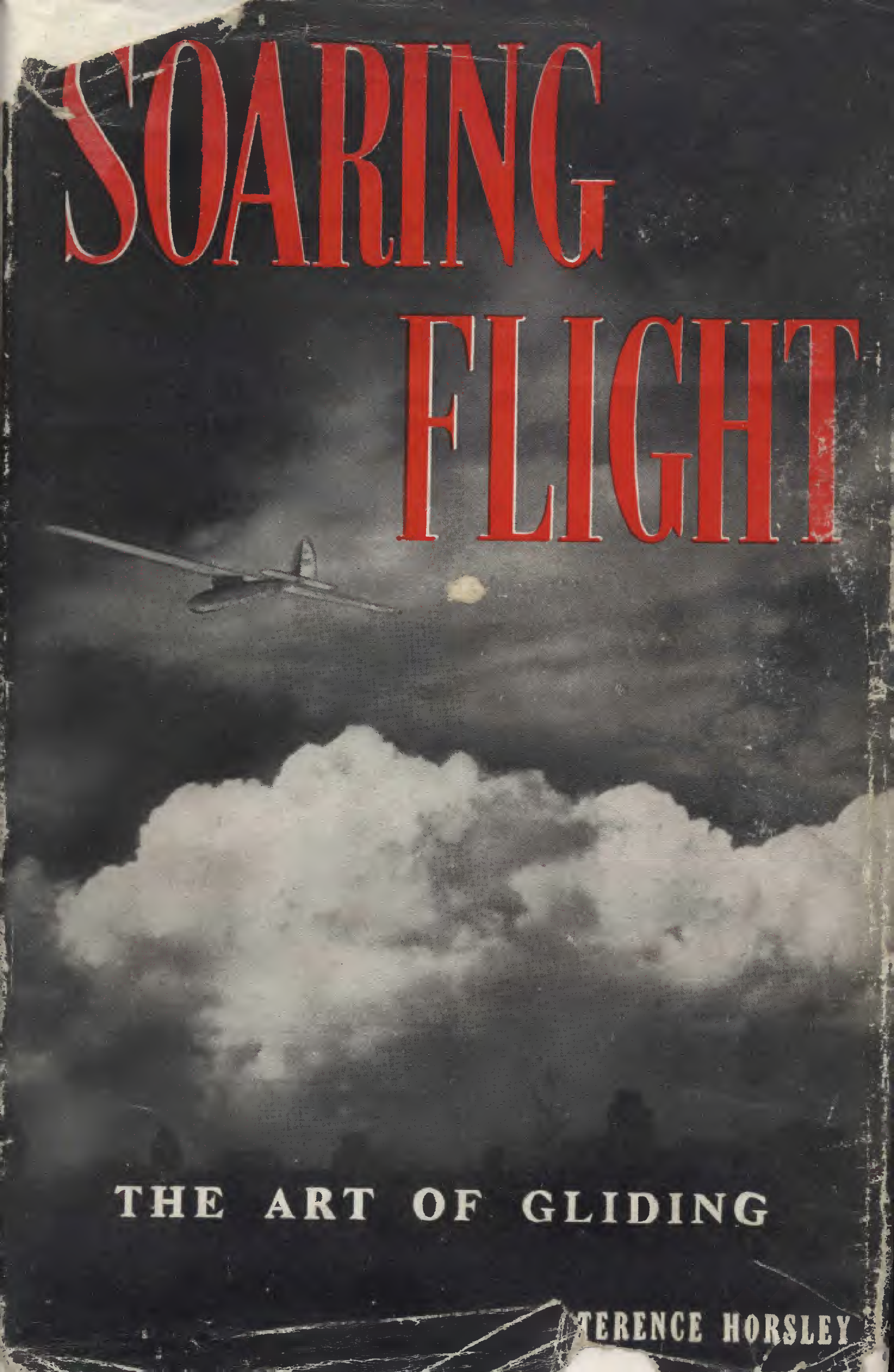

SOARING
FLIGHT
THE ART OF GLIDING
TERENCE HORSLEY

Ex Libris

From the Gliding Library of

Wally Kahn

SOARING FLIGHT

BY

TERENCE HORSLEY

Author of

FIND, FIX AND STRIKE

EYRE AND SPOTTISWOODE

LONDON

1944

Other Books by Terence Horsley

THE ODYSSEY OF AN OUT OF WORK
ROUND ENGLAND IN AN £8 CAR
NORWAY INVADED (WITH JAMES TEVNAN)
FIND, FIX AND STRIKE
FISHING FOR TROUT AND SALMON
FISHING OCCASIONS (*in preparation*)

THIS BOOK, FIRST PUBLISHED IN 1944, IS PRODUCED IN COMPLETE CONFORMITY WITH THE AUTHORIZED ECONOMY STANDARD AND IS MADE AND PRINTED IN GREAT BRITAIN FOR EYRE AND SPOTTISWOODE (PUBLISHERS), 15 BEDFORD STREET LONDON, W.C.2

CONTENTS

ILLUSTRATIONS

PREFACE

THE experts are unlikely to find anything in this book they don't know—and know better. It is probable that some of them will write to tell me so. A more cantankerous, aggressive, argumentative and loyal body of friends a man could not wish to have. All I ask is that they should leave me with my trousers.

