric to ribs and spars until the glue is set. One coat of dope can be applied whilst the tacking strips are still in place, and to facilitate removal of the latter, it will be found of advantage if the strips are varnished so that the glue will not adhere.

A word of warning regarding final inspection before covering will not be out of place. Try ailerons in place in skeleton to see that they hinge freely and to check the run of controls. If the control wires rub on ribs, the latter must be modified to clear unless the control run can be easily altered. It is possible to alter rib bracings and strengthen with ply or extra diagonals, and preferable to do this than to allow cables to rub. It is not generally realized that a cable or wire can be chafed by rubbing on so soft a material as wood.

See that all nuts are correctly tightened on bolts and locked—the lightest method is to cut bolts flush and lock by three or four centre pops on line of threads. Do not over-tension bolts or wires. Apart from the danger of excessive strain set up therein, there is the obvious result of the timber members being crushed. Spruce is a soft timber, and in many places it is well to protect from crushing by a facing of thin three-ply.

When testing controls in skeleton the point where cables emerge from the wing surface should be noted, and it is well to affix a thin three-ply or "non-flam" patch from rib to rib (or to one rib alone, as seems most convenient) with a slot therein large enough to allow for full control movements and the wire passed through and tied in place will then be correctly positioned with the fabric applied.

Another point for an inspector of amateur construction to watch for particularly, is in connection with front spar construction, where it is usual to call for packing strips between rib booms to bring spar and ribs level to receive the three-ply nosing. It is tempting and apparently time-saving to leave the spar flange deeper and notch it out for the ribs instead of adding the packings. Such a practice is very dangerous, as every notch is liable to develop into a fracture. Similarly when marking out, never use a scriber —a soft pencil is safer. Assembly processes should be possible without edged tools—a sharp chisel used in close proximity to a finished spar is a potential source of danger—the least slip and a dig in the spar may lead to serious trouble.

It may appear to be "gilding the lily" to suggest sand papering wooden parts, but it is well worth while to so remove raw edges which may lead to fractures and the smooth surface will be better for receiving shellac and resisting damp.

Where wooden members pass in close proximity, they can be rendered extremely stable by the insertion of small packings where needed, and adding a binding of glued tape. Raw edges of ply are best protected in like manner and glued tape again can be used to hold down thin ply where unsupported, such as in the scalloping between ribs.

In building control surfaces, the fixing of control levers to spars and ribs should receive particular attention—it is a weak point on several designs, and the fixing of an extra fillet before the unit is covered is the best means of ensuring adequate strength of attachment at this point.

Where pedals are used a balance cable should be fitted so that when the pilot's weight is thrown on to the pedals in a heavy landing, the balance cable anchored back to a suitable pulley takes the strain instead of allowing the load to be taken by the rudder levers.

Another final inspectional point is to look for places where the fabric pull may tend to deflect and warp the component. Many designers leave such practical points for the man in the shops, and end ribs can often be seen pulled hollow for the want of a light stay from the centre of their unsupported span to the spar or the next rib attachment vertical.

Metal Fittings.

Although comparatively few fittings are used in gliders and sailplanes, those few are all important. Where sheet mild steel or duralumin is to be bent, it is well to observe that a radius of three times the thickness of the plate is the minimum to be used unless the parts are subsequently heat treated. If welded mild steel fittings are called for, they should be normalized after welding to relieve the strains set up by this process. The heat treatment of all metallic materials should be carefully carried out in accordance with the specifications to which the material is ordered. When soldering, beware of leaving flux about—nothing is so liable to set up corrosion.

Beware of deep scriber marks on metal fittings—they are a potential source of failure. Remove sharp edges and do not leave rough file marks or allow vice-jaws to indent the surface of the fittings.

To facilitate assembly, all pins and bolts should be taper ended, and wherever possible pins should be used instead of bolts as being lighter and quicker to assemble and dissemble, but do not substitute the one for the other without the designer's approval. He may have depended upon the clamping effect of the nut to stabilize the fitting against wracking or other loads.

Final Erection.

Having built our various components and tried them together for hinging and assembly reasons at various stages of manufacture, it is well to weigh them before and after covering. These advance weights in the case of a new design are eagerly looked for by the designer to enable him to check his estimates and to know that the incidence setting and position of components relative to each other and the centre of gravity can remain as fixed.

With the machine finally assembled, one can look round for the places where rain and moisture are liable to collect and provide drainage holes therefor. Small holes, say quarter of an inch diameter at the lowest points of each bay of the fuselage, will be found effective, and the edges should preferably be protected with glued fabric. On covered surfaces eyelets can be used. These may be of non-flam doped-on.

Centre of Gravity Check.

Now with the completed machine before us, we must check the centre of gravity. To do this with a skid in place is fairly simple, if only approximate figures are needed as a check on an existing design. The use of a roller on which the machine can be roughly balanced with a 180lb. passenger in the seat—feet on controls, will enable the centre of gravity to be checked by setting up at flying level and dropping a plumb line from the leading edge from which to measure back to the point of balance.

A word of warning here is necessary. When the wings have a sweep back or are of unequal taper in plan view, the centre of gravity must be taken from the mean chord line and it will be necessary to determine from a plan view drawing the mean leading edge line so that the dimension measured from some definite point on the leading edge near the centre section can be correctly interpreted as a fraction of the chord.

Where a chassis is fitted it is well to take the exact weight with the machine at flying level, resting with main wheels on one scale and the tail skid on another (a spring balance may be suitable).

Then let us take as a datum line the foremost point of the fuselage and call this "d.l." Now measure the distance from d.l. to the point of support of main wheels in a horizontal plane and call this "D"—at this point we have to record the main weight on the wheel scales and we will designate this "W." Similarly we must measure, again in a horizontal plane, the distance from d.l. to the rearmost point of support and call this "d"—at the same time recording the weight at the rear scale, which we will refer to as "w." Now working from our datum point, we have the moments $D \times W$ plus $d \times w$, and if the sum of these in inch lbs. or foot lbs. be divided by the total weight, i.e. $W + w$, we shall get a distance which we will call "x" and which represents the distance at which the total weight is acting behind the datum line d.l.

By means of a plumb-line dropped from the leading edge at the centre section and measurements therefrom to the centre of axle and line d.l, we can thus interpret the centre of gravity distance x relative to the important components—main plane and chassis.

A person of known weight should be in the pilot's seat as this is preferable to taking weight and centre of gravity empty, and making a calculation for the pilot. The centre of gravity of a man varies considerably with different attitudes of legs and arms, so that it is far better to have a pilot in situ when taking centre of gravity weights.

Repairs and Maintenance.

In the carrying out of both minor and major repairs, the general principles of conscientious work as laid down above should equally be followed, so that one feels a pride in the finished job.

Small tears in fabric surfaces may be repaired by a neat frayed edged patch of fabric doped on, but larger holes must have the edges drawn together by herring-bone stitching and then be patched. Patches should overlap tears by at least one inch and, when fixing, the old doped surface should first be softened with either brush-wash or dope to secure the best results.

Small fractures of the three-ply covering can often be made good by carefully drawing together the splintered edges to a level surface and there "binding" them by means of a glued on patch of linen fabric.

Larger holes may need cutting to a clean, even shape, and can then be covered by a patch of thin three-ply overlapping the old ply by about half-an-inch and small screws may have to be resorted to to hold the overlap joint. If the damage is yet more extensive, a section of ply may be removed to the next ribs, formers or other support and a new panel applied—again with an overlap joint and bevelled edge to the patch. In some positions it may be more convenient to make a butt joint in a panel of three-ply with a two-inches wide butt strap of similar or slightly thicker ply on the inside, and with brads turned and clenched thereon to secure both edges. A final seal of glued tape makes the job sound. Where the nature of the damage permits, the hole should be cut to a clean circular or elliptical shape which is stronger when patched than a rectilinear.

In rib repairs the use of " splints " glued and screwed and bound with glued tape is a convenient method of making good minor fractures. In other cases a thin panel of ply from top to bottom booms of a rib and stabilized by picking up the diagonal may save a rib from more extensive repairs. The cutting out of thin three-ply for gussets, etc., is easily accomplished by means of either tinsmiths' snips or tailors' shears.

In spar repairs great care should be exercised to observe the need for avoiding sudden changes of section. In a box spar the new flanges should be so arranged that the one in twelve plain scarff joints are staggered at least eight inches and the three-ply side patches should be extended with tapering or " bird-mouthed " ends and should be staggered so that the extra strength on the one side reaches farther than on the other.

Additional spacing blocks in the hollow spar will in most cases be desirable to enable the fish-plates of ply to be screwed thereto.

Mild steel fittings which have been distorted may be trued-up and re-normalized if they are then carefully examined for signs of cracking. If in doubt, replace by new ones ; better be safe than sorry !

Maintenance.

The general maintenance and inspection of sailplanes and gliders calls for but little comment. The main requirements are that every control should be periodically examined, cables should be run between finger and thumb for signs of fraying. End attachments and splices should be examined for signs of pulling and wear. All turnbuckles or strainers should have threads covered and be locked. Every control and other fixing pin should have its locking pin in place. The alignment of ailerons with main planes with the control stick set neutral should be observed. It is usual to allow a droop of quarter to half-an-inch at the trailing edge so that flying loads bring level.

By sighting tail unit to main planes the general equality of rigging can be determined.

Safety-belt attachments, clearances of rudder pedals from the structure, security of pulley fixings, freedom from sloppiness in moving parts

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of the control system, are all points which the ground engineer should examine periodically and especially after a crash or heavy landing.

In major repairs it is best to dismantle the component as the part should be adequately supported during repair and not under strain, due to its own weight.

A careful record should be kept of all repairs and modifications carried out and preferably this should be pasted in the machine log book.

When dismantled and during transport, the adequate support of all components should receive close attention. Abnormal strains can otherwise arise and cause failures in the air.

Finally, learn to know your machines—look at the side view and try to follow the direction in which the shock of heavy landings in different attitudes must be dissipated, and so you will learn where to look for signs of weakened joints —the cracking of the glue or a hair crack on the varnish which may indicate a failure.

Do not be persuaded to " risk it "—yours is the responsibility and yours should be the decision.

The following books are recommended as containing useful information on the above subject.

Gliding, published by the Dorset Gliding Club, price 1s. 3d., from 10 Victoria Street, Weymouth.

Air Ministry publication A.P.1208. (Airworthiness Handbook).

Air Ministry Rigging Manual, A.P. 1107.

Whilst the articles which appear in the *Sailplane*, published by the British Gliding Association should not be missed.

GLOSSARY OF TECHNICAL TERMS USED IN THE PRECEDING CHAPTER

Monocoque. A shell-like structure in which the skin, supported by formers and stringers, takes the loads.

Jig. An arrangement or device in which an article being built is so held as to assist in maintaining its correct form, outline and/or relationship with other portions of the adjacent structure.

Trammels. A beam carrying adjustable pointers which can be set at varying distances and there clamped so that comparative measurements on a structure may be quickly checked.

Gusset. A tie-plate or web—in this case of thin three-ply—which serves to join together two or more members to which it may be applied on one or both sides.

Boneing Strips. Straight pieces of wood of rectangular cross-section, truly parallel and of sufficient bulk to maintain their straightness when resting freely on portions of a structure the accuracy of which it is desired to check by sighting.

Non-Flam. A non-inflammable substitute for celluloid. Made from cellulose it is useful because it can be fixed to doped surfaces by sticking with dope alone and is therefore used in the form of inspection windows over control pulleys and in strip form over hinge gaps although in the latter position the strip is fixed by screws in order to facilitate access to the hinges for dismantling. Also used in the form of annular rings stuck on fabric over portions of the structure which may require to be inspected occasionally, this being accomplished by cutting out the centre disc of fabric and afterwards doping a circular patch over the framed opening which has maintained the fabric in a taut condition.

Centre Pops. The indentations produced by a centre punch which is of pointed steel. Used for marking centres preparatory to drilling holes in metal, but in this case resorted to because the impression spreads out the metal of nut and bolt-end on the pitch circle of the screw-thread and so locks the nut to the bolt.

CHAPTER VI

AUTOMOBILE AND AEROPLANE TOWING

By C. H. Lowe-Wilde

AMONG various methods of launching gliders and sailplanes, those of direct towing by means of motor-car and aeroplane have become definitely established and some considerable amount of authentic information is now available. Though in many respects both means are governed by similar conditions, there are clearly defined differences covering design and operational aspects and it is proposed therefore to deal with each separately.

Auto-Towing.

As a means of launching only, either for instructional or advanced machines, the motor-car offers many advantages over the better known manually operated elastic catapult, and it is probably safe to say that except in the few cases where the topographical conditions of the site prevent a motor-car approaching anywhere near the top or bottom, the only excuse for the use of the latter method is that of cheapness.

Direct towing by means of a motor-car results in very gradual acceleration in contrast to the disconcerting suddenness of the catapult, and also permits of a degree of accuracy and consistency impossible when dealing with a crew. In training the beginner, the elastic catapult in its very crudeness, compels the use of a cheap and primitive type of machine, utterly incapable of any real performance and therefore entirely useless when once the initial stages of instruction are passed.

It is customary to "ground-slide" the pupil first of all. Should there be much wind, or if the crew develop more power than is expected, the machine is liable to leave the ground unexpectedly, and as a result of some movement of the controls, a crash frequently results. In any case, control speed is only reached for an odd second or two and an undignified and short slide along the ground on wing tips and skid is the net result.

