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PITMAN'S "SIMPLY EXPLAINED" SERIES

GLIDING AND SOARING SIMPLY EXPLAINED

By

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"The Aeroplane Simply Explained," etc.

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PREFACE

THIS book aims at giving a brief but general picture of **Gliding** in its relation to flying training. I have taken it somewhat beyond the stage which the individual can reach to-day, since **Soaring** facilities are not readily available in wartime. I feel, however, that no study of engineless flight would be complete without a brief description of soaring methods, and it is felt that even the theory of this fascinating subject should prove of use to the would-be airman.

M. L.

CONTENTS

GLIDING AND SOARING SIMPLY EXPLAINED

Man and Machines. The glider has found a place in the armoury of war. It has become an aerial slip-coach for the carriage of troops and supplies to a battlefield. Once cast loose from its parent plane, it descends to earth : in warfare, we do not ask more of these engineless machines. Yet, in another capacity, the glider has its uses to-day : it forms a valuable basis for flying training and, as such, much of its fascination remains.

By the outbreak of war, gliding had attracted considerable attention in this country. Motorless aircraft were climbing high enough to acquire a coating of ice in summer. A glider pilot had flown from Heston to Southern Cornwall. A magnificent flight carried a British machine from the Home Countries to the French coast. With no more elaborate aids than wind and sunshine a man had soared across the English Channel.

On the Continent, flights of over three hundred miles were made. A Russian pilot soared over twenty thousand feet. A German, flying in Brazil, encountered a fierce aerial upcurrent at seventeen thousand feet. He was caught up like a feather in a draught and might have reached some amazing altitude if the aircraft had not broken up round him. He carried a parachute, so this was not the end of the story.

In the meantime, hundreds of young men and women in England were counting their early flights in seconds. There were some twenty gliding clubs where people could learn flying at the cost of a few shillings each week-end.

The Glider Pilot. The glider pilot will need most of the qualities that make a good air pilot. The super glider pilot may need something more, and here he makes common cause with the seaman, who must rely on tide and wind rather than a man-made engine. As the best seamen are often those who have had a grounding "in sail", so the best all-round pilots may come from those who have had experience in sailplanes and gliders.

The glider pilot travels slowly in a sensitive craft. He can better observe the phenomena of flight, of winds and atmosphere. What may be a mere incident to the air pilot is often an essential of flight to the man in the glider. He becomes intensely alive to what is happening about him. He develops a sort of sixth sense, a super airsense : and airsense is an acquired state of mind which makes the pilot know his aircraft and do the right thing at the right time without stopping to think how or why.

Some years ago two men in a racing plane flew low over a steep ridge. The wind blew strongly over this contour and set up a violent eddy which made the plane suddenly behave like a bucking horse. One of the pair was thrown out. Now both men were good pilots, but had they had gliding experience, they might have seen the danger that lurked over that harmless looking ridge.

On an air route that crossed the Alps the accident rate was high. The Airways Company considered the problem and then replaced all their ordinary pilots by others who had had gliding experience. Good results were immediate; the accident rate dropped to normal and the route over the mountains became as safe as any other.

THE PRIMARY GLIDER

In describing motorless aircraft, people often speak of sailplanes and gliders. Sailplanes are the advanced types capable of cross-country flights and high soaring. The term "Glider" commonly denotes the more primitive aircraft that literally glides down from its starting point like an aerial toboggan. The primary types used for early instruction are properly *gliders*. They are not intended for soaring and are made purposely inefficient in this respect.

In this simplest form the elementary glider is little more than a framework fitted with the essential controls and lifting surfaces (Fig. 1). It is a monoplane type with normal wings and tail and a stout skid for landing gear. It is strongly made. It can stand up to rough usage and will often tolerate considerable mishandling before reacting dangerously. The pilot sits in the open in a bucket seat which is placed centrally on the skid. In more advanced types, seat and controls are often surrounded by a nacelle or boat-shaped shell, which improves the streamline and general efficiency of the aircraft.

The type commonly adopted for training purposes at present is known as the Cadet (Fig. 2). This has an enclosed cockpit and

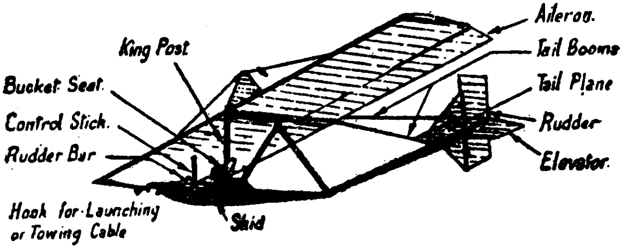

FIG. 1.

PRIMARY GLIDER

fuselage and in appearance is more like an aeroplane. It has skid landing gear, but can also be fitted with a small detachable wheel undercarriage. It possesses smooth control and has a better gliding

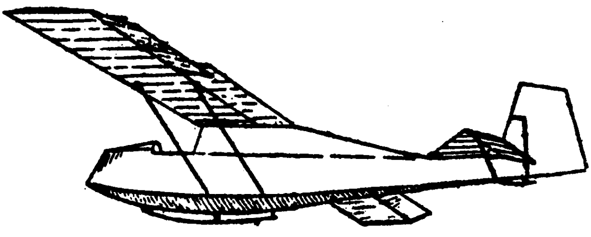

FIG. 2.

THE CADET

performance than the more primitive types. When fitted with longer wings it can be used for soaring.

The Controls. An aircraft can be controlled in three planes and has three sets of control surfaces. (*a*) (*The Rudder.* Like the rudder of a boat, this causes the nose to swing either left or right. (*b*) *The Elevator.* In level flight, this causes the nose of the machine to rise or descend. (*c*) *The Ailerons.* These are movable portions of the hinder or trailing edge of each wing. In level flight they control the heeling or banking movements of the glider.

These three sets of control surfaces are more fully described in a companion book, *The Aeroplane Simply Explained.*

Their functions are, broadly speaking, the same for a glider as for a light aeroplane.

The Rudder. The controls which govern the movements of the rudder, elevators and ailerons are situated where they can be easily operated by the pilot as he sits in the bucket seat. Where his feet would naturally rest there is a bar which pivots on a central pin and is connected by cables to the rudder. Pressure on this bar by the left foot alters the position of the rudder so that in flight the nose of the glider swings to the left (Fig. 3). For a right swing, pressure is applied with the right foot.