In preparing the manuscript for publication, some of them have already been of great assistance, not only through advice and criticism, but through their generous contribution of drawings and photographs. I am specially indebted to Mr. J. S. Sproule, Mr. F. N. Slingsby, Dr. Alan Slater, Mr. Kit Nicholson, Mr. Philip Wills, Mr. Harold Perrin, Mr. Mickey West, Mr. Dudley Hiscox, Mr. Ashwell Cooke, Mr. H. Hastwell, Mr. Pat Miller, Mr. J. S. Barlee, and to the proprietor of *The Sailplane* for permission to reproduce numerous drawings and accounts of notable flights.

Finally, I am indebted to my publisher, Mr. Douglas Jerrold of Messrs. Eyre and Spottiswoode, for his courage and optimism in printing more consecutive words on gliding than anyone has ever dared to do before.

TERENCE HORSLEY.

ROYAL NAVAL AIR STATION,
ARBROATH.
September, 1944.

FOREWORD

By Rear-Admiral R. H. Portal, D.S.C.

Millions of people in this country are deeply interested in aviation: tens of thousands are actively engaged in flying. Where are we to find the outlet for this interest and spirit of adventure in the years to come, when the need of the Services for flying men, and women, has fallen to the level of peace requirements? The author of this book points the way in his description of the merits of soaring flight in gliders, not only as a fascinating hobby, but, by inference, as a training ground for the development of the qualities of courage, initiative, discretion and self-reliance, and as a school for furthering the "knowledge of the air" which is so indispensable to the flying man.

I have always thought that the gliding clubs bear much the same relation to the flying Services as do the sailing clubs to the maritime Services: they should provide the cradle in which the air sense of the nation is fostered, the community in which the kindred spirits meet and in which esprit de corps is born, and the playground in which the nation's youth can learn to live dangerously, and not too dangerously at that.

Those who are interested in the future of our flying Services, whether primarily in the Fleet Air Arm, the Royal Air Force or Civil Aviation, will hope to see a great revival and extension of gliding clubs. It appears certain that modern technical developments will add enormously to the opportunities for soaring flight and the pleasures to be derived from it: efficiency will undoubtedly be increased and costs should be so materially reduced as to bring the sport within the reach of all. This book cannot fail to arouse the interest which the topic deserves, and I am confident that it will be welcomed by those who are responsible for this country's future in the air.

IMMORTALITY?

I THOUGHT I had discovered immortality one day in 1938 when the heather-clad crest of Sutton Bank slowly began to recede below me. It was a triumph in three dimensions—physically over those whose white faces grew smaller and smaller as I rose away from them, mechanically over the force of gravity from whose grasp I was slipping, and spiritually over the bonds which bind the soul to the earth.

It was no fluke. A west wind of a bare walking speed was insufficient to support the weight of a paper bag on its wings, let alone a sailplane loaded with 200 lb. of human freight. It came stealing across the valley from Thirsk, leaving the leaves of the spinneys unmolested and spilling over the ridge without the strength to displace a hair.

Attempts to escape from the earth had been made many times that afternoon. As each fresh galleon of towering cloud drifted towards the plateau, another pilot would be whipped skywards on the end of his steel cable, and there, at 400 feet, pursue in desperate circles any upward current which would cut the cords binding him to the earth.

Each time, like a wounded bird incapable of further effort, he sank slowly back to the heather and announced with a shake of his head that it was "no good." The words were sometimes different, but their meaning was the same—that a wind of barely four miles an hour was insufficient for hill soaring at Sutton, even with a lapse rate as high as it was today.

Then my turn came. As I adjusted the Sutton harness, I determined to test the theory I had evolved as I lay back watching the sun glint briefly on the white wings of my competitors. The theory was simple and has no doubt been proved at other times. It was just that a rising air current was likely to be found on the other face of the hill—the face sheltered from the draught, where the shape of a great horse was cut in the turf and received the sun on its bare flanks. Here a hot bubble would accumulate in a breathless stillness and finally break away as its lighter mass overcame the stiction of its rocky anchorage. I hoped to catch it as it rose, an invisible bubble which would not stop until it condensed in vapour as a new cloudlet among the galleons 4,000 feet overhead.

And so it turned out. Two hundred of the four hundred precious feet which I had gained before dropping the cable had gone before I flew over the burning side of the horse. But immediately the smooth air began to toss in restless eddies. The theory was correct, and that moment a globule of invisible space was breaking away at the start of its journey to the clouds. In ever tighter circles I forced the sailplane into its core. It could scarcely have been more than 250 feet in diameter. Sometimes I flew out of it, and sank smoothly towards the steep hillside. But the gain in the rough air was outdistancing the loss in the smooth. The bonds which bound me to the earth were parting one by one. The needle of the altimeter advanced in tens of feet, until I felt it safe to take my eyes off the instruments and exult in the sight of white faces receding from me.

We were climbing in the centre of the "bubble" at a steady 5 feet per second. The hand of the altimeter crept round to 500 feet. Each surge of rising air became more powerful than the last and the smooth calms gradually disappeared, until all around me was nothing but a turbulent sea of invisible eddies, driving me faster and faster towards the purple foundations of a great cloud. The needle of the rate-of-climb indicator now kicked to 10 feet per second. The air grew colder, and the chill of it struck beneath my open shirt as the shadow of the peak overhead suddenly veiled the sunlight.