Sooner or later, a more powerful launch is applied to the machine until it leaves the ground, but the actual time of flight is generally very short.

In many cases, this, the first flight of the pupil, is successful, but it is really a very doubtful indication to the instructor. Flying, like cycling, can only be learnt by trial and error, and a flight lasting a matter of seven to twelve seconds does not give much time in which to profit by any error; on the contrary, the ground generally intervenes.

The well-designed primary training glider should almost fly " hands off " and generally has very ineffective controls. Pupils are told not to move the controls to any great extent, that actually the machine should fly straight with little or no interference on their part, and it is not difficult to imagine either a frightened or a very slow thinking individual sitting tight in his seat, muscles rigid and not making any control movement whatever. The first few flights of such a pupil, as judged by catapult-launched standards, would be called good, yet that other type of beginner who violently lashes the control column about may very probably crash on his first or second flight simply because it was not of long enough duration for him to sort out his " trials and errors " and he may therefore be potentially a better pilot.

In imparting instruction by auto-towing methods, a machine with two tracks (skids or wheels), is used and it is therefore laterally stable when standing still or running over the ground.

During the initial stages, the pupil is towed over level ground just below flying speed and the use of the controls thoroughly drummed in.

According to the length of run available, each lesson may be of minutes' duration, and at all times the machine is under the complete control of the instructor in the car as, while such speed is given as may be necessary to allow the elevators to raise and depress the tail, the ailerons to roll the machine laterally and the rudder to change course, at no time should it be possible for the pupil to cause the machine to leave the ground unnecessarily.

If there is little or no wind, runs may be made in any direction, but in any case the car easily returns the machine to its starting point.

As a result of the greater control and regulation which auto-towing allows at all times during instruction, together with the resultant reduced chances of accidental damage, the use of a more advanced type of machines is justified, which in turn allows of instruction being carried forward to a more advanced stage for a given capital expenditure.

The following figures representing operating costs may be of interest to gliding club committees and may be taken as quite accurate. The use of an old car of 20–30 h.p. is presupposed, there being very many American types highly suitable and nowadays obtainable at a very modest price. Such a vehicle may average under aerodrome conditions, about fourteen miles per gallon of commercial petrol at 1s. 2½d. and 400 miles per gallon of lubricating oil at 4s. per gallon.

Under single-seater instructional methods, about thirty-six to forty runs brings the pupil of average ability to the " A " and " B " licence stages. The total " air-time " will be in the neighbourhood of twenty-two minutes, and this can all be done with the aid of two persons, i.e. car-driver and instructor, on any aerodrome possessing a reasonably good surface, and independent of wind direction. The distance covered by the car will be between fifteen and twenty miles and should not cost more than 2s. By means of dual instruction in a two-seater sailplane, the same degree of proficiency should be reached in thirty flight lessons, resulting in a reduction in running costs.

Thus, in any given time, auto-towed instruction at insignificant cost offers a safe and speedy means of handling pupils and quickly takes them to the soaring stage, because (1), they are flying a moderately efficient type of machine the whole time; and (2), auto-towing, by reason of its more accurate regulation, results in the development of a higher standard of flying when up to the " B " licence stage.

Machines intended for auto-towing have to be properly designed and constructed and also must at all times be efficiently maintained, as their conditions of flight are exactly similar to those imposed on power aircraft, and in addition they may commonly fly at much greater altitudes than are usually reached by gliders used for instruction.

In advanced towed gliding, the machine may be almost immediately over the car at the top of the climb with the result that an additional load representing the vertical component of the tension of the cable, is applied to the wing structure. This may result in as much as overload and is a figure to which the machine should be stressed in arriving at the load factor (often erroneously called " Factor of Safety ").

Single-seater machines used for instructional purposes should have the point of attachment of the cable well towards the nose of the fuselage as the take-off and straight towed flight is much more stable. For high angle flying, the attachment may be situated on a line projected through the centre of gravity of the machine at an angle of from 25 degrees to 30 degrees ahead of the vertical. These conditions are necessary to prevent the imposition of high tailplane and elevator loads, but it cannot be too strongly emphasized that no one but an experienced pilot should attempt to take off a machine fitted with a release positioned for high angle flying, as during the initial part of the climb, the machine tends to assume such an angle as may result in a complete loss of control and subsequently slip into the ground sideways. If properly positioned, however, and the machine accurately trimmed, the machine should assume a steady rate of climb with the control column practically central after the first fifteen feet has been gained, seemingly flying tangental to an arc whose radius is that of the length of the cable and thus completing the climb at the top in an almost horizontal attitude without the use of the controls.

The cable release must not be operated until the machine has been levelled out, otherwise it will " rear up " when the cable drops off, with the danger that in gusty weather it may even go over on its back.

High angle flying is done at a speed slightly in excess of the normal gliding speed of the machine, therefore the skilful pilot takes advantage of this in the form of a gain in height when he drops the towing cable, by easing back the stick until the excess speed falls off.

In America, a light manilla rope of three-eighths to half-an-inch diameter is frequently used in place of the steel cable used in this country, and there are certainly advantages on both sides. The rope, however, is more bulky, tends to absorb a lot of water in damp weather, thus gaining a lot of weight, and wears much quicker as a result of being frequently pulled along the ground.

If steel cable is used, it should be extra flexible, four-seventeenths construction with a breaking load of at least 1,000 lbs. In the end for attaching to the machine, a shock absorber comprising two five-sixteenths of an inch mild steel rings of about two inches diameter to which is attached a fifteen-inch double loop of five-eighths of an inch diameter braided elastic cord.

The attachment on the car should be so arranged that the cable or rope can be released instantaneously in the event of any emergency, and should be positioned, as near as possible, centrally between the front and rear wheels. If it is attached to the back of the car, the frequent rises and falls due to ground irregularities imposes serious live loads on the machine when in the air.

Too much care cannot be exercised on the design of the attachment on the machine. It should be stressed to at least eight times the loaded weight of the machine and should release with little effort under load variations of nought to four times machine weight.

It should also definitely release the cable whatever the angle of pull in either a fore and aft direction or sideways. Particularly it must clear the cable under conditions of no load as otherwise a pilot who lost a little height at the top of the climb before operating his release might carry on in ignorance of the fact that he was still attached to his cable.

And finally, it must also drop the cable when the machine is on the ground, both with and without loads.

During the take-off and climb the car must be closely watched, and it is usual to fly slightly to one side; therefore the release attachment must be strong enough to take the lateral load without material distortion.

In auto-towing, great responsibility rests on the car driver, and it is safe to say that the most skilled pilot may be crashed through an error of this driver. Of preference, the car used should be capable of at least thirty-five m.p.h. in an intermediate gear with a reasonably good rate of acceleration from a standing start, but if a change of gear has to be made it must be during the first twenty or thirty yards' run and before the machine has attained flying speed. It is important that the driver maintains his course during the take-off and does not swerve. The acceleration must be smooth without any tendency of the car engine to choke, and as the maximum towing load is felt when the machine leaves the ground and commences to climb, a good pilot will hold his machine in level flight a few feet above the ground for a few seconds to make sure the car is really getting away well.

In high angle towing it must be remembered that the machine is behaving more like a kite during the climb and that its wings are therefore considerably above their stalling angle. Should the car falter or the cable or tow rope break, the machine has little or no control and the pilot has to be very alert if a crash is to be averted. In such an emergency, the control column should be immediately pushed forward, the cable release toggle pulled at least twice and no attempt made to flatten out unless ample speed has been gained.

A dive of twenty to twenty-five feet should be sufficient for a moderately efficient machine to attain flying speed from such a condition of stall.

Auto-towing, under regulated conditions, has everything in its favour as a means of imparting gliding instruction, but should always be controlled by a level-headed instructor. It is to be remembered that a powerful car may easily develop a pull of 350 lbs. and this as a tow load imparted to the machine horizontally represents the same thrust as would be developed by a 50 h.p. engine.

Aeroplane Towing.

Aeroplane towing must only be attempted on a machine suitably strengthened and with properly designed attachments on the towing machine.

There is no analogy to the aeroplane towing of a glider, as contrary to all other types of vehicles all heavier than air craft depend upon specific dynamic conditions for their sustainment and under these circumstances it is obvious that unless the weight and aerodynamic characteristic of each machine be equal, the problem is a complex one.

Aerodynamic reaction varies as the square of the velocity and almost directly as the area; therefore at a speed of, say, 60 m.p.h., a machine weighing 1,000 lbs and having a wing area of 125 square feet bears little relationship in its general behaviour to a machine weighing 500 lbs. and having 200 square feet travelling at the same velocity.

The result of a variance of the conditions affecting either towing or towed machine is an increased or decreased cable load. If the load is increased, in the case of the towing machine it corresponds to an increment of drag and, unless the engine throttle be opened further, or a different flight attitude assumed, height will be lost. The effect on the towed machine is opposite in that an increased tow load corresponds to the application of more power and then an increase of height is bound to result unless the flight attitude is altered. The total result is a great change in the relative positions of the two machines.

These are the most important conditions which the pilots of both machines are called upon to deal with and errors due to inexperience may cause extremely heavy loads to be imposed on the structure of aeroplane and glider or sailplane.

On account of the difference in flying speeds, the sailplane leaves the ground first, and unless checked will take up a position above and behind the towing aeroplane, when the latter is in the air until the vertical component of the load on the cable is equal to the excess lift developed at the particular speed obtaining.

This in effect relieves the wings of the aeroplane of a like amount of weight, but increases the load on the sailplane's wings, but in the event of the former running into a violent down current, the structure of the latter may be temporarily but instantaneously called upon to sustain the greater part of the weight of both machines. Naturally the greater the vertical difference of position, the more serious such a contingency becomes, therefore it is advised that aeroplane towed flight be so governed and adjusted as to allow of the tow cable taking up an angle of about thirty degrees to the horizontal. As the disparity in wing loading increases, so does the tow cable tend to take up a steeper angle as the sailplane outclimbs the aeroplane.

Within certain limits, the attitude of the two machines may be corrected by the length of the tow cable, that is to say, the lower the loading of the sailplane, so should the tow cable be longer and *vice versa*, but in no case should machines be used whose normal speeds vary more than 100 per cent.

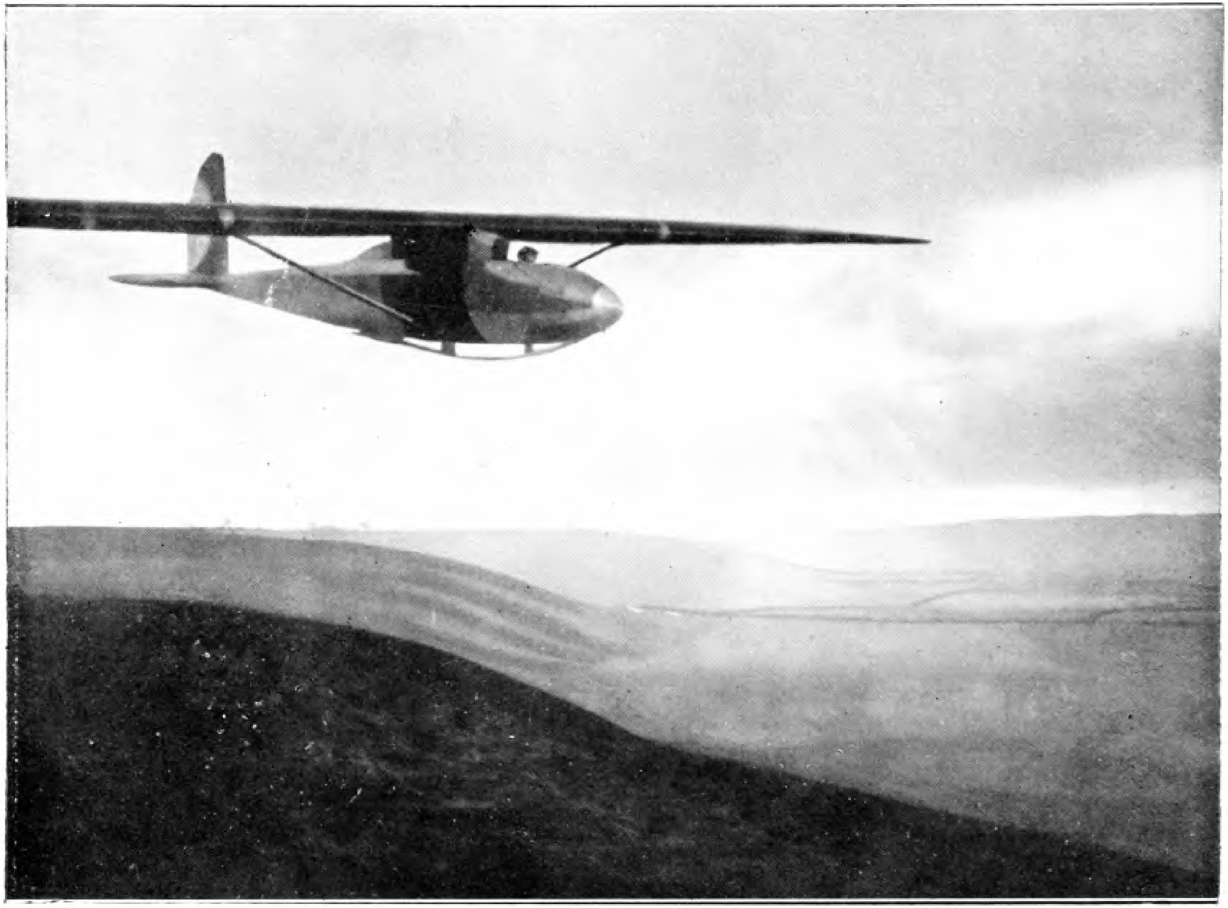
If the sailplane is to be easy to control, the cable attachment must be positioned specifically for the towing aircraft used, but in no case should it be farther back than is represented by a line drawn through the centre of gravity of the machine and forty degrees below the horizontal.