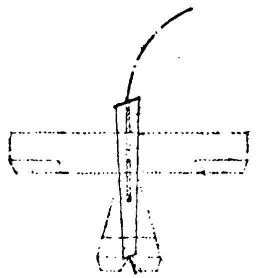

FIG 3—RUDDER CONTROL

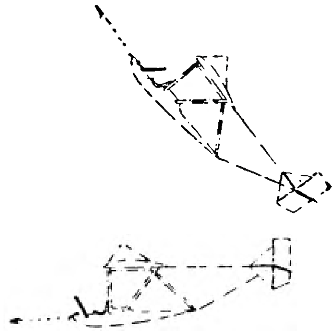

FIG. 4.—FORE AND AFT CONTROL

In some trainer types, notably the Cadet, the rudder bar is replaced by pedals, but the principle is the same. Pedals have an advantage over the rudder bar in that the pupil's feet are less likely to slip. They also resemble the rudder control which he will experience later in present aircraft.

Fore and Aft Control. In front of the seat is a movable, vertical level called the control stick. When he is seated, the pilot is able to grasp this stick and move it backwards, forwards and sideways. The backward-forward movement acts on the elevator cables. A backward movement of the stick raises the elevator. During flight this causes the airstream to bear down on the tail of the machine with the result that the nose rises. If the stick is moved forwards the elevator is depressed, and the airstream beneath it pushes the tail upwards. This causes the nose of the glider to descend (Fig. 4).

Lateral Control. The same relative movements occur when the stick is moved from side to side. This sideways or lateral motion causes one aileron to move up and the other down. In flight this brings about an increase of lift on one wing and a decrease on the other. One wing tip rises and the other drops; the aircraft heels over to one side, or banks. Movement of the control stick to the right causes a right bank and vice-versa (Fig. 5).

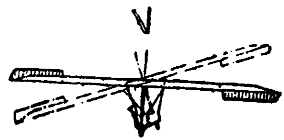

FIG. 5.

LATERAL CONTROL

GLIDING INSTRUCTION

The pupil who learns to fly a powered aircraft is invariably accompanied by his instructor. The glider pupil makes his first flight alone. It is true that there are two-seater gliders, but they are soaring types and are not suited to the technique of early instruction. Thus the gliding instructor is somewhat in the hands of his pupil. He must take him on trust during those early flights when success or failure largely depends on the pupil's ability to remember and do what he has been told. A good instructor never asks more, but rather less than his pupil can reasonably perform. A good pupil—in spite of temptations—will never try to do more than he is asked.

Gliding instruction to-day rests on the maxim slow but sure, in contrast to German methods which aim at hustling the pupil into the air—and the devil take the weakest and the hindmost. He usually does. British instructors are put through a very thorough course during which they must do, from the very beginning, all that is expected of their pupils.

Instruction may be of three types, according to the launching method used. This, again, may be decided by the nature of the surrounding country. The three methods are commonly known as *shock-cord launching*, *winch launching*, and *auto towing*. Much of the technique of instruction is common to all three. Where hills and gentle slopes are found, the shock-cord method is usually employed. The glider is in effect catapulted from the slope by means of an elastic rope.

On flat ground a winch launch is generally used. This and the third method, auto towing, are the only practical means when flat, open fields are used for a gliding ground. Auto towing is again confined to sites that permit fairly smooth going.

The *winch launch* is commonly used for glider training at present. It is regarded as safer and easier than the shock-cord method, which is apt, at first, to try the nerves of all but the most hardened stomachs. In the winch launch method a greater uniformity of launch can be obtained, and the instructor has a greater measure of control. As opposed to shock-cord launching from a slope, winch launching from the flat can be carried out in a variety of wind directions.

We will deal first with procedure on sloping ground where the shock-cord launch may be used. It has many adherents and will doubtless come into favour again after the war.

SHOCK-CORD METHOD

The shock-cord or launching rope is made up of numerous, fine rubber strands held together by an outer covering of woven cotton. Two lengths of this rope are joined in a V-shape, with a metal ring let in at the angle of the V. To each arm of the V a length of ordinary rope is spliced and knotted at intervals to afford hand holds for the launching crew. The nose of the glider is attached to the ring at the apex of the V. The tail is held firmly while the arms of the V are stretched at an angle of thirty degrees by the launching crew. The tension on the elastic grows, and if the tail is now released the glider shoots forward. The principle is much like that of a catapult.

Shock-Cord Launch. The power used to stretch the elastic may, in addition, be supplied by a hand-operated winch, or a car. In these cases the arms of the V are closed and attached to a single length of rope or cable which is connected to the back of the car. Where the man-power method or *hand launch* is employed, there may be anything from three to six or seven persons a side. Two or three more may be needed to hold the tail. One more will stand at the wing tip to hold the machine level. This is usually the instructor, who normally gives the orders to the launching crew. It will be seen that every member of a class of beginners is likely to have his time well occupied while waiting for his turn in the pilot's seat. In practice, hand launching requires a team of not less than a dozen if reasonably powerful launches are to be given.

The procedure for a hand launch is briefly as follows. The glider is drawn into position facing down hill on a slope that lies more or less towards the prevailing wind. The launching team take up their positions on the rope (Fig. 6). This is secured by a ring which engages a hook in the nose of the glider. Those acting as tail anchors get a firm grip on the tail booms of the machine or a

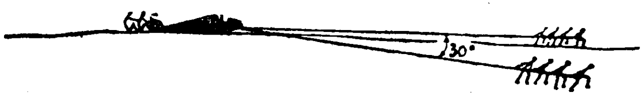

FIG 6.

SHOCK-CORD LAUNCH

special handhold provided for the purpose. In some cases the tail can be secured to a stake that is fitted with a quick-release mechanism.

When the pilot is strapped into his seat the instructor makes sure that the wings are level and that the nose is facing into wind. He then gives the order, "Walk." He follows this up by the order, "Run." The leading man on each side of the rope must make sure that he runs in a straight path so that the angle at which the rope is being stretched is not being increased or diminished. When the required tension is reached the instructor says, "Let go." The tail anchors immediately release their hold and the machine shoots forward. If the launch has been strong enough it lifts on the forward run and sails into the air.

The launching team must continue to run as long as there is any tension on the rope. The hook at the nose is so designed that the ring only remains engaged as long as there is tension. Gradually the pull of the elastic is exhausted and the machine, now well under way, overtakes the launching crew. At this point the slack rope drops away from the nose. The launching crew should now look behind to make sure that the pilot will fly clear of them. If the slope is inconsiderable and the power of the launch weak, the machine may skim forward only a few feet from the ground.