Down below the plains and moorlands of the North Riding revolved in a bowl of startling colours, from the river of green flowing out of the Vale of Mowbray into the Yorkshire plain, to the penultimate rim of the Pennines along the western horizon. And below, soon more than 3,000 feet, were the tiny splashes of white against the dark heather—the faces of friends who still looked up to see how I fared.

Although the gush of rising air had increased in strength, the lateral drift was still negligible. The outline of the white horse from which I had risen was on the perimeter of my never-ending circles, and the clubhouse buildings, the winch car, and the slim shapes of the other sailplanes at rest on the plateau were only visible while the bank of the aircraft gave me a vertical view.

Then the breath of the cloud reached down and drew me towards it. Not only were my bonds finally severed, but I was entering a darker world which was shut off from warmth and human companionship. I was now flying round the purple sides of a great inverted bowl. If I looked down, I saw out of the mouth of the bowl a receding circle of sunlit earth, every minute narrowing and constricting. The base of the cloud was not flat, as it had looked from below, but concave.

Within a few seconds the last link with the ground was cut, and it was time to concentrate on the instruments. It would have been easier had my craft been fitted with the full blind flying panel enjoyed by the air liners and the war planes. This was a wild, uncharted ocean to navigate with a mere A.S.I., a level bubble, a compass, and a variometer. It was made no easier by the increasing turbulence of the air, which at one moment gave me a climb of more than 20 feet per second, and the next showed a neutral reading. It was difficult to hold the level bubble central and to keep the air speed at the steady 35 miles an hour which denoted the best gliding angle. It grew very dark, and the compass card began to swing in fits and starts, which was the first sign that my circles were no longer steady. The A.S.I. began to play tricks, too. Within the space of a few seconds it dropped to 20 m.p.h. and rose again to 60 m.p.h.; and while the wind mounted to a shriek I glanced towards the wing tips, just visible in the mist, and saw them flex.

It was time to get out of the cloud.

I centralised all controls and waited. It is the only thing to do when nausea and careering instruments rob the senses of their balance—unless you force the aircraft into a spin with rudder and stick, and thus sacrifice your hard-won height. I held everything central. The situation was by no means lost, and as the compass steadied down, the light increased and the aircraft rode the currents more easily.

It was only a matter of moments before I broke out of the side of the cloud. I came out suddenly, like passing through a wall. I was on the sunny side, in the midst of a warm river of light, overhung by the bastions of vapour which still reached for many thousands of feet overhead. The air was smooth, the vault of heaven an unfathomed blue, and below it, half-seen and almost unreal, the earth spread out in a patchwork quilt. The ghoulish winds and the darkness of a few moments ago dissolved into a far-away memory.

I turned through 90 degrees and cruised along the mighty cliff from which I had just emerged. The altimeter stood at 4,500 feet, and of this we were losing about 200 feet every minute. There was not a ripple in the luxurious air, and as it passed around the hull and over the wings, it trilled in a clear flute-like note. For the moment it was pleasant to sit back, let the sun and the wind play on my face, and watch through half-closed eyes the drifting walls of our bastion.

It would have been easy to have turned again, and, like a mountaineer determined to reach the summit, have clawed a way aloft through the darkness of the cloud. But I lacked ambition, and when we sailed past a jutting point to leave the cloud behind, I headed onwards across the empty sky.

I broke the feeling of detachment by peering for a moment more closely at the earth in order to check my track. The launching site was well astern, and I was travelling eastwards up the Vale of Mowbray, with the wide roofs of Ampleforth College cutting a small pattern out of the green. My course would serve, for I was moving downwind, and the coast was still far enough away.

It was necessary soon to think of winning more height, and I chose a cloud directly ahead for the purpose. I was, perhaps, a thousand feet beneath its base when I reached it, but, true to type, it quickly produced its quota of restless airs, and soon I was circling again and climbing. This time I stopped at cloud base, which was at a little below 4,000 feet, and turning eastwards again steered towards yet another galleon. Each voyage from cloud to cloud cost up to 1,500 feet, but every time I won back the loss.

After flying for about an hour I saw to the north the red roofs of Kirby Moorside, and beside them the green oasis of Welburn aerodrome. I began to wonder if I could reach it, for there were friends there, and tea, and, what is more, willing hands to help me dismantle the aircraft preparatory to towing it back to Sutton. I was suddenly very mundane, like an angel that had tired of heaven.

Unfortunately, there was not a cloud in the sky by which I could get a lift should I have insufficient height to make the journey in a straight glide. There was a fine cumulus over the aerodrome itself, but its help would arrive too late. I thought, however, we could just reach port, and so I shaped a straight course across the wolds.

I was down to 2,000 feet, and I knew it was going to be a near thing, when a shudder ran through the aircraft. I held on for a second, and it came again, a restless shaking which denoted a rising current of air. It was as welcome as it was unexpected, for there was no cloud overhead and no sign that a thermal might be expected. Quickly putting on bank and rudder, I began to circle. Once again I climbed, smoothly and pleasantly, until at 3,000 feet I knew I had enough height to complete the journey. Over Welburn I should, perhaps, have landed immediately. I was at 1,000 feet, but even as low down as this the great cloud which still hung over the aerodrome was tugging at the wings. I made a rapid and last climb to 4,200 feet, and came down in a series of stalls and dives, cutting finally through the liquid warmth of the lower airs to a smooth landing on the green field.