One way of adjusting the slight attitude is to carry ballast (water or other substance) in the sailplane, but this must only be done if its structure is strong enough to carry the increased loads due to this and the vertical component of the cable load without seriously reducing the safety factors.

Towing by aeroplane demands a thorough knowledge of the governing principles on the part of both pilots, and also perfect co-operation.

On taking-off, the sailplane pilot gets his machine off the ground as quickly as possible, but immediately checks its tendency to climb quickly. It should be his aim to hold the machine down at a fine angle so as to fly along at about eight feet above the ground while the towing machine gets into the air and thus assisting it to accelerate quickly up to its flying speed by keeping the air resistance of the sailplane as low as possible. As soon as the aeroplane has safely got into the air the sailplane takes up its proper attitude above it and carefully maintains its position so as to keep the tow-cable taut.

If the cable is allowed to slacken, a violent



AN "ALL-BRITISH" SAILPLANE—THE PHANTOM

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jerk is liable to result when it eventually tautens, which may impose serious loads on the structure of both aircraft, while if the period between slackening and tautening-up is very long, the sailplane may lose its relative position and drop below the aeroplane. This is a definitely dangerous occurrence and should it happen the safest course is to operate the cable release and abandon the tow.

Except in very good weather, the business of keeping the tow-cable taut is a difficult one, particularly if the towing attachment is wrongly positioned. Probably the best policy is to fly well to one side of the aeroplane as if, and when, the cable slackens, both pilots slightly increase the amount of rudder " outwards," so as to take up the slack without control motions which materially affect altitude, and then by ruddering inwards just before the jerk takes place as the cable once again takes up the load. A little consideration instantly reveals the fact that the effect of a slack cable is complex in that in the case of the aeroplane it means a reduction of head resistance and therefore both a forward acceleration and a gain in height, while in the case of the sailplane it has the effect of reducing the amount of " thrust available " resulting in a deceleration and loss of height.

CHAPTER VII

ELEMENTARY AERODYNAMICS

By C. N. Colson

NO one can become really efficient in the art of soaring flight unless they have a reasonably wide and basically sound knowledge of aerodynamics.

That is to say, they must know why their aircraft flies, how it flies best, and exactly what conditions are necessary for its sustentation in the air. It is not necessary that the pilot should have more than a preliminary knowledge of the mathematics of the subject, for aerodynamics, being a young science, is largely based upon suppositions and he who would master it in its entirety has a life-time's work before him. I shall not therefore, appal the reader with a serried rank of formulæ but shall content myself with only the commonest and almost unavoidable ratios.

The first fact, often forgotten if one is to judge by some of the glider flying one sees, but really so well known as to make its repetition a platitude, is that all forms of present-day heavier-than-air craft depend upon motion relative to the air for their power to remain suspended in it. In connection with this motion it is well to realize early in your training that it is motion of glider itself relative to the air which is important and not motion of the glider relative to the ground. You have only to think for a minute and you will see that if the glider is "*in*" the air, then it must be travelling with the air just as fast as that air is moving, in exactly the same way as you yourselves often travel on a moving staircase at many London Underground railway stations. Now if the glider is flying in the same direction as the air is moving, or what is the same thing, as the wind is blowing, it will be travelling in relation to the ground at the same speed as the wind *plus* its own speed in relation to the air. We will suppose however, that the pilot could fly in such a manner that he could decrease his speed through the air to nothing, then with regard to the ground he would still be moving at the same speed as the wind, although with regard to the air he was stationary. This should serve to illustrate the fact that it is never safe for the glider pilot to gauge his speed from the ground unless he has first taken into account the speed and direction of the wind.

The effect of both these factors is to decide whether or not the pilot is able to soar or only able to glide down and land at some point lower than that from which he started, or at which he was released, in the case of a glider launched by auto or aeroplane towing. The direction of the wind is of paramount importance, and when I say direction, it should be understood that I am referring to the direction of that particular portion of air in which the pilot happens to be. That is to say, its direction measured three-dimensionally and not merely with reference to the points of the compass, for the general trend of the wind, be it north, south, east, or west, has but a minor effect on the soaring possibilities at any given moment.

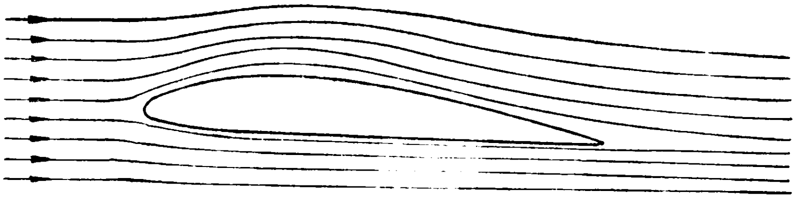
It does not require much imagination to realize that the air stream may be moving vertically upwards in one place, as for example under a large cumulus cloud, and yet moving downwards at another, such as on the lee side of a steep hill, yet all the while the *general* air current is the result of, say, a south-westerly breeze.

The sailplane pilot has chiefly to study these secondary movements of the air, for only by so doing will he be able to gain height and thus be in a position to reach his objective. I said at the beginning that he must consider his motion relative to the air, and this is true in so far as maintaining the sailplane in that air is concerned; but when the position of the sailplane with regard to the ground is considered, then he must also take into account the direction of movement of that portion of air in which the sailplane is being maintained.

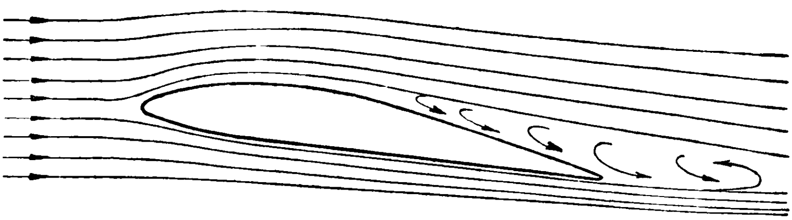
Let us, however, revert to the mere sustentation of the sailplane in the air, for it is essential that every pilot should know what it is that does this, and a clear idea of the facts will assist him greatly to keep a correct flying attitude. Every aircraft, be it a glider, sailplane, or power-driven aeroplane, has a minimum flying speed; below this speed the wings lose their lifting powers and the aircraft stalls—which is the technical name for losing lift—a dilemma which has no evil consequences if the pilot has sufficient height in which to dive and regain his flying speed, but which may often result in a crash if he has not that requisite height.

Examination of the wings of a sailplane will show you that, generally speaking, both the upper and lower surfaces are curved. This curvature may be varied in form according to the type of wing—or aerofoil section as it is called—being used, but whatever the section there is always a curved or cambered upper surface. It is this curvature which is responsible for over two-thirds of the total lift derived from the wing. Most people, new to flying, think that the wind blowing against the bottom surface of the wing holds the sailplane up in the air much in the same way as a surf board rides over the top of the waves. This is, however, only partly true. Imagine the wing being pushed through the air; what happens is shown in figure 1. It will be seen that the lines of flow are comparatively straight below but curve upwards above considerably; this upward curvature increases the velocity with which the air travels over the top of the wing. Now according to Bernouilli's Law—the basic law of aerodynamics which connects pressure and velocity for a fluid in motion—the energy of a part of a fluid along a streamline always remains the same; therefore where the pressure is high the velocity is low and *vice versa*. It follows, therefore, that where the velocity of the air is increased, due to it being forced round the longer path of the cambered wing, the pressure must be decreased, or in other words there must be a suction when compared with the pressure on the lower surface of the wing, and it is this suction which holds up the wing in the air.

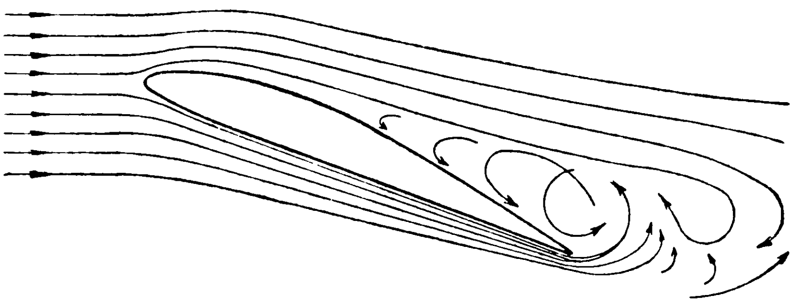
This, however, is only half the story of the cambered surface. Another thing which it provides is called *drag*; this, however, is an undesirable, and the better the aerofoil section, for sailplanes at any rate, the less the drag. Drag is the resistance the aerofoil offers to motion through the air. Now the way to help overcome this bugbear of the aircraft designer is to provide only surfaces over which the air will flow smoothly, for when the flow is broken down into eddies,



Wing at best angle of Incidence.



Wing at high angle of Incidence some eddies formed and lift impaired.



Wing at stalling point. Flow completely broken away from upper surface and lift totally destroyed.

Air flow over an aerofoil section.

FIG. 1.

as it is by rough or angular projections and surfaces, the drag is greatly increased. The cambered wing is the result of experiments in the laboratory and the wind-tunnel, and has the effect of maintaining a smooth, unbroken flow over the wing while at the same time providing that increase in velocity over its upper surface which gives us the lift we require.

Now as the lift is a desirable characteristic, because it holds the sailplane up in the air, and the drag an undesirable one, because it retards the sailplane in its path through the air, it stands to reason that the efficiency of any particular aerofoil or wing could be expressed as the ratio of the lift to the drag it gives under various conditions. This is actually what is done and for the purposes of ordinary aerodynamical calculations, this ratio is written as L/D, where L represents the lift and D the drag.

Both these forces are proportional to the area of the wing, the density of the air, and the square of the velocity at which the wing is moved through the air, or $L \propto \rho SV^2$ and $D \propto \rho SV^2$, where ρ is the density, S the area of the wing and V the velocity. Now the air flow varies for each wing section and also for every angle of incidence, this latter being defined as the angle between the chord line of the wing and its flight path—see figure 2, so in order to arrive at equations by which the lift and drag can be found, it is necessary to make use of coefficients to allow for each such variation. Thus we get $L = k_L \rho S V^2$ and $D = k_D \rho S V^2$ where k_L is the lift coefficient and k_D the drag coefficient. Figure 3 shows the position when the sailplane is

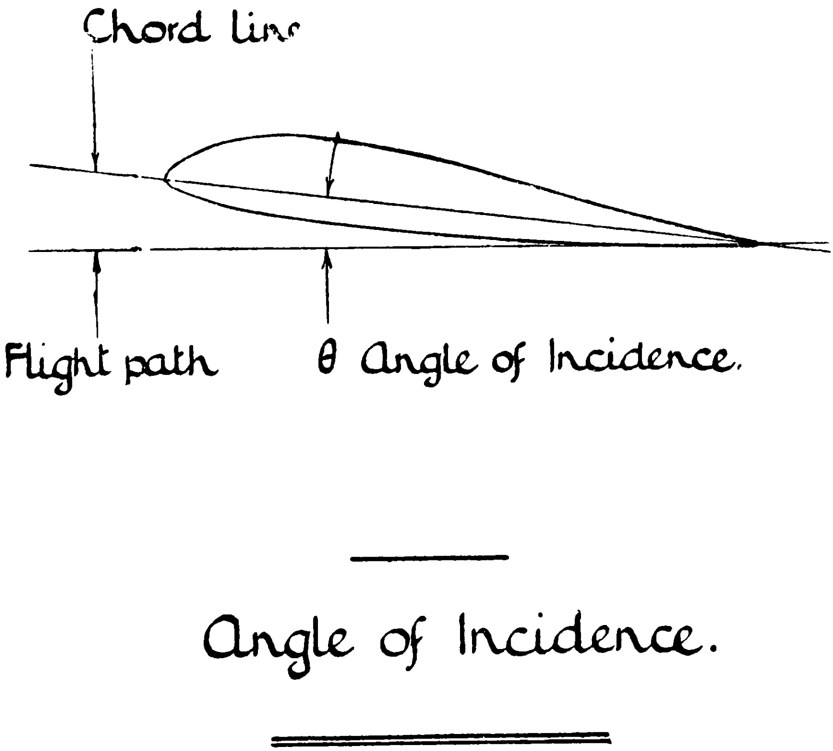
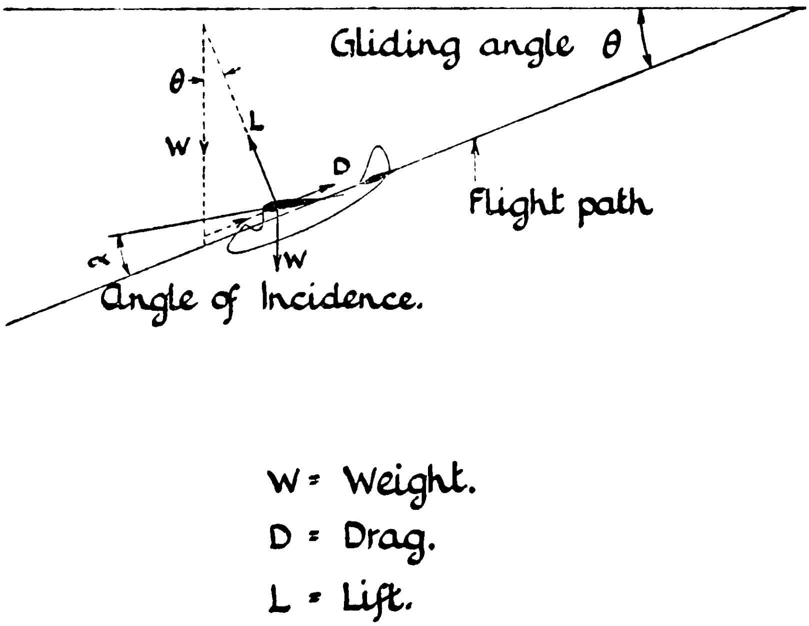


FIG. 2.

actually descending a gliding path. Now it is obvious that if the sailplane is to remain in steady flight, the forces acting on it must be in equilibrium, and that W, the weight, must be equal to the sum of the lift, L, and the drag, D. The lift acts normal, the drag along, and the weight vertical to the flight path, it can be seen therefore, by resolution of these forces, that the cosecant of the gliding angle is the ratio W/D. More often the tangent D/L is used and this is simply the inverted lift over drag ratio of which we have already spoken. The greater the ratio L/D,



Distribution of forces on a gliding flight path.