The power of these launches can easily be regulated. The number on the rope can be reduced to three a side and the release

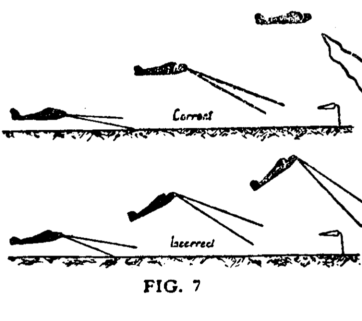

FIG. 7

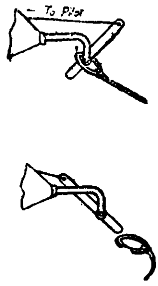

FIG. 8.

RELEASE MECHANISM

signal given before the elastic is fully extended. When a car is employed, the driver is usually accompanied by a passenger who watches the instructor and the machine. Verbal orders are replaced by hand signals.

During these launches there is one fault that must be watched for. Even with the stick held central the nose may tend to rise on a strong launch. This tendency must be checked by easing the stick forward where necessary so that the attitude of the glider remains more or less horizontal (Fig. 7). The machine will still be climbing, but on an even keel and not with the nose up. Climbing nose up wastes much of the forward impetus of the launch and there is some danger of losing flying speed. In exaggerated cases the launching rope is dragged up nearly vertical, disengages while there is still tension, and snaps down on to the launching crew. If at this point the pilot is still hanging nose upwards in mid-air, his flight may be suddenly and unpleasantly cut short.

WINCH LAUNCH

The Winch. When training takes place in flat country the shock-cord launch becomes almost useless. Winch launching or auto towing are used instead and the elastic rope is replaced by a length of fine, steel cable. Winch launching will have wider application since the method is less affected by the state of the ground. Auto towing can only be used where the surface of the ground allows a car to be driven at effective speeds.

Generally speaking, winch launching will form the universal method in glider training at the present time. It takes place on flat sites, such as large fields, or possibly race-courses, or any smooth, open space that will give a run of five or six hundred yards. Aerodromes cannot be used for obvious reasons. Gliding is, in fact, not allowed within two miles of an aerodrome.

The function of the winch is to wind in a length of cable on to a drum as a fisherman winds line on to a fishing reel. The glider, being attached to the end of the cable, is pulled rapidly along until it attains flying speed and rises. When the machine has reached a sufficient height the cable is dropped.

The winch is a mechanically-operated drum that is capable of being driven at various speeds. It may be a special piece of apparatus carried on a truck or consist of a simple drum that can be attached to the jacked-up wheel of a car. In a number of cases barrage balloon winches are being adapted for the purpose. Whatever apparatus is used it must be so placed that the glider at the other end of the cable faces the prevailing wind. On a day of veering wind it may be necessary to move the winch from time to time. In general, winch and glider are separated by a minimum of three hundred yards.

The question of releasing the cable is important. In cases of emergency it can be "let go" from either end, but in normal practice the pilot always drops the cable by means of a release mechanism operated from inside the cockpit. Fig. 8 shows the mechanism, which consists of a closed hook that can be opened when the pilot pulls the release wire. Near the point of attachment to the glider a weak link is inserted in the cable. In cases of undue strain the break will occur at this point and obviate the alarming spectacle of an aircraft flying with, perhaps, forty feet of cable dangling from the nose. As an additional safety precaution, the winch can be cut loose by severing cable close to the drum. This is done by a blade operated on a lever or by someone wielding an axe. Where no special apparatus exists the axe becomes a recognized part of winch equipment. Someone is always detailed to stand within easy reach of it during a launch.

The winch driver needs good eyesight, concentration, and the ability to react quickly and correctly to the instructor's signals. In practice he will himself be a qualified glider pilot. In many cases the instructor himself may operate the winch, where he is in a position to exercise a fairly close control over his pupil.

The Launch. When the glider is in position and the pupil is strapped into his seat, the instructor, or someone acting under his orders, holds the wing tip and signals the winch driver to take up the slack in the cable. This is done by slowly revolving the drum. When the cable is taut the *stop* signal is given. There are three flag signals to denote the power of the intended launches. The chosen one is in each case confirmed by the winch driver before the final launch signal is given. Whenever possible, the stations of winch and glider are connected up by telephone, but this does not replace the visual flag signals which are embodied in a recognized code. As soon as the glider begins to move, the man on the wing tip runs forward, retaining his hold until sufficient speed has been gained for lateral control. Flying speed is soon reached, but the pilot does not climb steeply during the early part of the launch. This will afford him a measure of control should the cable snap or the winch stop unexpectedly. If the latter happens, he must immediately release the cable and, in either case, put the nose of the machine down to retain flying speed.

In a high-winch launch, which is only undertaken by advanced pupils, the machine may in contrast to the shock-cord launch, be climbed steeply after the first few seconds (Fig. 9). The launching attitude differs from that adopted in the shock-cord method, although

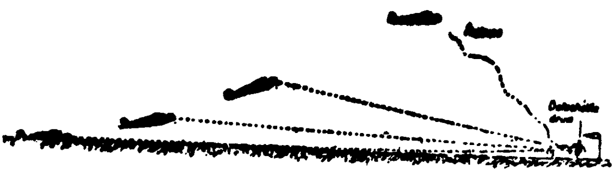

FIG. 9.

WINCH LAUNCH

with even a winch the pilot must level out before he reaches the top of his launch. This is because he will pass more or less directly over the winch, and if he has not already released the cable he will experience a strong downward pull. If the aircraft were still in a noseup attitude, the strain upon it would be considerable. In practice, the cable is dropped before this pasition is reached.

GLIDING LESSONS

First Lessons. In the earlier days of gliding the pupil began by an introduction to the machine which he was going to fly. Before an hour had passed he was sitting at the controls and probably steering the machine on a run over the ground. To-day he will begin with a lecture on general principles of gliding. This is followed by a talk on construction, maintenance and first line repairs to gliders. During his pupil days he will be required to take his turn on ground crew duties, and before practical training begins he will receive a lecture on these duties, which embraces the important subject of handling gliders correctly on the ground.

After this he is introduced to the machine itself. He is shown the controls and how their movements affect the control surfaces. He is shown how the lateral control is used to obtain lateral balance. If there is good breeze blowing, he can be given balancing practice without moving forward at all. The wind is moving over the wings and ailerons in much the same way as it would during flight. If the stick is moved to one side, the airstream acts on the ailerons and one wing tip rises. By making the necessary lateral corrections with the stick it is possible to keep the glider balanced on its skid.