As I stopped, and figures began running towards me, I had the illusion of victory. It was only an illusion, of course, like the cool lake which grows out of the sand before a lost traveller can die of thirst. But for the moment it was real. It was the thing for which every human being strives—a victory over the earthiness of our bodies and lordship over mortality.

AIRBORNE

AS a small boy I watched the birds and wanted to fly. At school I wanted to be captain of the "rugger" team. In adolescence I read Rupert Brooke and wanted to be a poet.

If a man goes on exchanging his ambitions long enough, there's a chance of him becoming either a flier or a farmer. I have enjoyed as much ambition as the next man, and it has not only been a natural lack of ability which has prevented the fulfilment of it, but a rising conviction that most of it was misplaced.

A mother in the midst of cooing to her baby son expressed the possibility of him one day becoming Prime Minister. There was nothing outrageous in the idea, for his father was a clever fellow, but her tone suggested that it was a desirable end for the little fellow. Oh, Absalom, my son, my son! In this passage through the veil of tears we are slow to learn. Politicians are ten a penny and only murderers and contented folk are rare. Who has not seen a Minister dodging questions like an unsuccessful actor tomatoes, or at least betraying by the restlessness of his hands over the buttons of an impeccable waistcoat the fate which awaits a man who confuses service with ambition?

I once went to dinner with a financier in search of missing millions, and at the end of it I felt that the measure of his success was the skill of his chef. Another potentate upon whom I looked with awe for years was discovered as I grew to know him with a mind so compressed into a single channel that he must have been a great bore to himself when he was alone. When he retired the vacuum of his mind asphyxiated him and he died.

Nor does the pursuit of pleasure when it is mounted on a million or two always give fair value. Pannier-laden ponies climbing over purple moorlands to unload excessive lunches after hurricanes of grouse have swept over the butts are as great a source of indigestion as satisfaction, while a hundred cartridges expended at a pheasant stand is not proportionally more exciting than a single shot fired from a hide on the edge of a bog at flighting duck. Yet there has been much of this, and there will be more of it before our old standards are adjusted.

The less exalted have revelled in title fights, speed records, murder trials, pit disasters, de-frocked clergymen on exhibition in coffins, race meetings and cup-finals—and a good many other things besides. I have had the reporting of most of them at one time or another, and have sometimes wondered how long the old-world fabric would last with so many corner-stones knocked from under it. Maybe war has been the reaction, like a rash which is the excretion of an unwise diet.

In 1939 there was little craftsmanship in the land. We had grown accustomed to the shoddy and the temporary and were too weak to demand good workmanship. We could not use our hands beyond their ability to drive a car or pull a lever. Left to fend for ourselves in a world shorn of its machinery, we would have starved. Most of us could neither cultivate the land nor hunt nor fish. The principal ability of the most highly developed examples of mankind was the mass direction of their fellows into willing enslavement. The sights and sounds and secrets of the earth were receding from a people whose heritage they had been for a million years. Efforts to escape at week-ends by driving small cars along concrete highways and peering through unbreakable glass windows at the green world on either side were not completely successful. I could have understood it if it had been urged by a lust for speed, but we drove decorously in columns. Perhaps we enjoyed the illusion of escape, for back at work on the following day we would hum or whistle over our machines. As dope to the remains of individualism, entertainment was laid on by the hour—canned music and canned pictures—while canned sentiment was turned out daily by female columnists in sugar-sweet doses. Oh, Absalom, my son, my son!

A wise old friend who took his pleasure in long tramps across the Cheviots discovered something one day to which his own enormous personal success had not blinded him. While I never appreciated his passion for wearing out shoe leather, I agreed that at least one of his lonely walks had been worth while. He fell into conversation with a shepherd on a distant fell. The sun was hot and the place far from an inn, and when the shepherd suggested that he might like a cup of tea at his cottage, he accepted.

"Go up yonder," said the shepherd, "while I round up these sheep; I'll follow you."

So my friend climbed the hillside and entered the white-washed cottage, where he sat himself down in a rocking-chair and looked around him. It was a small room, lined to the ceiling with books, and on the backs of the books were the names of men who had founded a greater literature than the world has known in two thousand years, and their tongue was Greek.

And when the shepherd came into the room and my friend pointed to the books, the old man nodded, giving the explanation that in the winter the nights were long and reading was a way of passing the time.

"You read Greek?" said his visitor.

The shepherd nodded, and when my friend pressed him he told an unusual story. It was the story of a family who for generations had lived and died as shepherds among the hills, so that either the hills or sheep or both were in their blood. But as a boy this particular member of the family was blessed with an inquiring mind and an infinitely retentive memory, so that scholarships fell into his lap almost as fast as apples in the autumn. From a village school to a grammar school and thence to the university were sensational but inevitable jumps. And in due course the shepherd's son was offered and accepted a fellowship of his college. For three years he sat in the seat of learning, lecturing in the classics which had been his love, and while he lectured the small voice of the hills kept whispering in his ear. And after three years he resigned, packed up his books, and a few weeks later set them up on the shelves of this room, where they had remained ever since—save on the winter nights, when for a while one of them would be carried to the firelight by the rocking-chair.