FIG. 3.

i.e. the greater the efficiency of the glider; the flatter the gliding angle.

This can be seen even more clearly in figure 4. Imagine for the moment that the efficiency is so great that the gliding angle is nil, that is the sailplane will fly on a horizontal path without losing height. An examination of the forces shows that the lift, L, as it still acts normal to the flight path must, as that flight path is horizontal, be acting vertically ; but this then, will be directly opposite to the action of the weight, W, hence

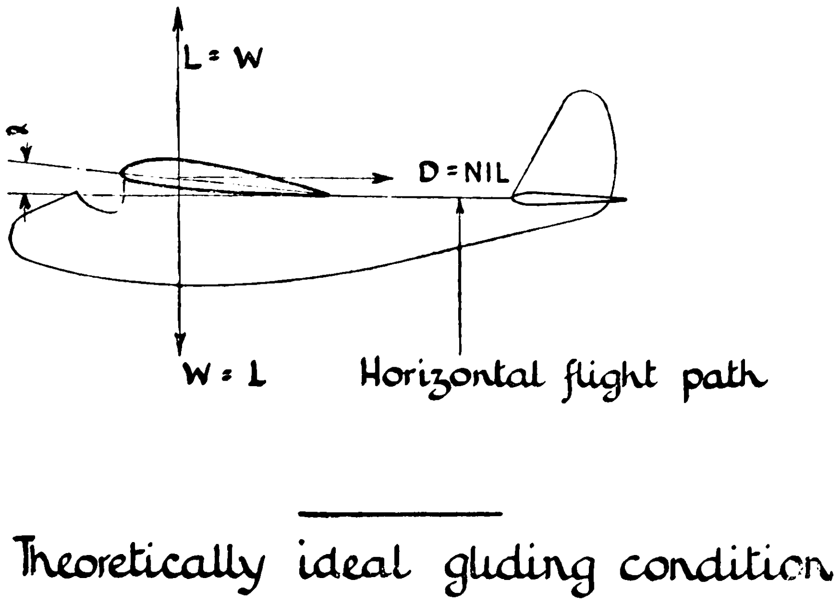


FIG. 4.

these must balance one another. We still have the drag, D, left to account for, and as this is not a power-driven aircraft, we have no thrust from the engine to set against it ; hence it follows that if horizontal flight is possible, this drag must have been reduced to nothing. Unfortunately such an ideal state of affairs cannot be reached, and we must therefore be content with as low a drag as possible.

The very modern sailplane has been brought to a pitch of perfection far exceeding anything yet achieved in power-driven aircraft as far as the L/D ratio is concerned, and values as high as 24 to 1 are not unknown. This means that from a height of only 200 feet a distance of 4,800 feet could be covered in the glide, or nearly one mile! Primary training gliders of the Zögling type do not, of course, reach anything like these figures, and a ratio of about 8 to 1 is more generally met with in this class.

An examination of figure 3, together with the equations $L = k_{L}\rho SV^2$ and $D = k_{D}\rho SV^2$, should now be made, bearing in mind, as we have already seen, that for flight at a very flat gliding angle it is necessary for L to be large and D to be small, the nearer L approaches W and the nearer D approaches nil the flatter will be the glide. Yet another factor now comes in as desirable, and that is a slow sinking speed the formula for which is $\left(\frac{L}{D}\right)^2 \times k_L$. That this is desirable should be obvious, for naturally the whole aim of the sailplane pilot is to remain in the air as long as possible and to be able to utilize up-currents of the lightest nature. It is possible to achieve this desirable feature in two ways. The first and most obvious is to have a sailplane which will fly very slowly. This is easy to arrange provided that a flat gliding angle is not required, for unfortunately we cannot get an aerofoil which will provide us with a high value of k_L at small angles of incidence, that is to say, that if we wish to fly slowly, then we must fly at a large angle of incidence. Now we have just seen that doing this increases the drag and thus makes the gliding angle coarse, and though this is the means taken with light-wind soaring gliders, it will not provide us with the efficiency we require for the sailplane.

The second method is to utilize an aerofoil which will give us a reasonally good k_L at a small angle of incidence, where we shall also get a very good value of L/D. By this means we secure a flat gliding angle though at a higher flying speed. Readers will no doubt ask—having read earlier in this chapter that lift was mostly obtained from the curved upper surface of the wing—"why is it not possible greatly to increase this curvature and thereby get a wing with a very high lift?" Actually there are such aerofoil sections, but in effect they are almost the same as flying with the wing at a large angle of incidence, for although their k_L maximum is very high, their L/D ratio is very bad; in other words they give us the good lift but also a large drag. As is usual in aerodynamics, the wretched designer has to compromise. Hence for high-efficiency sailplanes, we arrange that the best L/D is obtained at a very small angle of incidence. By so doing the drag is kept at a minimum, but the speed is allowed to increase; the flat gliding angle secured, however, more than counteracts

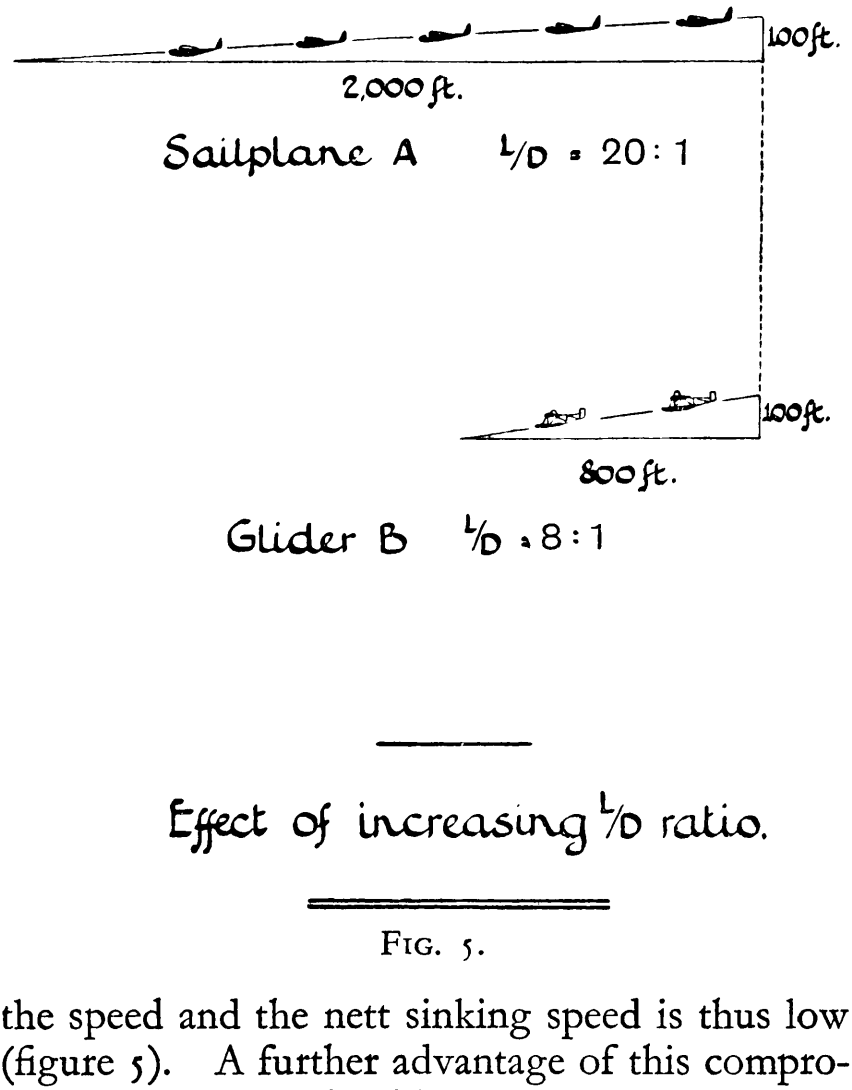


FIG. 5.

the speed and the nett sinking speed is thus low (figure 5). A further advantage of this compromise is that aircraft of higher wing loading, i.e. of a high weight per square foot of wing area, can be used. This allows the designer to make the sailplane strong and at the same time provides the pilot with the added advantage of a quick acceleration which materially assists him when flying in strong and gusty winds. A slow flying, lightly loaded sailplane may, it is true, be able to fly in very light breezes, but gusty weather may make its use almost impossible, particularly when landing.

The very flat gliding angle may also be looked upon as undesirable when it comes to landing, for a sailplane of this type, which will carry on some forty feet when only two feet above the ground, often seems almost impossible to get down ; hence there is much investigation going on with a view to fitting air brakes. These are various forms of fitments, whose object is to destroy a large part of the lift and/or greatly to increase the drag. Their use thus enables the pilot to coarsen his glide at will by making his sailplane inefficient. The type which destroys some of the lift have been used with some success in Germany, but I feel that far better and safer results will be obtained with the drag increasing type. This type is already in extended use on a power-driven aircraft, namely the Puss Moth built by de Havillands. When this aircraft was first produced, it was found to have such a flat glide that pilots had some difficulty in getting into small aerodromes, and so the fairings on the compression legs of the under-carriage were made rotatable. When these are turned broadside on to the direction of flight they offer a large flat surface which puts up the total drag of the aircraft considerably thus making the glide much steeper.

The effect of air brakes which destroy some of the lift of the wing can, by their very nature, only be of a negative kind, and it is often just when using these brakes, such as for example when coming in to land over an obstacle, that the pilot wants every bit of lift he can get; if he were coming in at a high angle of incidence somewhere near the stalling point, then the application of such brakes might be sufficient to stall the wing and cause a serious crash.

Even the drag-increasing type are not without their dangers, for their application naturally increases the sinking speed of the aircraft—a point which pilots may forget—and their incorrect use may cause very heavy landings.

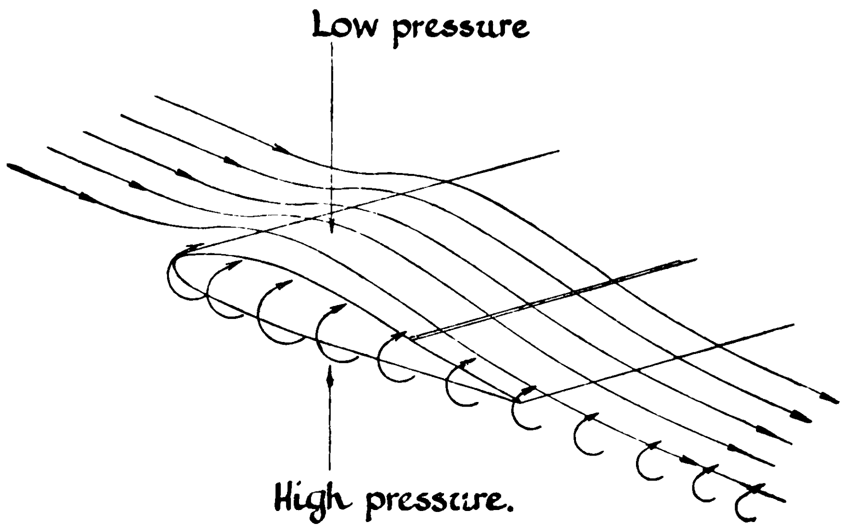
However such problems are almost as much structural ones as aerodynamical ones and we must confine ourselves in this chapter to the latter side of the question.

I have already mentioned some of the advantages to be gained from reasonably high wing loading, but now it may be as well to examine this a little more fully.

From the equation for lift, $L = k_L \rho S V^2$ we see that a small lift—and hence small weight—

combined with a large area, will give us a low value of V, that is a low speed for any given value of k_L, therefore if we wish, as we naturally do, to have a glider which lands slowly, then we must have a large wing area for a small weight, i.e. a light wing loading. Light wing loading, however, is not good when we wish to fly in gusty weather; a machine like a feather will obviously get thrown about all over the place, whereas one which is more heavily loaded will fly through bumps without undue trouble; it will, however, land faster, and so once again we have to compromise in designing high-efficiency sailplanes by slightly raising the landing speed. For primary gliders of the Zögling type, loadings of about 2 lb. per square foot of wing area are used, but for sailplanes this may be 3 lb. or even more.