Before the first trial run is given he is shown how to operate the cable release and is put through a short course of cable release drill. The instructor will then make sure that he knows how to fasten the harness that holds him securely in the seat. He is then made to see that the lateral control is central : the ailerons should be flush with the wings. He must centralize his rudder. He need not worry about the fore and aft movements of the control stick at this stage. It is not intended that he should leave the ground, and the stick is therefore held forward to prevent the machine rising on its forward run. The winch is set in motion and the glider is pulled over the ground sufficiently fast for the lateral and rudder controls to become effective. If the pupil succeeds in holding the wings level and steering a more or less straight course, he has done all that was asked. He will probably experience several of these "slides" before he is allowed to leave the ground. He thus learns the elementary feel of the rudder and lateral control besides getting accustomed to the sensation of movement.

Ground Hopping. On the next stage the stick is held more or less central, and this allows the machine to rise slightly on a gentle launch and land of its own accord. The pupil is encouraged to resist any attempt at fore and aft movement. He is told to watch some point on the ground ahead of him—in this case the winch—and concentrate on keeping the wings level and the nose of the machine in line with the selected point. The flights at this stage last but a few seconds, yet this flying towards a fixed point is already important. It is the basis of steady gliding in the early stages. The pupil who watches the ground beneath him nearly always tends to erratic flying. He often fails to notice a dropped wing or a tendency to sideways drift. Rarely does he follow a straight path and, worst of all, the ground seems to cast a fatal spell so that he dives towards it. The pupil who habitually watches his control is nearly as bad.

The person who watches a point ahead of him will both observe and develop a sense of what is happening. Gradually the strength of his launches will increase until he skims a few feet from the ground. He is now making what is called a *ground hop.* He will have learnt something of balance and directional control and must soon pay attention to the fore and aft movement of the stick.

During these early ground hops the instructor will set the elevator control so that when the winch decelerates the machine will assume a gentle gliding angle. Under these conditions it should land smoothly of its own accord. The winch is only speeded up sufficiently to allow a climb of four or five feet and the cable generally remains locked to the glider. If the pupil carries out these flights successfully, the winch is driven faster on successive launches until a maximum height of ten feet is reached. From this point he is instructed on the use of the fore and aft control.

Landings. The first uses of the fore and aft control will be made during landings. If the machine possesses a detachable undercarriage, this is now removed. The elevators are set so as to give a normal gliding angle when the winch decelerates. The angle will be such that the machine must be levelled out for its proper landing position. After the top of the launch has been reached, that is, when the winch has decelerated, the machine begins its glide to earth. As the ground approaches, the angle must be checked somewhat. This is done by gentle easing back the stick. The movement must be firm and gentle; if the stick is "yanked" back the nose will be pushed up, with a probable loss of flying speed. The possible results of this will be explained later.

As the ground gets nearer the stick is eased back a little further, as if the pilot were trying to hold his craft off the ground for as long as possible. It should never be allowed to get into a nose-up position. It will by now be almost horizontal and in this attitude it should sink gently on to its skid with little or no perceptible bump.

Those who fly powered aircraft know that a light aeroplane with a two-wheeled undercarriage lands with the nose definitely *up* and wheels and tail skid touching the ground simultaneously. This is called a *three-point landing* and forms a contrast between aeroplane and glider technique (Fig. 10). It is also the reason why some power pilots begin their gliding days with a series of strange landings.

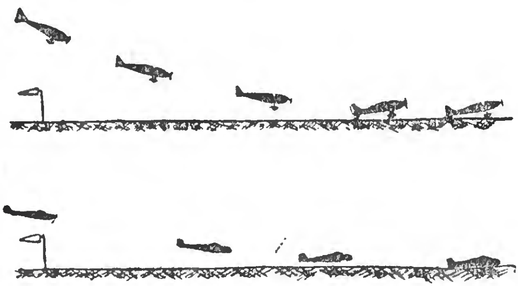

FIG 10

It will be seen that landing consists of a carefully-timed movement between two extremes of attitude. If levelling-off occurs too high or too suddenly, the glider will "sit down" with a graceless nose bump unless the mistake is quickly rectified. If there is time, the nose should be put down to gain fresh speed before being brought to its level landing attitude. Sometimes a pupil attempts to level out too late and touches the ground while the machine is still flying in a gliding angle. He may be travelling fairly fast and the glider often bounds into the air again. In this case the nose should be quickly lowered to prevent a complete loss of flying speed occurring several feet above the ground.

Air Speed. Early in his flying career the pupil must learn the importance of air speed. The upward lift resulting from the air flow over the wings of an aircraft in flight is largely dependent on the speed of that flow. The faster the flow, the greater the lift. The slower the flow, the less the lift—up to a point. Below a certain point the lift tends to disappear quite suddenly, so that the machine may be just flying one moment and falling like a stone the next. Therefore, speed matters—speed in relation to the surrounding air. This speed must remain above a certain point if the craft is to remain airborne. Below that point the lift vanishes for all practical purposes and the controls, in theory, become useless. When this happens the aircraft is said to be *stalled.* When a *stall* occurs at a reasonable height the machine may regain flying speed as it falls. If it happens near the ground the results may be serious.

In elementary gliding flying speed is largely a matter of correct gliding angle. The nose of the machine must be kept sufficiently down to ensure the necessary forward speed through the air. The primary glider pilot has no instruments to tell him how fast he is flying and must learn to judge his flying speed. A safe speed is always indicated by the brisk sound of the wind or the general sense of a steady draught. Comparative silence or the absence of briskly flowing air denotes danger.

Airspeed is also reflected in the feel of the controls. At proper flying speed they are firm to the touch, the aircraft answers readily to a slight movement of rudder or stick. As stalling approaches, the controls become loose and "sloppy", and when they are moved the machine answers sluggishly, if at all. Now is the time to put the nose down and find safety in extra speed. The good pilot steadily develops his sense of hearing and touch until, almost by instinct, he flies at the proper speed.

Turns. As the flights grow progressively higher the cable is released and the pupil may be told to make gentle turns. These are accomplished by a combined use of rudder and lateral control. For a right-hand turn, right rudder and a small amount of right bank is applied. That is, pressure with the right foot on the rudder bar or pedal and slight right-hand movement of the control stick. In turning a powered aircraft an appreciable degree of bank may be needed to prevent the machine skidding outwards during a turn. Gliders are amenable to lightly banked or even flat turns, which can be accomplished under conditions that might prove dangerous in an aeroplane. Flat gliding turns are liable to produce a spin in powered aircraft.