It is not the luck of most of us to find a niche so easily. But in the secret places of our hearts there is recognition of the need of it. My personal groping took the usual course of searching for an outlet in forms of violent exercise—passions which accounted for the expenditure of thousands of hours in such pursuits as ice-skating, squash racquets, rugby football, and golf. But these things were of the body, and the spirit enjoyed them only indirectly. The most perfectly hit tee-shot or nimbly executed scissors jump fails to reveal anything deeper than a pleasant sense of timing, while squash racquets and rugby football ultimately degenerate into a losing battle of endurance against advancing age. I even tried playing chess, to discover that the mind and the spirit are not the same thing.

So I think that the ordinary man must inevitably gravitate towards things of the earth. It is here that he will find truth and friendship, and maybe something more. The logical outcome is that we must all eventually become farmers—a prospect which three years spent in carving a garden out of a piece of virgin ground fills me with less alarm than it may some others. Apart from the garden episode, I slid downhill by a thousand hours or so on rivers and lochs—most of them at night—in pursuit of fish. While no one will ever persuade me that the soul of man does not react to the heavy plop of sea-trout in a starlit pool, I think that the challenge of the skies thrown out to the pilot of a motorless aircraft is one equally acceptable. That at any rate is my present state of mind and is the reason for this book.

I am not of a seemly age to be forthright. But in this instance the temptation has been great and the desire to write while the rose smells sweet irresistible. In writing I realise that I shall trespass even farther than I had originally intended, for the subject of soaring flight is so bound up with the wide heavens and their meanings that experience of them acquired while temporarily flying an aeroplane for the Fleet Air Arm cannot be left out. I only hope that reference to it will not bring down on my head the accusation summarised in the war-forged phrase of "line shooting," but rather that it will be taken as useful evidence of the character of the sky, first suspected and then learnt in sailplanes. I have spent about a thousand hours in the air, and what I have learnt of its tricks, its hates, its loves, its beastliness and its glories has partially come out of Service experience.

I think it is proper to say that I am under no illusions about flying. I know without being reminded that he who flies will, sooner or later, wish with all his heart that he didn't. Maybe the moment will come on some dark night when the radio has "packed up" and he is lost: maybe in a fog when an oily sea and the belly of his aircraft are as close as bed-fellows, or as likely as not in a sailplane in cloud, when aching eyes through the strain of instrument flying and a pitching seat have added vertigo to a desperate weariness. I know all this, but I know, too, that the next morning he will wake up and, looking into the sky, feel an urge to be there again.

So I am impenitent, believing that even slender experience may add a tithe to the sum of knowledge. More particularly do I believe that it may add to the world's pleasure, and that such excursions as I have made may be a sign to others. I have known the insidious lethargy which can overtake the human soul whose body is imprisoned in the canyon of a city street, and there will be many bodies, once free, which will be so imprisoned. We have only a little time in which to escape, and perhaps I hold a key.

Soaring is actually no farther out of reach than the first tee at a golf club. In pursuit of pleasure man will go farther and spend more money than is demanded for a place among the clouds. Moreover, he has shown himself in war to be frequently fearless, often enduring, and not seldom capable of perceiving a vision which extends beyond the earth at his feet.

I have known faint hearts express the sincere belief that the sky belongs to the immortals who wear wings on their tunics. I am certain that the sky is ready to receive even an object who has spent forty years beneath a bowler hat. I have known men of sixty who started to fly in engineless aircraft and discovered that living was by no means done.

I made the discovery for myself only after I was thirty. It was one silent summer evening on a Derbyshire moor. I had gone there to see the new sport of gliding. The moorland top that night was dotted with human figures who worked like ants, dragging the slim shapes of their motorless aircraft to the cliff edge, where they were catapulted into space, or arranging them far back on the plateau, whence they were snatched into the sky by a steel cable, to be left suspended over the purpling valley a thousand feet below.

It was B. M. who asked whether I would like a trip. There was a two-seater available, and because there was a mystery phenomenon abroad at that moment—a mystery called an evening thermal—he was to be launched immediately.

The two-seater sailplane of those days was a crude machine compared with the streamlined dragon-flies which came later. It had a square, fabric-covered fuselage, while a single high wing was supported on struts. I took the rear seat, and listened to the clank of the safety link as B. M. tested the cable-release gear. Then in a moment a flag dropped and the cable tightened. We were snatched into the air after a few bumpy yards on the skid, and were climbing steeply like a kite hauled into the teeth of the wind. Four hundred yards away a winch was reeling up the wire at a speed of 30 miles an hour, but all that I could see was the sky, and all that I heard was the flute-like noise of the wind in the rigging and the creak of timber as the fuselage absorbed the tractive power of the cable. When we were almost directly above the winch my pilot pulled the ring on his instrument board, and the wire was released. Leaning over the side, I saw it coiling down to earth like a great snake, while beyond it I looked along the dark line of the cliff edge. We were passing across it now and sailing out over the deeps of the valley, deeps from which the sun had already withdrawn.

We were free, poised in almost perfect silence, as though in suspension between the floor of a translucent ocean and the rippled surface on which other sailplanes floated hundreds of feet above. As I have said, it was a special evening, a moment of the lifting of the valley airs upon which a sailplane could ride without the buffeting of wind.

B. M. turned our craft towards Castleton, and steadily climbing through the silence made out across the valley. The smoke of a chimney stood straight up from below like the column of a temple; the great lozenge-like trees were motionless in a warm hush; the cattle browsed at all angles, lacking the direction of a wind.