Now assuming that we do not wish to increase our landing speed any more and are therefore limited to a wing loading of, for example, 3 lbs. per square foot. The structural considerations and factors of safety prevent us from building our sailplane below a certain weight, and this weight, together with our predetermined wing loading, gives us a definite wing area. Having got thus far, we now have to consider how we can best use that area. Those following the trend of German sailplane development in recent years will have seen that the most efficient types are being built with wings of very wide span and narrow chord or, as they are usually called, wings of high aspect ratio ; that is, a high value for the



Circulation at wing tip

FIG. 6.

ratio of the span over the chord, and reduction of drag is the reason for this.

Reference to figure 6 will show what happens at the wing tips. I explained earlier how the increased velocity of the air over the upper surface of the wing lowered the pressure and thus produced lift, well at the wing tips it is just this low pressure which creates trouble! Here, where the wing comes to an end, the air from the region of high pressure below it can easily flow up over the tip with the result that it creates those eddies or vortices shown in the sketch. These are detrimental in two ways. Firstly, they definitely disturb the even flow over the wing, thus decreasing its efficiency for a certain distance inward from the tip; and secondly, they induce a downward velocity which, when compounded with the horizontal velocity, provides a resultant wind flowing in such a manner that the lift acts slightly backwards instead of vertically upwards. This backward slope of the lift when resolved produces a drag force as well as vertical or useful lift, and this drag is called the induced drag. See figure 7.

Now it is obvious that whatever the span of the wing, the area at the tips thus impaired will remain the same. Moreover, if the wing was of infinite span, then there would be no tips and hence no induced drag; finally, the greater the span for a given wing area, the smaller the proportion of the whole wing the impaired portion will be. This, then, is the main reason why the high-efficiency sailplanes are built with wings of large span. The rounded wing tips so often seen are yet another way of decreasing the end-losses due to the flow from below, and although there is little unanimity among designers as to the best shape, there is no doubt that tips tapered both in plan form and profile are considerably more efficient than are square tips.

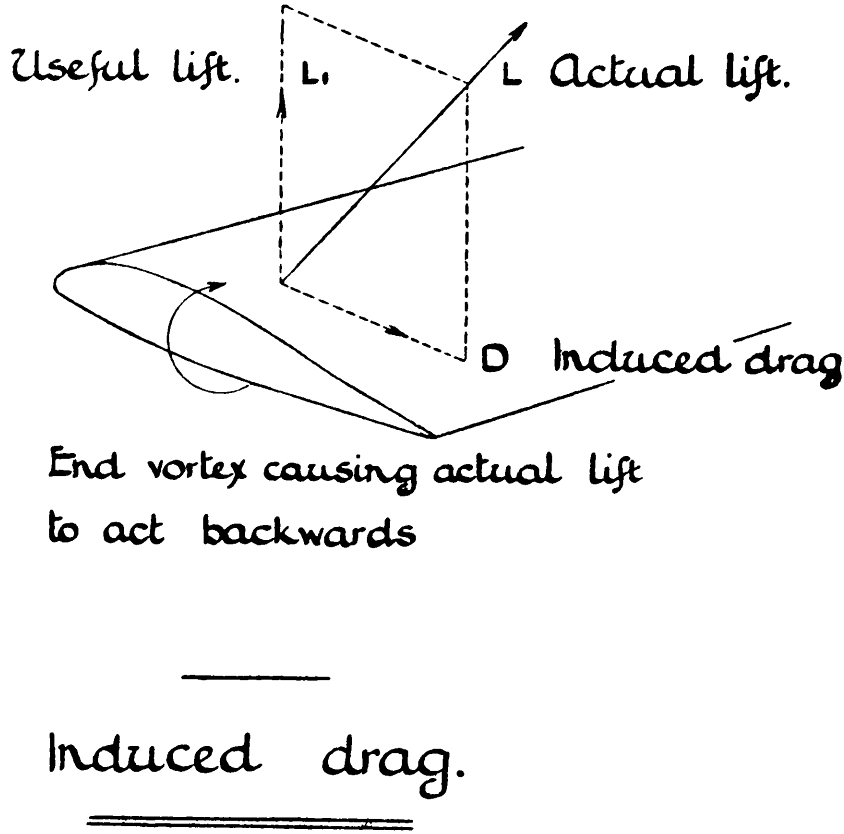


FIG. 7.

A more modern way of looking at it is to consider not aspect ratio, but span loading; that is, the load per foot run. The way of stating it then becomes, that for a given wing loading the lower the span loading the lower the induced drag and the higher the efficiency. Although increasing the span helps to decrease the induced drag, it does not, however, make any difference to the profile drag. This is mainly due to the skin friction of the wing and remains more or less the same whatever the lift coefficient or the angle of incidence.

The question of span loading shows, to a certain extent, why high-efficiency sailplanes are usually built as monoplanes and not as biplanes. There are, moreover, fewer wires and struts to increase the drag and also fewer parts to cause interference with each other. Where a strut joins the fuselage, for example, there is bound to be a certain degree of interference between the two, and this causes eddies or vortices which, as at the wing tips, create still more drag. Interference also takes place between the top and bottom wings of a biplane, thus decreasing the efficiency of both of them. As a general rule it may be said that the biplane only justifies itself when a high degree of manœuvrability, together with a light structural weight is required, as for instance in a modern high-speed fighting aircraft.

To summarize the foregoing, we can say that for efficiency the sailplane must have a wing giving a good L/D ratio ; a large span with low span loading so as to keep the induced drag to a minimum, and its surface must be smooth in order that the drag due to skin friction is as low as possible. Herr Kronfeld told me that once his " Wien " behaved very poorly, and on landing he found that several days' dust had been allowed to accumulate on the wings; removal of this at once restored his sailplane's efficiency!

Profile drag is an evil which has to be guarded against when designing the fuselage, just as much as the wing, for every projection produces eddies and eddies *are* drag. Moreover the wing and tail surfaces must be fitted on the fuselage in a way which allows the air flow to proceed undisturbed, otherwise the result is still more eddies. When Herr Lippisch first produced the "Fafnir" he had fairings of large radius running from the cover over the pilot's head to the wing roots. These looked as if interference would not be possible; it was, however; and it was not until the radius was reduced that this sailplane was really safe to fly, as previously the flow over the wing and back to the tail surfaces had been completely dearranged. This shows how difficult it is, even for the most skilful of designers, to predict exactly what the flow is likely to be round any particular projection.

At the beginning of the chapter, I stressed the need for the pilot to realize that it was his motion relative to the air which was important. This, of course, is particularly so when it comes to actual soaring. Soaring flight is only maintaining the sailplane in an attitude giving its lowest rate of descent, over an air current which is rising faster than that rate of descent, the nett result being a gain in altitude. Hence the necessity for realizing exactly what that attitude is and how it is attained. I hope, therefore, that I have made it clear that the best angle of incidence is that at which the best value of L/D is obtained, moreover it is important to remember that this is emphatically not necessarily the slowest flying speed, for increasing the angle of incidence will only increase the drag and make the resulting angle of descent steeper, with a probable increase in sinking speed.

We will now consider the question of how the sailplane is made stable in the air so that it will return to its normal flying attitude after a deviation from it, without undue delay; and will, moreover, maintain a steady gliding attitude without either pitching or yawing; i.e. raising and lowering its nose or swinging from side to side.

For this stability to be attained the sailplane must be in equilibrium, and for this to be the case then the air forces acting on it must balance one another.

Now, we will consider for the moment what happens to a sailplane's wing when the angle of incidence is varied. It should be understood first of all that the lifting force on the wing acts through the *centre of pressure* and that for most aerofoil sections this centre of pressure moves according to the angle of incidence; when the angle is increased, then the centre of pressure moves for-

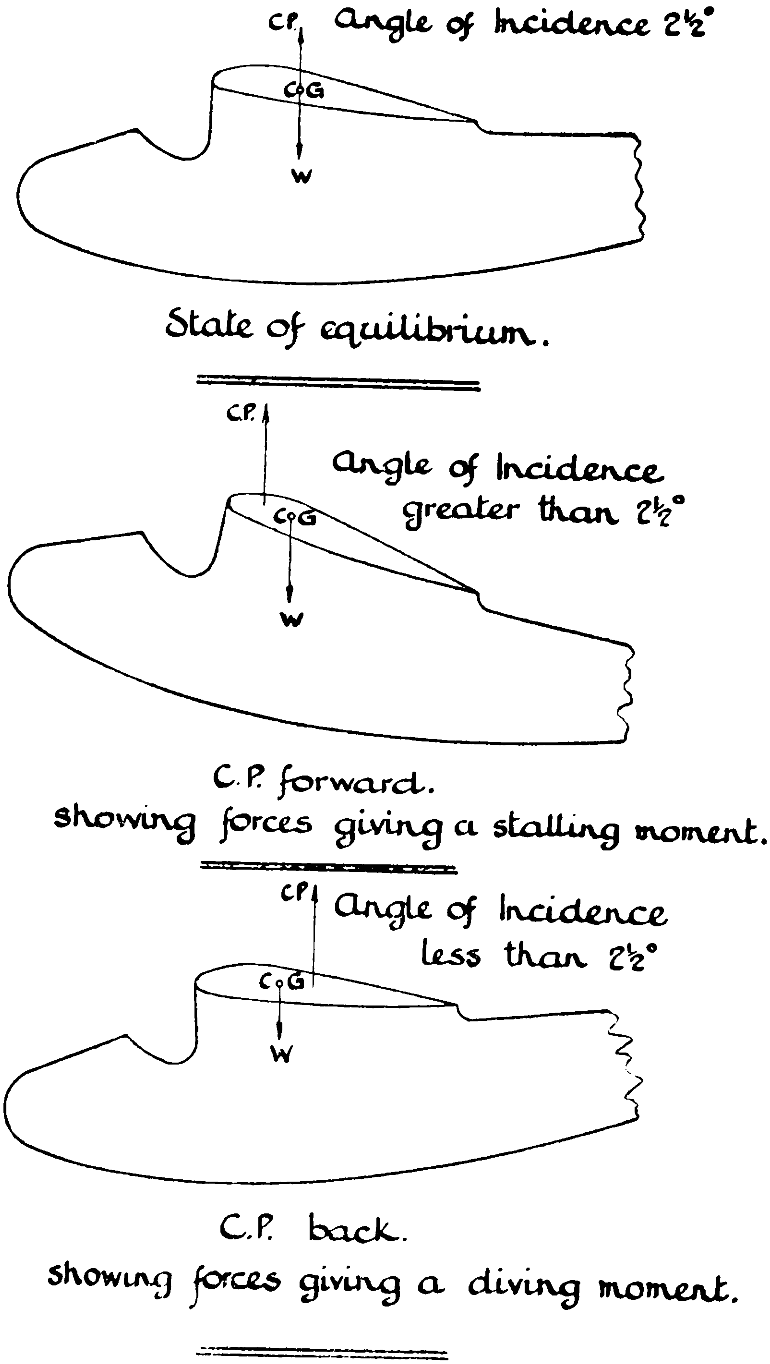
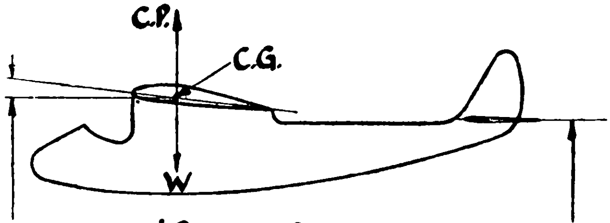


FIG. 8.

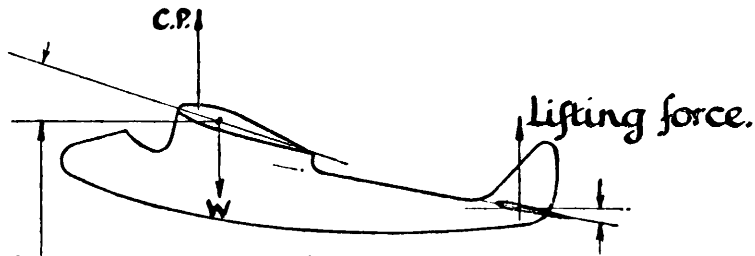
NOTE.—2½ PER. CENT. IS MERELY AN ARBITARY VALUE TAKEN FOR THE SAKE OF CLARITY.

ward and acts through a line parallel to the wing spars which is nearer to the front spar than before; when the angle is decreased, then the reverse takes place, and the centre of pressure moves back. As, however, the weight must always act through the *centre of gravity*, then it is obvious from figure 8 that when the centre of pressure is forward there must be a stalling couple acting on the wing and tending to increase the angle of incidence still farther, whereas if the angle is decreased, the couple aggravates the trouble, and increases the dive. Thus it will be seen that there is no possibility of a simple wing being stable. Imagine, now, that a tailplane is affixed behind this wing in such a manner that its angle of incidence is nil, when the wing is at its best flying angle. As shown in figure 9, an increase in the angle of incidence of the wing will now produce an up-load on the tail plane which will restore the aircraft to its original position where the tail plane had no lift. Likewise a decrease in the angle of incidence of the wing will produce a downward force on the tail plane, having therefore a tendency to raise the nose once more.