The stalling speed of an aircraft rises during a turn. It is, therefore, necessary to fly faster, the increase in speed depending on the steepness of the turn.

Retrieving. As the pupil's confidence and ability grow, the higher and longer in duration do his flights become. He may now be landing several hundred yards away from his starting point. The glider must be retrieved, and this sounds simple enough. It is, in fact, perfectly straightforward, but failure to observe a few rules has resulted in many damaged aircraft.

At the end of each flight the pilot must *remain in his seat* until the crew arrive. He can, however, remove his harness. The retrieving crew normally consists of two in a car. The tow line is a length of rope, wire or chain which is connected up by the usual ring to the hook on the nose of the glider. The towing car is stationed near the probable landing point. At the end of the flight it is driven up behind the glider, which is turned round by the driver's assistant. The machine is now facing tail to wind and the pilot can safely leave his seat. In doing so he should see that the harness is placed in the seat and not left trailing where it may be damaged by getting caught up in the skid. He then goes round to one wing tip, which he holds during the return journey. If there is any appreciable wind, or a glider is being towed into wind, it may be necessary to have someone exerting pressure on the nose.

The retrieving car has returned. The machine is disconnected and turned into wind; where instruction is taking place on a slope it may be necessary to carry the machine over the last part of the journey. It should be lifted by the front of the skid and under the leading edges of the wings, as near as possible to the point of attachment of struts or bracing wires. The tail should be lifted by two persons, holding on (in the case of an open primary glider) to the extremities of the tail booms.

Advanced Training. When the pupil has mastered landings and simple turns he will be given increasingly higher launches, climbing to four or five hundred feet before he releases the cable. From this height he may be told to practise descent in a series of "S" turns, or from a still higher launch he may make a circuit over the field.

From a height of three hundred feet he should be able to make a straight flight lasting well over thirty seconds, and this, before the war, entitled him to his "A" gliding certificate. The "B" gliding certificate entailed two straight flights of at least forty-five seconds, followed by a flight lasting over a minute, during which the pilot had to execute an "S" turn.

When turns and circuits are mastered satisfactorily the pupil will be instructed in side-slipping and approaches, followed by spot landings. In this case, he usually makes a circuit, followed by a landing in a given circle.

From this point he may proceed to the beginning of soaring flight. The opportunities for this may be few or non-existent at present, nevertheless, even in theorv, it makes a fascinating study. The second half of this book is devoted to the subject. The principles of soaring are covered by a brief sketch in an endeavour to show to what lengths the art of gliding can go.

ADVOIDING TROUBLE

Damage to gliders and those who fly them can be largely avoided. A glider should never be left in the open unattended, or without making certain that it is secured. The wing tip which is touching the ground should lie into wind and should be weighted down with sandbags. It may be necessary to weigh the nose. If there is wind or any apparent likelihood of wind, somebody must remain in attendance. Countless machines have been damaged or completely wrecked in the past through failure to observe this rule (Fig. 11). In moving a glider in the open, someone should always remain at the wing tip. A routine drill is now laid down for the regular inspection of gliders and glider gear, and daily flying

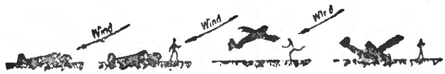

FIG. 11

certificates are issued, signed by the officer in charge, for all gliders to be flown on the day in question. If a glider is derigged during the course of a day's flying it must be inspected and recertified before being flown. The first daily flight of each machine is normally undertaken by the instructor in charge. After every 250 winch launches a minor inspection is made, and a major inspection after every 750 winch launches. In the first instance, when it is built, each glider is subject to a rigorous inspection and a certificate of airworthiness must be issued before the craft can be used for instructional purposes.

Avoiding Obstacles. It sometimes happens that an obstacle lies in the path of a glider when it is approaching the ground. This is most likely to happen when the pilot has flown outside the boundary of the flying field and has misjudged his approach. In such cases he may be confronted by a hedge or tree, which he will strike if he maintains his normal gliding angle. A steep turn, under such conditions, may give rise to a stall, or there may be, in any case, no room to turn. If the obstruction appears about level with the nose there is often a strong temptation to pull back on the stick in the hope of scraping over the obstacle. In practice, the machine often pancakes on top of it.

At times like these the pilot prays for an engine. He forgets that gravity, which he has come to regard as an enemy, may also prove his friend. By putting down the nose of the aircraft the pull of gravity gives him extra speed, which may enable him to climb over what lies ahead. In practice, he should put the stick forward and make a shallow dive just before he comes up to the obstacle. With some extra speed in hand he then pulls the nose up sufficiently to clear the obstruction, remembering to push the stick forward again as soon as he is safely over (Fig. 12).

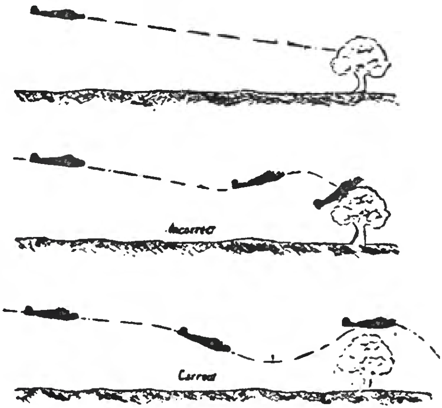

FIG. 12

SOARING FLIGHT

So far we have dealt with flights that rely largely for their duration on the amount of muscular or mechanical effort that is expended at the start. Once the momentum of the launch is ended the machine descends.

Quite early in flying history we find glider pilots trying to maintain height. Some fifty years ago Otto Lilienthal, when suspended from two pairs of bat-like wings, learned the secret of hovering above a hill (Fig. 13). He could remain suspended in air long enough to shout advice to the gaping photographers who were gathered below. He could even rise at times, and in the latter years of his experiments could almost count his flying times in minutes. Within fifty years of Lilienthal's death a man in a sail-plane soared for a night and two days.

Primary type of glider may be capable of soaring, but those aircraft designed for it are porperly called *Sailplanes*. They range

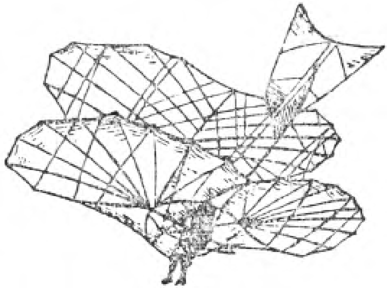

FIG. 12.