Never before or since have I experienced such a sensation of perfect flight. We climbed from 400 hundred to 2,000 feet in a few minutes, wafted through a veil of liquid gold towards the west. Once we passed close to another craft, from which the pilot gave us a great shout of greeting. So might two gods have called to each other from their kingdoms. For half an hour we cruised, almost as far as the black brow of Mam Tor, and back again over the hamlet of Hucklow. By then the thermal was dying, the lift from the valley departing, and soon B. M. brought the ship down to an effortless berth in the heather from which we had sprung. At that moment I swore that I would master the sailplane pilot's art, and it was on these airways between Mam Tor and Bradwell Edge that I served my apprenticeship.

If I have introduced soaring at the level of a heavenly vision, it is because this particular memory of it is on that plane. The conditions above the Derbyshire moorland that night were rare. They come round only three or four times a year, and if you happen to be ready for them, and the volunteer ground crew are ready too, then you can enjoy perfect flying. More often the attainment of freedom is the result of battle with wicked eddies, often a groping through clouds in which your head reels and you wish you were safely back on the ground. Nine times out of ten height also means cold, and as its achievement is frequently unexpected, you are liable to find yourself flying in a summer shirt in a temperature which is below freezing point. Even more often, the upper air stratas are barred by a roof of lifeless cloud, and the limit to soaring is the narrow channel along the crest of the home ridge. Equally possible is a wind from the wrong direction which prohibits any soaring at all. But I paid my subscription to the Derbyshire and Lancashire Club that night and began my education.

THE AIRCRAFT

THEIR slim shapes are smooth to touch and slippery like ice. Their rounded backs catch the light and reflect it like polished glass. Their curves are symmetrical, continuous, and blended into one another as geometrical designs which are happily married. When their wings are against the sky they are transparent, and you can see their ribs against the light beyond. No bird had better-shaped wings, no wings were ever spread in such a challenge. To see them is to know that they can fly. It doesn't need a designer to talk about aerodynamics and to prove with figures that their lift is so-and-so and their angle of glide so-and-so. It is clear that they belong to the wind and the sky and that they are part of it as much as the clouds of a summer day.

The perfection of their shape is the secret of their efficiency. Added to this is the perfection of their finish. It is not always realised how damaging even a screw-head can be to the air current which flows over it, how the friction between the very air and the sides of an aircraft can mount up and create drag. I remember one grey day when the wind was blowing warm and softly over a ridge how the sailplanes came in one by one, defeated by the light airs. Then one pilot, narrowly failing to soar, found furniture polish and rags, and went to work on the bright panels of his aircraft and then on the wings until they gleamed in the dull grey of the day. And, finishing at last, he was launched again, and flew and climbed, and held a full hundred feet above the ridge. It may be difficult to believe that a little clinging dust could make the difference between being earthbound and airborne; but today there was proof of it, and for those who are more scientifically minded it is an established fact that $\frac{1}{2,000}$ inch of dust can break down the laminar air flow over a surface into a turbulent flow.

A clean design is the draughtsman's aim. But the design can be improved by the finish. The lovely shapes of fighters may be nearly perfect, but their skins are far from peerless. If the rivet heads on fuselage and wings are smoothed, another ten or fifteen miles an hour can be expected at full speed. If the