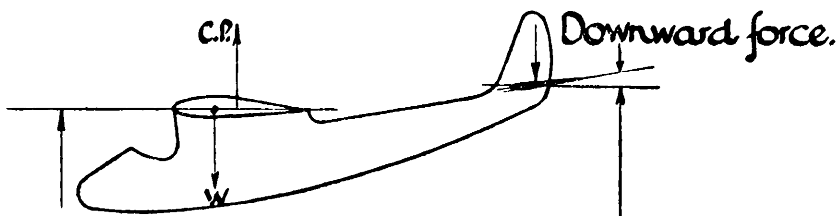
Directional and lateral stability are closely interconnected and can only be dealt with at one and the same time. Reference to figure 10 will show that if the sailplane is displaced laterally in a roll, then there must be an unbalanced force



Wing in equilibrium. Tail plane exercises no moment.



C.P. forward. Tail plane providing a lifting force counteracting the stalling moment.



C.P. back. Tail plane providing a downward force counteracting the diving moment.

FIG. 9.

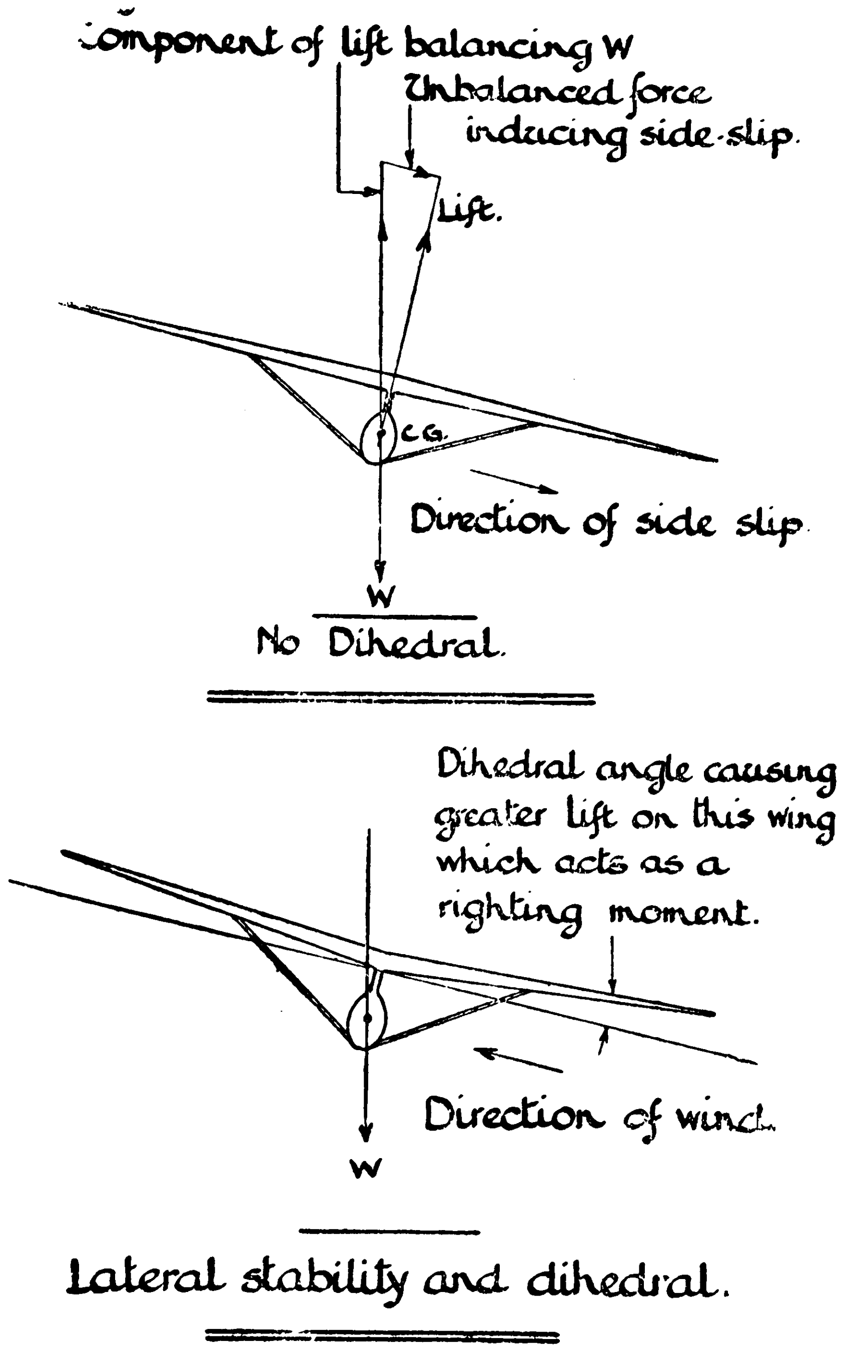

Component of lift balancing W
Unbalanced force inducing side-slip.
Lift.
C.G.
Direction of side slip.
W
No Dihedral.
Dihedral angle causing greater lift on this wing which acts as a righting moment.
Direction of wind.
W
Lateral stability and dihedral.

FIG. 10.

acting on the wing which will produce an ultimate side slip, as the lift acts through the centre of gravity and cannot act as a restoring force in any way. This side slip brings into play righting moments due to all or any of three things. Firstly, there is side area situated above the centre of gravity; the action of this is easy to understand, for it can be seen that any sideways movement of the sailplane must at once produce a righting force on such area; in order, however, to maintain directional stability such side area must be behind as well as above the centre of gravity, as then it acts exactly the same as the vane of a weathercock, hence the accepted expression for this type of stability of "weathercock stability," and it should be noted that rear-fin area causes the sailplane to turn into the side slip, unless of course, the pilot is deliberately holding the sailplane in the side slip by means of the rudder.

Secondly, there is dihedral, which in truth is the angle subtended between the two halves of the wing, but which is generally measured as the acute angle which either wing makes with the horizontal.

The action of dihedral in producing a righting moment laterally is to a certain small extent the same as fin area if the wing is above the centre of gravity, but by far the major portion of its action is due to the fact that the relative angle of incidence of the wing entering the side slip is greater than that of the wing remote from the slip and it therefore exerts a greater lifting force, thus righting the sailplane. When the sailplane is side slipping, the air does not meet the wing directly from the front, but on a line inclined to the fore and aft line and simple geometry will show that this has the effect stated above.

Finally, sweepback of the wings also produces a righting moment by virtue of an increase of relative angle of incidence of the wing nearer the slip in a similar fashion to the action of dihedral, but its effect is much less and it is seldom taken into account for this purpose. Its main use is that it provides a means, albeit a somewhat clumsy one, of placing the centre of gravity with regard to the centre of pressure.

It is not possible, nor is it desirable, in a volume such as this, to go more deeply into the vast subject of aerodynamics and I therefore conclude with a list of books which I recommend as stepping stones to a further knowledge of the reasons why a sailplane flies and why any particular one flies better than another.

Elementary Applied Aerodynamics, by T. G. Whitlock (Clarendon Press).

Simplified Aerodynamics, by Alexander Klemin (Putnam).

The Airplane, by F. Bedell and T. E. Thompson (Macmillan).

CHAPTER VIII

METEOROLOGY

By Captain F. Entwistle

THERE is little need to emphasize the importance of meteorology in relation to any branch of aviation. An aircraft moves in, and is supported entirely by, the air, so that a knowledge of the movement and behaviour of air currents should form part of the mental equipment of every air pilot. In the case of motorless flying, this knowledge is even more important, for no pilot can succeed in soaring or sailing flight unless he has a first-hand acquaintance with air currents and can recognize the conditions which produce them.

Vertical Air Currents.

Soaring flight depends on the fact that the motion of air over the earth's surface is not entirely horizontal. There are various causes present which may act, either singly or in conjunction, to produce a vertical component in the motion of the air which would otherwise be horizontal, depending as it does on the horizontal variation of atmospheric pressure over the earth's surface. It is proposed to consider these causes in turn, together with the disturbances in regular wind flow which they produce.

Dynamic Up-currents.

The most obvious way in which deviation from the regular horizontal wind flow may be

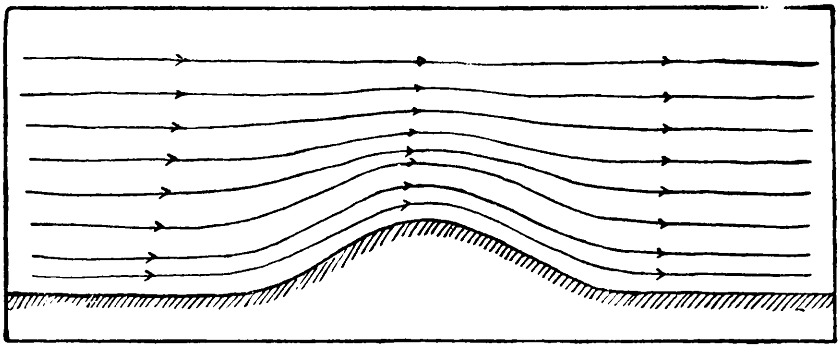


FIG. 11.
IDEAL CASE OF STREAMLINE AIR FLOW OVER A SMOOTH HILL

produced is by means of an obstruction such as a ridge of hills. If we can imagine a perfectly smooth plain broken only by a smooth rounded hill, the wind would follow the contours of the ground in regular stream-lines (see figure 11). On the windward side of the hill there would be a definite upward component to the wind which would reach a maximum at the steepest part of the slope. This area would be suitable for soaring flight.

Such ideal conditions rarely occur in actual practice. Owing to the broken nature of the earth's surface, eddies are set up, due to friction between the moving air and the ground. This eddy motion increases as the wind speed increases, and it also depends on the nature of the surface over which the wind is blowing. Large obstructions, such as trees or houses increase the eddying considerably and they also affect the height through which the eddying effect is transmitted.

Vertical Temperature Distribution.

There is, however, another factor which has an appreciable effect on the eddy motion near the earth's surface and the general question of wind flow. It is a well-known fact that air temperature decreases, on the average, with increasing height above the earth's surface. The average rate of decrease in this country is 3°F. per 1,000 feet; the *actual* rate of decrease on a particular day, however, may be widely different from this average value, particularly at lower levels.

There are two extreme cases of vertical temperature distribution which it is necessary to consider from the point of view of the subject under discussion. The first is that in which the thermal structure of the air is said to be "adiabatic." This may be understood by considering a mass of air near the ground, which becomes heated above the temperature of its surroundings and rises owing to its increased buoyancy. As the air rises it becomes progressively cooled by expansion owing to the fact that it finds itself in a region of continually decreasing pressure. If the temperature of the rising air is not affected by conduction of heat to or from the surrounding air, and it is dry or, at any rate, not saturated with water vapour, it becomes cooled at a uniform rate of about 5⅖°F. per 1,000 feet. This rate of decrease of air temperature with height is termed the "dry adiabatic lapse rate." It follows that if the *general* lapse rate in the lower levels is greater than the dry adiabatic lapse rate, air rising from near the ground will go on rising, for at any height it will be warmer, and therefore lighter, than its environment. In such conditions the atmosphere is said to be *unstable*.

Now let us consider the case in which the general lapse rate is *less* than the dry adiabatic. In this case the tendency of the air to rise will be checked, for at any height it will be colder and therefore *heavier* than the surrounding air. The smaller the lapse rate the more pronounced will this tendency become. In the extreme case when the air temperature actually *increases* with height, forming an "inversion," the atmosphere is very stable and rising air currents cannot subsist. The two extreme temperature lapse rates described, and the average lapse rate over England, are shown diagrammatically in figure 12.

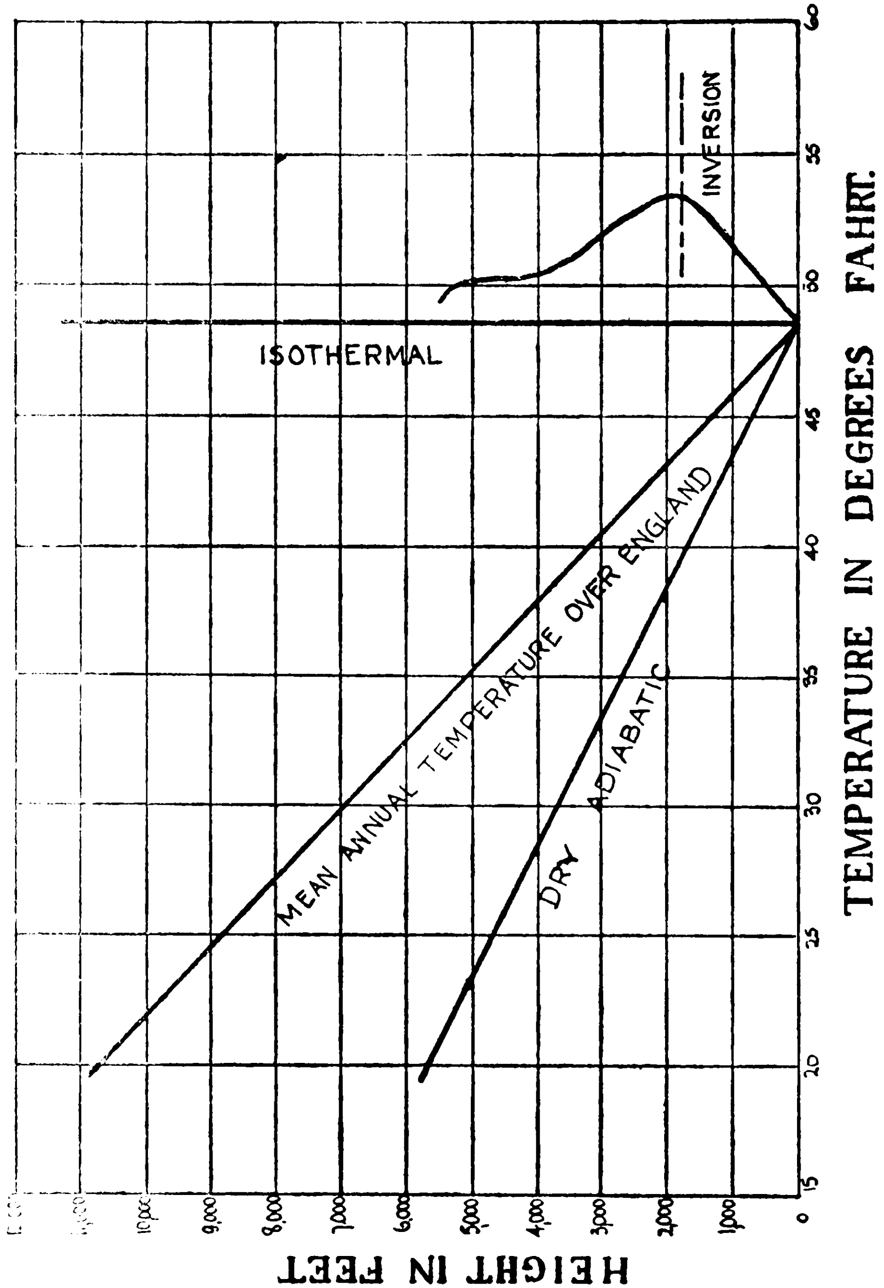


FIG. 12. BY KIND PERMISSION OF THE ROYAL AERONAUTICAL SOCIETY.