LILIENTHAL'S GLIDER

from simple craft of limited soaring capacity to the graceful, stream-lined sailplanes with their huge wing-span and ability to rise into the clouds.

The Sailplane. All modern sailplanes have enclosed cockpits and a covered body or *fuselage*. They are of high wing, monoplane type. The cockpit is usually situated in the nose and often in front of the leading edges of the wings. Sometimes a transparent cockpit cover fits like a streamlined dome over the pilot's head. The controls are like those of the primary glider.

The elementary types may have few instruments, but the dash-board of a high efficiency sailplane may carry many recording dials. In additional to normal clock, compass, altimeter, airspeed indicator, and barograph, there is one instrument, the *Variometer*, which is essential to the soaring pilot. A pointer on a dial tells him how fast he is rising or sinking in terms of feet per second. In addition to these, sailplane may be equipped with blind flying instruments.

High soaring flights frequently take the pilot into thick cloud, where all sight of his surroundings is blotted out. Now his sense of direction and attitude leads him astray. He cannot be certain whether he is turning or banking. What *feels* like a dive may prove to be a spin. A pull on the safety belt and tendency for his maps to float upwards may be the first indication that he is flying upside down. It might be thought that the magnetic compass would give him some indication of what his aircraft is doing. It would surely indicate a turn either to the left or right and tell him in what direction he is flying. Unfortunately, in blind flying conditions, the compass on its own cannot be relied upon to do any of these things. Sudden changes of direction produce misleading reactions and the instrument behaves differently according to the direction in which the aircraft is heading. If followed

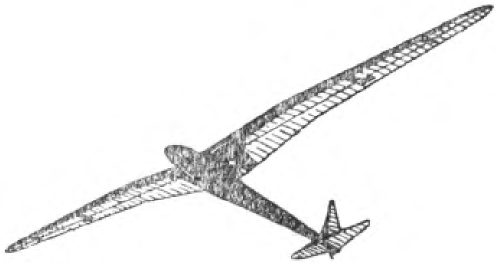

FIG. 14.—HIGH EFFICIENCY SAILPLANE

blindly, it will prove no better than a wil-o'-the-wisp. Blind flying instruments, though by no means foolproof, tell the pilot what is happening and help him to keep the aircraft in its proper attitude during level flying and throughout various manoeuvres. He has to learn to trust the instruments rather than his senses, which may at times disagree with what the instruments say.

Strangely enough, getting down can prove more of a problem than getting up. There may be occasions when it is difficult, if not impossible, to prevent the aircraft rising. To guard against involuntary soaring, the sailplane may be fitted with *Liftspoilers.* These may be slots in the wing that can be opened at will so that rising air rushes through the wings instead of lifting them. Other devices are sometimes fitted that interfere with the airstream and greatly reduce the efficiency and lifting qualities of the wing.

Sailplanes are constucted largely of wood but, for their weight and proportions, they are enormously strong. The *skin* or covering of the fuselage is usually of thin plywood and this, or oiled silk, may provide the covering of the wing structure.

The landing gear consists of a light springy skid. This may be separated from the base of the fuselage by vertical rubber cylinders which act as additional shock absorbers. A small wheel may protrude for half its diameter beneath the base of the skid.

On cross-country flights the pilot usually carries a parachute. He should be warmly clad. The cockpit is somewhat cramped and he may ascend to heights where ice formation is not uncommon. As one noted sailplane pilot has said : "It may require a good deal of moral courage to dress for the part." He may set off in front of spectators and the duration of flight cannot be guaranteed. He may done a parachute, helmet, goggles and thick flying clothing in the heat of a summer day, and, if he is unlucky, he may land again two minutes later in front of the admiring crowd.

SOARING

A sailplane climbs or maintains height on a rising current of air. Everybody is accustomed to the thought of horizontal currents which we encounter almost daily in the form of wind. Not everyone is aware that the atmosphere sometimes abounds in vertical currents that are flowing both up and down. A hint of rising currents is seen in the little spirals of dust that sometimes whirl up from the roads in summer ; birds rising in ascending circles with no apparent movement of their wings. Pieces of paper and and leaves are lifted in the same mysterious way.

There are various causes which tend to produce these rising currents and for this reason soaring methods can be grouped under several distinct headings. We will deal first with the simplest kind of soaring current that is found in the region of a hill.

Slope Soaring. Although nearly all practical gliding instruction may for the present be confined to flat sites, slope soaring remains an important basis for the study of soaring flight.

Air is a fluid, and wind is a currrent of air that flows over land and sea. If wind meets a solid obstacle in its path, it usually has to find a way round. The path it follows will depend on the shape of the obstacle. If this be a ridge of hills, the wind tends to be forced *upwards* and over the summit (Fig. 15). It will be seen that a portion of the wind is deflected upwards for some distance and that there is, in effect, a rising current of air over the top of the hill. This current may be sufficient to lift a sailplane several hundred feet into the air.

The strength of the up-current will depend on several factors. The force and direction of the wind in relation to the hill, the shape

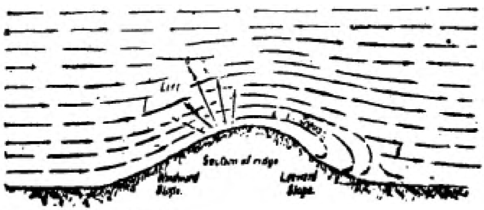

FIG. 15.

SLOPE SOARING

of the hill and the type of country over which the wind has passed immediately before reaching the hill. A single, round hill is of little use to the soaring pilot, since the wind tends to flow round such an obstacle rather than over it. Curiously enough, a good lift is sometimes found over a hilly spur that juts out into wind. A ridge of rounded hill with not too steep a slope is best for soaring purposes. For reasonably continuous use as a soaring site, it should lie more or less at right angles to the direction of the prevailing wind, which in this country is between south and south-west. If the ridge is horseshoe-shaped it is better still. It will afford lift under a wider range of conditions, besides tending to focus the flow of the wind against the slopes.

It is not possible to lay down hard and fast rules as to where lift will be found on any given soaring site. Generally speaking, it will be found to run parallel with the windward edge of the hill and extend outwards for some distance, according to the strength of the wind. If a pilot flies along the ridge under these conditions he will be following a line of rising air and will maintain height as long as he remains in the windward region of the hill. In practice, he will follow the length of the ridge, turn when he reaches the end and retrace his course. He can go on repeating this, keeping in the line of rising air, the path of his flight being a series of elongated figures of eight (Fig. 16). In theory he can remain in the air for as long as the wind holds, and before the war some clubs put in over fifty hours flying during a week-end.