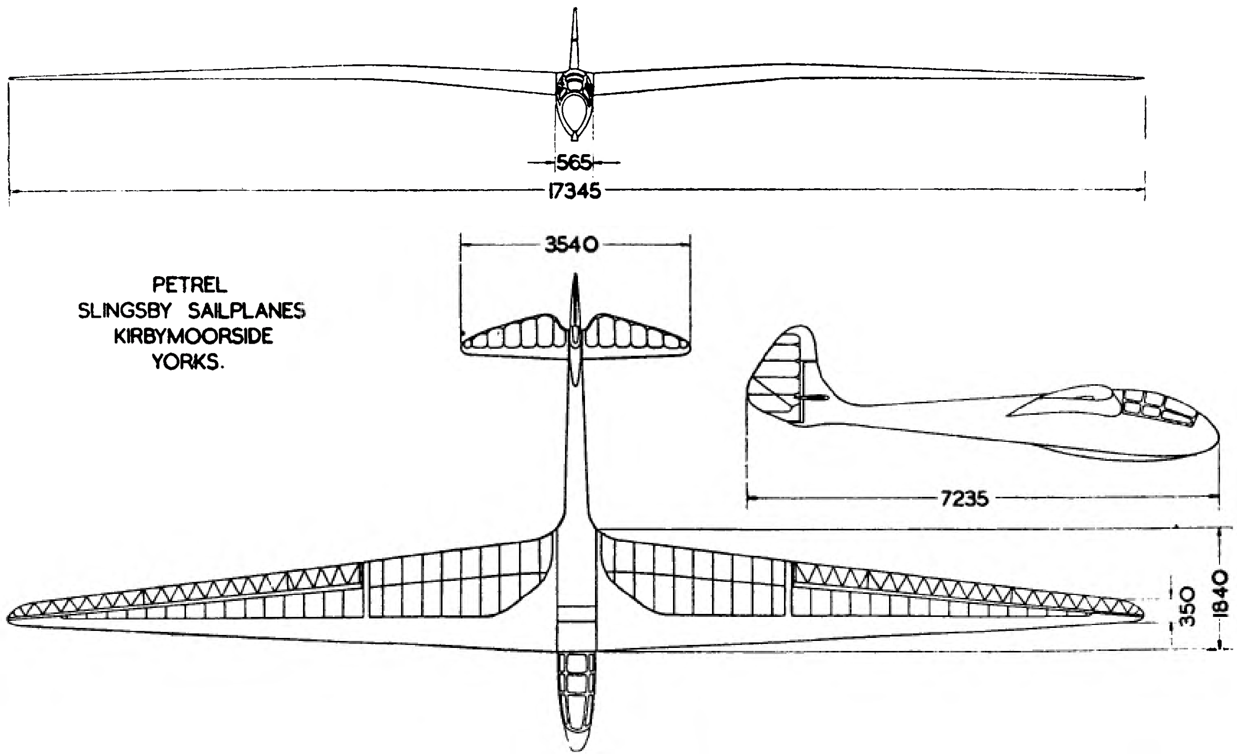

565
17345
3540
PETREL
SLINGSBY SAILPLANES
KIRBYMOORSIDE
YORKS.
7235
350
1840

Fig. 1.

whole aircraft is swathed in some hard jacket of bright varnish, further speed is discovered. This is the degree at which the sailplane designer aims.

In the history of aviation many hundreds of aircraft have been taken from the workshops to the testing fields. None of them which have been basically ugly have survived to build a great name for themselves. Maybe it is a high-placed tail plane which breaks the symmetry of the design, or the broken flow of the fuselage at the pilot's cockpit, or the ugly placing of the flaps. Whatever it is, it is plain to the man with half an eye, and the thing which looks wrong will prove wrong.

The Spitfire is a work of art. Modelled in silver or gold, it might be an ornament pleasing to any generation—on the altar of a Grecian temple or in a Roman villa. The best sailplanes are as worthy, and because there has been no need to fit their wings with cannon, or stress their bodies to withstand the strain of high speeds, their sleek surfaces are of finer finish and their streamline more complete. Hence, by comparison with any powered aircraft their efficiency is higher.

In a preliminary test of the Slingsby Petrel, it was estimated that the range of this glider in still air was over 12 miles from a height of 2,500 feet. The difference between the gliding performance of a Spitfire and such a sailplane is shown in the table of approximate comparative figures on the next page and below.

FIG. 1.

PETREL

First produced in 1939, a British high-performance sailplane.

SPAN	57 ft.	STALL	29 m.p.h.
ASPECT RATIO	14	RATE OF SINK AT 35 m.p.h.	1·8 ft. per sec.
WEIGHT	385 lb.	GLIDING ANGLE	1 : 25
WING LOADING	4 lb.	SPEED RANGE	32-70 m.p.h.
ORIGINAL PRICE	£260		

Note.—All measurements in the drawing are in millimetres.

Petrel.	Spitfire.
Span, 57 feet	37 feet
Loaded weight, 600 lb.	6,000 lb.
Rate of sink, 1·8 feet per sec.	20 feet per sec.
Angle of glide, 1 in 25	1 in 8
Stalling speed, 29 m.p.h.	80 m.p.h.
Wing loading, 4 lb. per sq. ft.	40 lb. per sq. ft.

The Petrel and other sailplanes like it are the product of the cabinet-maker's art. Built of silver spruce, with a stressed plywood skin, faired and polished, they have the aerodynamics of an arrow. Of necessity, being without an engine, they must fly "downhill." But the gradient which will give them flying speed is so slight that they appear to be flying straight and level. For the man sitting in the cockpit a small forward movement of the control column depressing the nose a fraction further will cause the speed to increase as though the aircraft had been put into a violent dive. To double the speed the downward angle of the nose is increased so slightly that were this a motor-car on a smooth road it would be almost insufficient to start it rolling.

The cockpit of all high-efficiency types is totally enclosed, forming a cabin into which it is just possible for a large man to squeeze. The pilot's parachute is strapped to his back and forms a cushion in a recess behind him. To abandon the aircraft it may be necessary to jettison the cockpit cover.

The controls—and they are the same for all sailplanes—consist of a stick and a rudder bar. At any speed above the stall the control they exercise is absolute. They are light—two fingers will operate them—and they are as positive and as instantaneous in action as in a fighter at 250 m.p.h. Provided that the aircraft has speed, any aerobatic may be performed. To loop, the nose need only be depressed until 70 m.p.h. is reached. Thereafter it can be flown round the loop by easing back the stick. If the nose is pulled up, and rudder applied as the aircraft stalls, it will fall into a stall turn or a spin as desired. To come out of a spin, a touch of opposite rudder with the stick central will bring it out immediately. If the aircraft is dived its streamline will make a zoom possible until nearly all the original height has been regained. At high speed vertical banks and flick rolls can be executed, and on half a dozen occasions a pilot braver than most of us has done an inverted loop. All these things are accompanied by an organ-like note of the wind—a deep, pure sound which is lovely to listen to.

The instrument panel is neat and simple. There is an air-speed indicator reading from 20 m.p.h. to about 80 m.p.h., a compass, a fore-and-aft level indicator, and a variometer—the latter an exceptionally sensitive rate-of-climb indicator showing descent or climb from 6 inches to 20 feet per second.

This little instrument is so important that a brief description of how it works is worth recording. The absence of it held up British progress in thermal soaring for many years.