The foregoing temperature considerations have an important bearing on eddy motion and on air flow generally. The more the temperature lapse rate approaches the adiabatic state, the more the eddies formed near the ground tend to spread upwards and to grow, while in an inversion they tend to keep near the surface and to be damped out.

Flow of Air Over a Hill.

We are now in a position to consider more fully the question of air flow in undulating country.

In the case of an isolated hill the air circulation is complicated owing to the tendency of the air to flow round the sides of the hill instead of over it. The air which flows over the summit is the air lying above a certain height. Below this critical height the air is deviated laterally and flows round the sides of the hill. Actual observations made in Germany and elsewhere and theoretical calculations show that vertical motion caused by the dynamical ascent of the wind over the hill exists up to a height above the summit, equal, approximately, to one-third the height of the hill. Above this height the stream lines remain undeviated.

In the case of a long ridge of hills at right angles to the wind direction the air must, of necessity, pass over the summit. In such a case the vertical motion extends up to a height above the summit, equal, approximately, to four times the height of the ridge.

Effect of Temperature Lapse Rate.

The actual height to which the vertical motion extends above a hill, in other words the effective soaring area, depends, however, on the temperature lapse rate. When the lapse rate is large, the effective soaring area extends to a greater height than when the lapse rate is small. If a temperature inversion exists at some height above the hill no vertical motion is possible above the level of the inversion. The stream lines are compressed, in effect, between the inversion and the summit of the hill. Such a situation gives very steady soaring conditions free from undue turbulence. Such conditions occur more particularly in winter in relatively settled conditions associated with an anticyclone. The presence of an inversion is indicated frequently by a uniform sheet of strato-cumulus cloud covering the sky.

If the inversion extends right down to the summit of the hill as, for example, in the early morning during the winter half-year, when a layer of cold air rests on the earth, no vertical currents exist above the summit and soaring flight is not possible, even if the wind is apparently favourable.

Eddy Effects near a Hill.

The smoothness of the air flow over a hill depends on a number of factors, notably the regularity of the surface, the slope of the hill, the wind speed and the temperature lapse rate. In the case of a hill of regular surface with gradually sloping sides, if the wind is light or moderate and the temperature lapse rate small, the wind circulation will approximate to the ideal case illustrated in figure 11, and no eddies of appreciable size will be formed.

As the steepness of the slope of the hill-sides increases, there is a tendency for stationary eddies to be formed on both the windward and leeward sides of the hill, the wind tending to blow down the hill near the bottom of the slope on the windward side and up the hill on the leeward side (figure 14). Between the main upward or downward current and the return current close to the hill, a shadow area, or region of dead air will be found to exist. Eddies of this kind are, however, by no means constant. They persist, in general, only if the temperature lapse rate is less than the dry adiabatic and the wind speed is less than about 20 m.p.h. If the lapse rate is greater than the dry adiabatic or if the wind speed is much in excess of 20 m.p.h., the wind flow over the hill becomes generally turbulent and the more definite larger eddies of figure 13 are difficult to distinguish.

It follows from the foregoing considerations that the best soaring area is, in general, that above the slope of a hill on its windward side. If the glider is flown too far below the summit of the hill it will enter the shadow region or turbu-

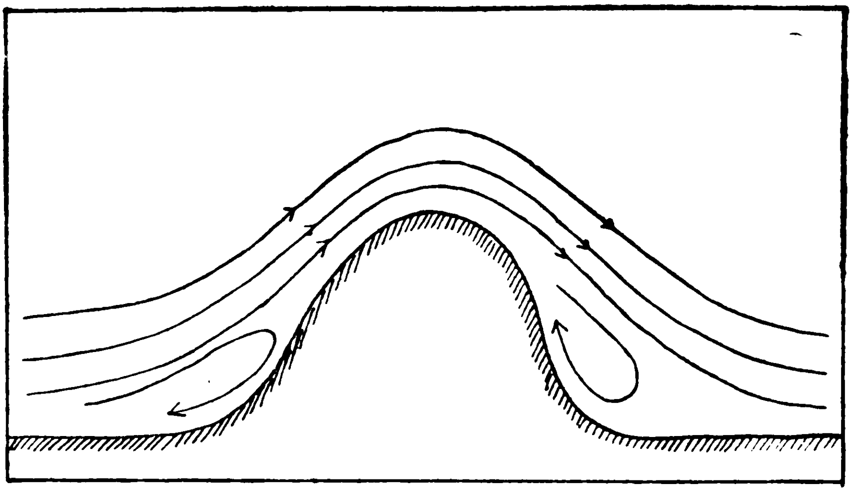


FIG. 13.

AIR FLOW OVER A TYPICAL HILL WITH STEEP SLOPES, SHOWING STATIONARY WINDWARD AND LEEWARD EDDIES.

lent area and loss of height must inevitably follow.

If the side of a hill is so steep that a sharp discontinuity is produced as, for example, in the case of a cliff, the wind flow becomes more turbulent than in a rounded hill and is, consequently, more difficult to negotiate. Figures 14 and 15 illustrate the types of disturbance produced when the cliff faces to windward and to leeward respectively. In the latter case the eddies may persist for a considerable distance to leeward.

The examples of wind flow cited will suffice to illustrate the general problem of dynamic up-currents. The more broken and irregular the hills, the more turbulent will be the flow of air

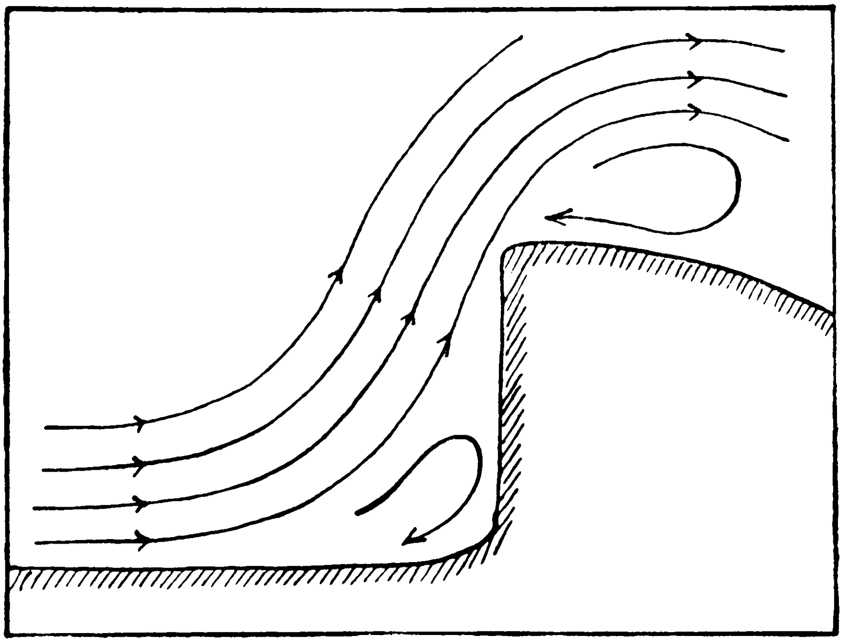


FIG. 14.
AIR FLOW OVER CLIFF FACING TO WINDWARD.

over it. Neighbouring hills in close proximity will also tend to modify the wind circulation. It cannot be emphasized too strongly that before a gliding terrain is finally selected, the wind currents in its neighbourhood should be investigated, in various wind conditions, as exhaustively as possible.

The most important example of up-currents produced by surface friction is that of a wind blowing from the sea in a coastal region. Owing to the increased friction which occurs in the transition from sea to land, the wind experiences a strong retardation or decrease in velocity.

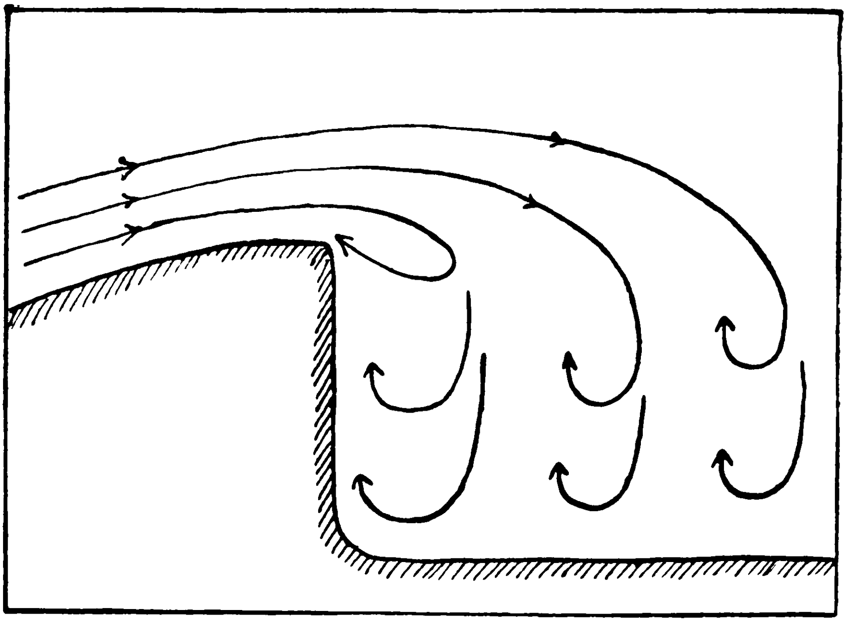


FIG. 15.
AIR FLOW OVER CLIFF FACING TO LEEWARD.

Frictional Up-Currents.

This decrease is compensated by a corresponding ascending current over the coast (see figure 16).

Ascending currents along the coasts, due to this cause, occur more particularly in summer when the wind tends to blow from sea to land. Evidence of the upward current is seen in the long line of cumulus cloud which persists along the coast. Reference to this type of cloud will be made later.

If there is high ground bordering the coast, such as a ridge of dunes, the upward current tends to be increased. Such a distribution

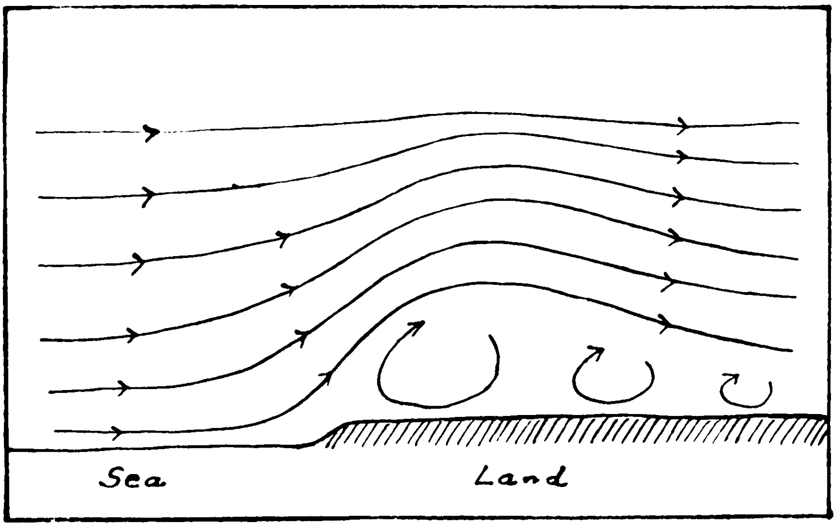


FIG. 16.

AIR FLOW FROM SEA TO LAND ILLUSTRATING FORMATION OF ASCENDING CURRENT OVER COAST.

provides much better soaring conditions than an inland hill of the same height. Even relatively small dunes produce considerable vertical velocities.

Thermal Up-Currents.