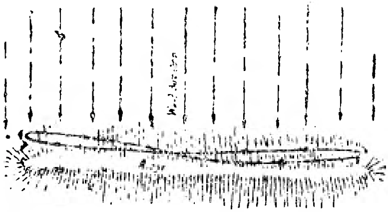

FIG. 16

As the wind passes over the hill it quickly tends to resume its horizontal flow. There is no lift over the down wind or leeward slope and conditions may be found there that are dangerous for sailplanes. Part of the air current may curve downward and cause a *downdraught*. If a sailplane is caught in a strong downdraught it may be dashed on to the face of the leeward slope. Curiously enough, powerful soaring currents *have* been found in the lee of a ridge.

If the slope is abrupt and the wind strong, there is some possibility of downdraught forming even on the windward side. In meeting the steep hill face the wind is forced up so sharply and steeply that part of it curls over backwards like the top of a wave that surges against a rock (Fig. 17). This is apt to create dangerous landing conditions at the hill foot. These matters, however, seldom trouble the beginner. The peculiarities of a well-tried soaring site

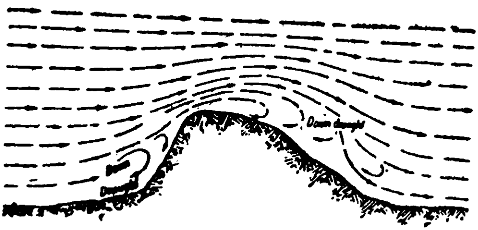

FIG 17.

FORMATION OF DOWNDRAUGHTS

are usually known and novices are not permitted to try their hand at soaring except under safe wind conditions. The early soaring stages require great patience. Light wind conditions are often insufficient for soaring in elementary sailplanes, while a stiff breeze creates conditions that are unfavourable for the learner. When the wind is blowing at the right strength it may be from the wrong direction. A day comes when conditions are at last ideal. A steady breeze is sending up a line of smooth lift over the slopes. It is on such days that the first man up breaks the sailplane !

Launching methods for slope soaring are the same as those described in the earlier pages. The machine may be hand or winch-launched from the top of the hill. If the hill is not above a few hundred feet the machine may be winched up from the flat ground at the bottom. After climbing above hill-top level, the pilot drops the cable, turns towards the ridge and flies into the up-current. If the hillside falls away steeply, a sailplane can be lifted bodily by the launching crew and heaved over the edge.

THERMAL SOARING

It is obvious that slope soaring tends to tie the pilot down to one locality. This form of lift cannot be the answer for long cross-country flights that must often be made over stretches of more or less flat terrain. How can a sailplane soar high enough for the long glide across the Channel ? What forces draw the pilot up into the wet surroundings of a cloud ? The answer is found in rising currents that are not necessarily dependent on the mechanical deflection of wind by ground contours.

Most people are familiar with the saying that hot air rises. When air is heated it expands; it becomes less dense and consequently lighter. It rises when it is relatively warmer and, therefore, relatively lighter than the *surrounding air*. The earliest balloons were filled with hot air that caused them to float in the denser and heavier surrounding atmosphere. A column of air need not necessarily be hot to rise; it need only be appreciably warmer than the surrounding air.

Thermal Currents. When the sun shines in summer it warms the surface of the ground. The ground, in turn, may warm the air above it, as anyone who has walked the pavements in a heat wave will know. Now some places on the ground give off more heat than others, which may even absorb much of the sun's warmth. This will depend on the nature of the soil and vegetation.

Marshy ground, expanses of water, sometimes woods, all tend to absorb heat. Cornfields, ploughland, chalk, tarred roads tend, on the other hand, to radiate heat and warm the surrounding air. Thus, over a stretch of country, the air is warmer in some places than in others. This warm air does not rise immediately but collects for a while, then suddenly breaks away like a bubble. When it does this we get a rising air current that tends to climb faster as it rises. It is called a *thermal current*, but the glider pilot refers to it familiarly as a *thermal*. Small thermals create those whirlpools of dust that are sometimes seen in summer. As they leave the earth behind them the thermals grow bolder and stronger until at several thousand feet they may become a great upward surge. They have been known to carry sailplanes up at a rate that would not disgrace the climb of a Spitfire.

Hunting Thermals. In summer, thermals may be encountered in varying strengths and numbers. On some days the air may be dull and lifeless, while on others thermals abound like bubbles in soda water. Thermals travel with the wind, and they are, of course, no more visible than any other current of air, but their presence may be detected, or at least suspected, in a number of ways.

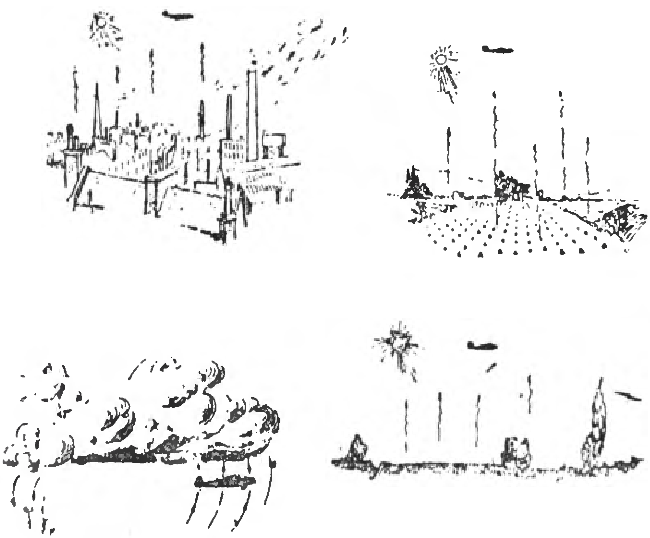

FIG. 18.

SOURCES OF THERMAL LIFT

As soon as a sailplane flies into a lively thermal it experiences a sudden lift, which is registered by the Variometer. This instrument indicates the rate of lift in feet per second and the pilot can gauge the strength of any thermal that he encounters. In order to make full use of the thermal he must circle within its limited area of lift. In practice, he usually counts seven from the moment that he notes the rise on the Variometer. At the end of seven seconds he puts the machine into a steep turn and continues to spiral upwards until his Variometer tells him that the lift is exhausted.

If he is making a cross-country flight his next concern will be to find another area of lift. Corn and stubble fields, acres of light ploughland, the red-tiled roofs of a town—all may give birth to an up-current (Fig. 18). Heath fires, or even a factory chimney, may start a thermal. Water absorbs the sun's heat and the relatively warmer ground round the banks of a river may yield a degree of lift.

Sometimes lift is found in unexpected places. A sailplane may soar over a valley in the late afternoon. This is because the air on the hillsides has cooled and, becoming heavier, has flowed downwards. In doing so, it forces the warm air up from the bottom of the valley. Thermals have been found after sunset a mile or more out to sea. They are caused by an offshore wind, warmed by its passage over the still warm land, meeting the colder air over the surface of the sea.

Cumulus Clouds. Apart from likely hunting grounds, there are also positive indications of existing lift—rising smoke or even a circling bird. The chief sign that the pilot seeks is the presence of cumulus clouds (Fig. 18). These masses often fill the sky in summer and resemble mountains of billowing cotton wool. As the air rises it becomes affected by changes in temperature and atmosphere and the moisture in it finally condenses into a cumulus cloud. It is true that thermals are also encountered in open blue sky, but a cumulus cloud is usually a sign that a rising current has existed or is actually to be found beneath it. A cross-country flight may, therefore, consist of a series of hops from cloud to cloud. The force of a thermal usually increases as cloud base is reached. Within the cloud itself the up-current finds new life and the lift becomes stronger still. Clouds that are melting away or that have ragged edges or from which rain is falling do not normally produce up-currents.

The area of lift is not necessarily uniform beneath the base of a cloud. In fact, it is common to find a rising current under one edge and a downdraught on the opposite side. Downdraughts frequently exist in the space between clouds. They are thus quite often an indication of an approaching thermal.

Cloud Streets. Clouds sometimes form in long lines what are called *Cloud Streets*. Although the area of lift may be narrow, it is often possible to fly considerable distances along these lines of cloud, and circling becomes unnecessary.

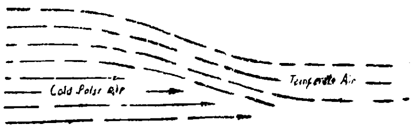

FIG. 19

The direction of the *street* may not coincide with the track of the intended course and the pilot must then switch to another *street*, making sure that he has plenty of height before doing so. The downdraughts between cloud streets are often severe.

Cold Fronts. In addition to hill lift and thermals there is yet another source of rising air. There are times when vast masses of air of polar origin suddenly flow down over the country like a cold draught blowing into a warm room. There are thus in existence *two* masses of air, the one cold and the other temperate. The colder air, being the heavier and denser of the two, drives in like a wedge beneath the warmer layer. As the cold wedge advances the warm layer is prized up and rises. We thus have a moving wall of rising air (Fig. 19).

The advancing mass of polar air is called a *Cold Front.* These fronts may extend for considerable distances and it is not uncommon for one to stretch across England. They can be forecast with considerable accuracy by meteorologists and have been the cause of many premeditated and succesful cross-country flights.

Storm Riding. The cold front is heralded by a line of rolling cloud. In the background the sky darkens and the clouds have ragged edges or skirts of falling rain. In the space between the warm and cold layers tremendous electrical forces are generated and discharges occur in the form of lightning. In these places the air is very distributed. Hail may be encountered and up-currents so violent that no wise pilot would venture into them of his own accord. According to experts, these currents may reach an upward velocity of eighty miles an hour—that is, some seven thousand feet per minute.

Strong rising currents may exist beneath the bellies of thunder clouds. A sailplane can be involuntarily sucked up into their midst—into a dark cauldron of hail, seething air and lightning. The sailplane is tossed like a shuttlecock and wrenched upwards with a speed that may defy all efforts at descent. All this happens in a thick, wet blanket of mist, and even when aided by blind flying instruments the pilot is not in a happy position.

In practice, cross-country flights are not usually made under such comfortless conditions. The proper place for storm-riding lies some distance out ahead of the front, that is, of the long wall of cloud. Here the sailplane rides forward as the cold front advances on a tide of *comparatively* smooth rising air. The best lift occurs before the centre of the front.

When at close quarters with this confused mass of cloud it is not easy to determine where the centre is or the exact direction in which the front is travelling. It may split in halves and the pilot must then make up his mind which is the proper half to follow. At other times a promising cold front may break up and disappear. There are no set rules in this game and the cross-country pilot can only develop his talent through constant observation and practical experience.

Warm Fronts. The exact opposite of a cold front may occur. A wave of warm air may flow in over colder surroundings. It cannot undercut the cold, heavier layer, so it flows upwards and over the top of it. The lift generated by these warm fronts is slight and generally insufficient for soaring purposes. Were a sailplane able to rise on this slow upward drift it could attain tremendous heights and fly considerable distances. The pilot would, however, spend most of his time flying blind through cloud.

CROSS-COUNTRY FLYING

Aero Towing. The start of these flights may be made from a high winch launch or from an altitude previously attained from hill lift. The most certain method, however, lies in being towed by a power plane until an area of lift is encountered. Aeroplane and sailplane are connected by a light steel cable that is flagged at intervals along its length. Both pilots have quick-release mechanisms.

As soon as the initial climb of the take-off is complete, the sailplane pilot takes up a flying position some twenty feet above the towing plane. He endeavours to hold this throughout his towed flight. He will need to keep an eye on the tautness of the cable; a slack sagging cable may result in a sudden snatch and consequent strain on the sailplane. An overtaut cable shows obvious strain. To correct slackness, the sailplane must slow down a little and this is accomplished by raising the nose. In practice, a light backward pressure is applied to the stick. Where the cable is too tight, extra speed is gained by a gentle easing forward of the control. Under proper conditions the cable should extend horizontally from the tail of the towing craft and then sweep through a gentle curve up towards the nose of the sailplane.

At some two thousand feet, or possibly before, good thermal conditions may be encountered. When he is satisfied on this point, the sailplane pilot releases the tow line and circles in the newly-found lift.

Retrieving. The question of getting home after landing is not the least of the cross-country flyer's problems. Helpers and good staff work are needed. Part of the equipment consists of a long trailer that can house the dismantled sailplane. The flight may be followed by car, and if a plan of action can be stuck to the trailer may be close to the spot where the sailplane lands. The pilot will, if possible, choose a landing ground that is conveniently near a road.

Together with the pilot we have reached the end of the set course. It has taken us well beyond any point that the learner can hope to reach during war-time. In doing so, I have tried to show the possibilities of motorless flight.

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