Considerable vertical currents can be produced owing to the irregular heating of the earth's surface by the sun. On a fine day in summer, particularly if there is little wind, the ground rapidly becomes heated, causing the air at lower levels to approach the unstable adiabatic state. When this occurs, streams of air flow upwards from the ground; if the air is sufficiently moist, a small cumulus cloud forms at the top of each rising column of air at the height at which the air becomes cooled below its dew point, the latter causing condensation. A typical sky of this type, in which the cumulus clouds are growing, is shown on the opposite plate. As the cumulus cloud grows, a powerful upward circulation develops within it, drawing in air from lower levels. The best soaring area is found, thus, just below the base of the cloud. A fully developed cumulus cloud is shown on the opposite plate.

While cumulus clouds are evidence of thermal up-currents, the absence of such clouds does not necessarily mean the absence of vertical currents. The extent to which cumulus clouds form depends on the general temperature lapse rate in the air. If this is initially large, very little surface heating is sufficient to start the ascending currents, which may extend to a considerable height. On the other hand, the general lapse rate may be small and there may even be an inversion at a certain height beyond which the upward circulation ceases. In such cases the air may not be cooled as low as its dew point, particularly if it is very dry, and no clouds would form. Such

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UNDEVELOPED CUMULUS CLOUDS

By kind permission of the Royal Aeronautical Society

A FULLY-DEVELOPED CUMULUS CLOUD

Facing page 136

conditions are more frequent in the interior of a continent.

The extent to which the ground becomes heated depends on the nature of the surface. Thus, thermal up-currents are more pronounced over some kinds of terrain than over others. Bare, rocky, or sandy soil becomes heated much more readily than land covered with grass or vegetation; a field covered with ripe corn produces very good thermal currents. Such factors are of considerable importance when making use of thermal currents for soaring flight.

Frontal Up-Currents.

The ascending currents considered hitherto have been the effect, either directly or indirectly, of the topography of the earth's surface. The most powerful up-currents experienced, however, are due to purely meteorological causes which are, in the main, independent of the nature of the surface below. These up-currents are due to the interaction of air masses which, being of different origin and therefore of different thermal structure, produce disturbed conditions along the boundaries where they meet. These boundaries are known as "fronts" and they may be distinguished on a weather map (see page 140) by means of an abrupt change in one or more of the meteorological elements such as wind, temperature, and humidity. Fronts are associated with the well-known type of pressure distribution known as a "depression." The most important type of front from the point of view of the production of vertical currents is the "cold front" along which the cold northerly or north-westerly winds of polar origin in the rear of the depression undercut the warmer south-westerly winds on the southern side of the disturbance. Strong up-currents are produced along the line of the cold front, giving rise to heavy cumulus clouds and frequently heavy rain or hail and thunder-storms. This type of disturbance is also known as a line-squall. The upward currents in advance of a travelling line squall have been used successfully for long-distance soaring flights.

The Weather Map.

The various types of ascending current already detailed may be used either individually or in conjunction for soaring flights. A successful flight can be carried out, in favourable conditions, by utilizing the up-currents along a long range of hills. Thermal currents can be used to maintain or increase height in passing from one hill to another. Similarly the sea breeze along a coast can be utilized in conjunction with the up-currents produced by neighbouring hills. Successful soaring flight, however, depends on the ability of the pilot to recognize and take advantage of the most favourable conditions. A valuable

Photograph by G. A. Clarke

A HEAVY LAYER OF IRREGULARLY ARRANGED, BUT TYPICALLY FORMED, STRATA-CUMULUS

Facing Page 138

aid to this end is the weather map which provides a picture of the meteorological conditions, including wind distribution, over a large area. The construction of regular weather maps, at least four times a day, forms part of the routine of every meteorological service.

For practical use a recent weather map is essential, but much useful information can be gleaned from the daily weather chart, based on morning observations, which is issued by the Meteorological Office to subscribers. Certain London newspapers also publish a weather chart based on observations taken the previous evening.

A typical weather map, showing the meteorological conditions over north-west Europe is illustrated in figure 19. The continuous lines are lines of equal pressure and are called *isobars*. These lines are drawn by interpolation between the various station pressures plotted on the meteorologist's working chart (the individual pressures have been omitted from the chart in figure 19). The barometer readings taken at the observing station are first corrected for instrumental errors and temperature changes and are also reduced to a common datum level, usually mean sea level. The isobars shown on the map thus depict the distribution of barometric pressure at sea level.

The wind at the individual stations is shown by arrows flying with the wind, the wind force

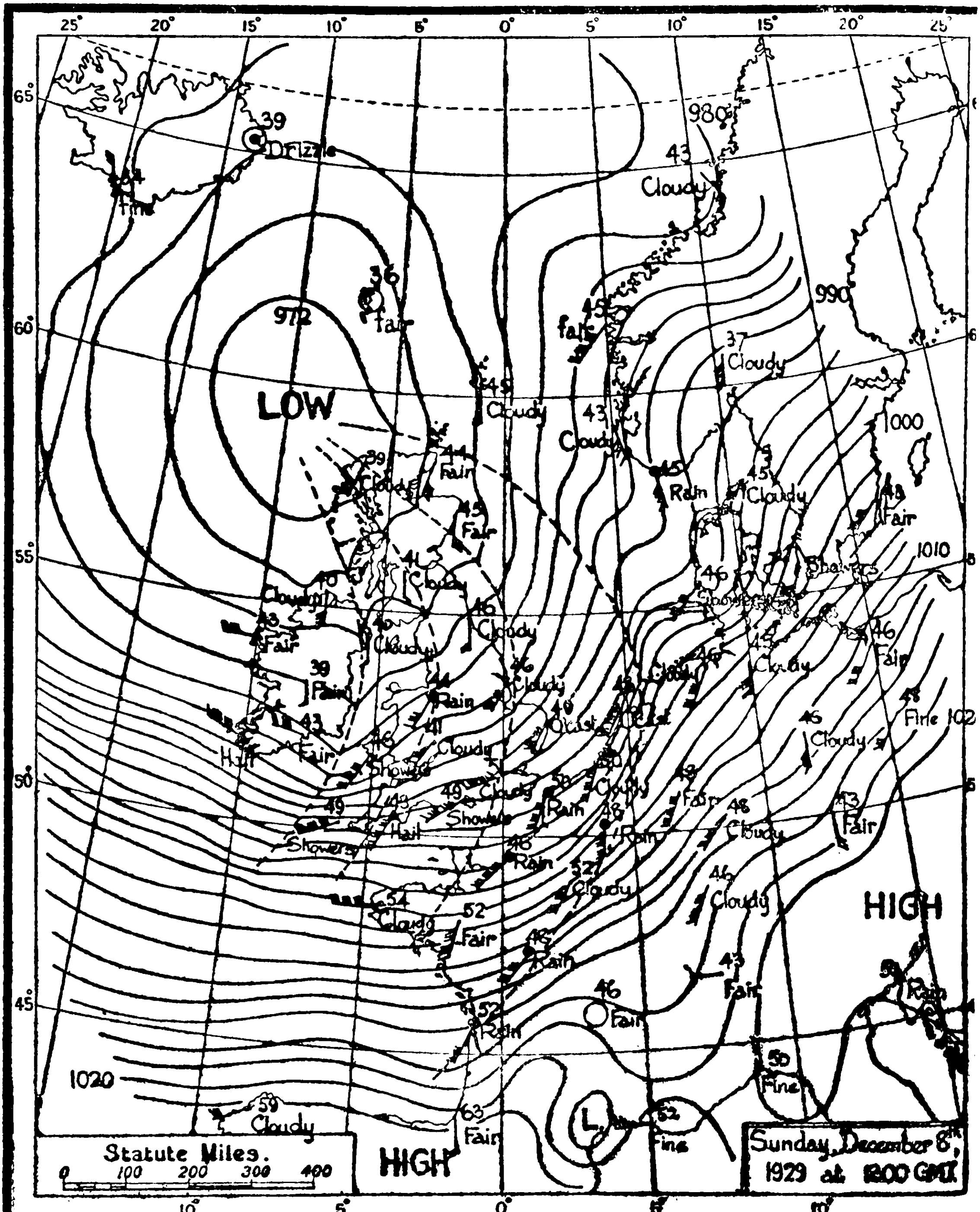

FIG. 19.

SHOWN BY KIND PERMISSION OF THE ROYAL AERONAUTICAL SOCIETY.

being shown by the number of feathers on the arrow. The latter are on the Beaufort scale, which is a numerical scale ranging from 0, calm, to 12, hurricane. The equivalent wind speeds in an open situation at a height of 33 feet above the ground are given in the following table:

Beaufort Number	*Description*	*Mean Speed m.p.h.*
0	Calm	0
1	Light air	2
2	Light breeze	5
3	Gentle breeze	10
4	Moderate breeze	15
5	Fresh breeze	21
6	Strong breeze	27
7	Moderate gale	35
8	Fresh gale	42
9	Strong gale	50
10	Whole gale	59
11	Storm	68
12	Hurricane	above 75

It will be observed from the map in figure 19 that there is a definite relation between the wind and the distribution of barometric pressure. The wind arrows tend to follow the run of the isobars but are inclined at an angle of the order of 20 degrees to the side of lower pressure. Also the closer together the isobars the stronger is the wind. The actual speed of the wind at a given place depends on height above the ground, the mean speed usually increasing with increased height. Thus, in an open situation, the speed of the wind at a height of five feet above the ground would be rather less than three-quarters of the speed at thirty feet above the ground. Obstructions such as houses or trees, however, cause the wind to blow with much less regularity. The direction of the wind also tends to change with height, turning in a clock-wise direction. At a height of about 1,500 feet above the ground the wind direction approximates to the direction of the isobars. In fine, settled, weather the change of wind with height is usually more pronounced at night than in the day-time.

The wind in any given locality does not always conform to the rules stated. For example, on the coast on a summer afternoon the wind tends to blow from sea to land, even though the isobars may run parallel to the coast line. Again at night in clear, quiet weather the wind tends to blow down the slopes of hills in a direction which may be quite different from the direction of the isobars.

The remaining elements shown on the map in figure 19 are temperature (in degrees Fahrenheit) and weather. The broken lines emanating from the centre of the depression mark the positions of a series of cold fronts which moved across the country from west to east.

CHAPTER IX

FORECAST

BY THE EDITOR

THE position of a prophet is never an enviable one, and the writer tackles it with reluctance, in the belief that if certain features are openly discussed, the future gliding enthusiast may be saved much disappointment. During the past two years the gliding movement has received far more than its fair share of Press publicity, and although this has mostly been encouragement rather than criticism, its exact value and effects are difficult to judge. Excellent demonstrations organized by famous journals and business houses because of their publicity value have set a standard which, so far, the British gliding movement has been unable to maintain, not through any fault of their own, or even lack of funds, but because experience cannot be bought. The inevitable mistakes have been made, and have duly been recorded; but given normal conditions it appears that the movement is now settling down to serious business. In the first flush of enthusiasm, clubs sprang up like mushrooms overnight, and owing to lack of experience or leaders were still-born. To-day, however, a number of amalgamations are taking place, and there seems reason to believe that the number of thoroughly sound and competent gliding organizations will be increased.

There is no doubt whatsoever that the ultimate aim of gliding must be soaring, and even this must, and need not, be regarded as something vague in the remote future. Catapult launches on flat ground or off low hills are merely a means towards an end; this fact must be realized and faced by those in control of clubs, or their days are unquestionably numbered. Auto-towing to greater heights is little more than a substitute, and as stated above, the answer in every case is soaring. The great barrier which is holding up this development on any scale is the lack of suitable sites. Such sites are admittedly not easy to find, and even when found have a habit of being inaccessibly located, the tendency of which will be to limit the sport to holiday periods only. In the writer's opinion, however, the situation is not so serious, as undoubtedly the majority of the best soaring sites have not yet been discovered. To-day the beginnings of a systematic search for suitable terrain have been begun, and it should be a point of honour with every gliding organization in the country to co-operate in this search. Some sites such as Dunstable, Scar-

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borough, and Itford, have already shown their possibilities, but most of these have also demonstrated their limitations. To add to the present difficulties, the rapidly growing network of high-power cables spreading like a plague throughout the length and breadth of the country are complicating things still further. In spite of this it seems probable that some good sites will yet be found in Scotland, the West Riding, the Lake District, the Cotswolds, and lastly the South Downs, whose suitability for cross-country flying has already been demonstrated. Even if only three really first-class sites can be found, one in the south, one in the midlands, and one in the north, there seems to be no reason why great progress should not be made. Clubs will then have to combine, though not amalgamate, to support the essential organizations at these central soaring grounds, and the spirit of rivalry which is bound to exist at such centres will do much to accelerate further progress.

Another development worthy of attention, although as yet its possibilities are almost unknown, is aeroplane towing. As a substitute for launching from high ground, where deflection currents serve as a ladder to the clouds, aeroplane towing would appear to have great possibilities, but here again it will take time to build up the necessary experience. The critics of English motorless flight movement should not lose sight of the fact that in accordance with the greatest of all British traditions, it is " hastening slowly."

The gliding club of the future will probably still be impecunious, but it will probably be equipped with auto-towing machines, on which it will instruct its new members at the local municipal aerodrome, operate in its own soaring site as near to its headquarters as possible, this site will be by no means ideal, but will enable members to build up their actual soaring experience on deflection currents, and the qualified members will probably restrict their flying to periodical excursions to the nearest central soaring site, at which the sailplanes of several clubs will be housed and maintained. It is not suggested that soaring will develop as a sport for the masses, but there is little doubt that there will be a considerable following for this fascinating, if not the only genuinely sporting branch of aviation, for what other branch of aviation can offer such opportunities for enthusiasm and personal skill, and where personal wealth is almost a secondary consideration?

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