It depends for its operation upon an air container in which there is a leak—such as might be typified by an electric-light bulb with a small hole drilled in it. Any change in the pressure of the outside atmosphere is balanced by the passage of the requisite quantity of air through the leak. The vessel is connected by a tube to a measuring device which records the quantity of air which passes, and in the simplest type of variometer this takes the form of two glass tubes of very small diameter. Enclosed in each tube is a featherweight coloured ball which is lifted off its seat by a current of air. One tube is actuated by a current passing into the main container, and the other by a current passing out. The tubes are, in effect, the leak.

For the sake of heat insulation, the container itself is usually a vacuum flask such as might hold hot coffee upon its lawful occasions. The idea is that the air should not pass from it owing to expansion or contraction due to sudden temperature changes, but only due to a change in the outside pressure. A rise or fall of 2 or 3 feet on the part of a sailplane will provide a pressure difference between the inside of the vacuum flask and the outside air sufficient to set up a current through the tube which will, on its way, lift one or other of the coloured balls from its seating. The glass tubes are calibrated in terms of feet per second, and usually register from 6 inches to a maximum of 20 feet. It is an inexpensive and remarkably accurate instrument—so long as it is not expected to record such descents as are made in the power dives of Spitfires or

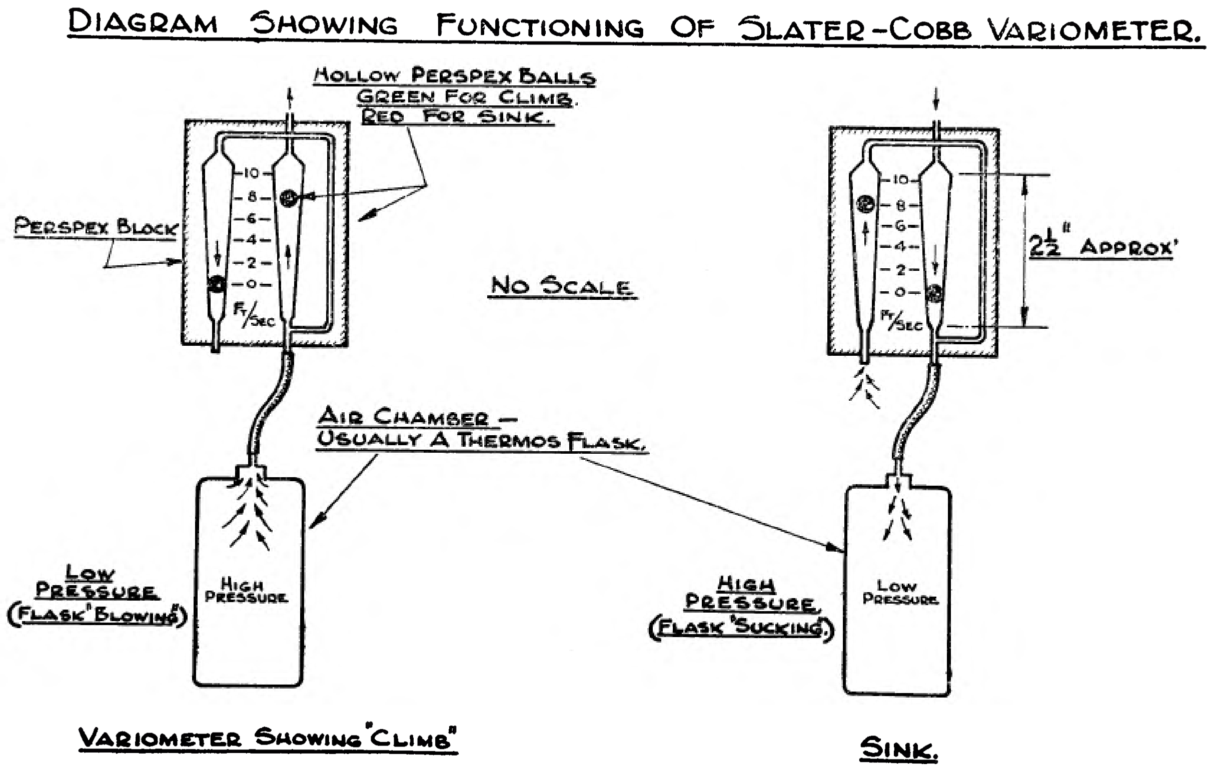


DIAGRAM SHOWING FUNCTIONING OF SLATER-COBB VARIOMETER.
HOLLOW PERSPEX BALLS
GREEN FOR CLIMB.
RED FOR SINK.
PERSPEX BLOCK
10
8
6
4
2
0
FT/SEC
NO SCALE
2½" APPROX'
AIR CHAMBER —
USUALLY A THERMOS FLASK.
LOW
PRESSURE
(FLASK "BLOWING")
HIGH
PRESSURE
HIGH
PRESSURE
(FLASK "SUCKING")
LOW
PRESSURE
VARIOMETER SHOWING "CLIMB"
SINK.

FIG. 2.

by corresponding rates of climb behind a 2,000-h.p. engine. A theoretical diagram of its working principles is given in Fig. 2 on the opposite page.

Refinements are fitted for blind flying consisting of an electrically driven turn-and-bank indicator, and perhaps an artificial horizon. In power aircraft these instruments are driven by the wind pressure, but the flight of a sailplane is so slow that dry batteries and small motors are used.

Without instruments, such craft cost before the war about £200. The minimum instruments required were an additional £15, while for a more complete blind-flying panel it was possible to spend £100 or more. The latter figure is ridiculous, and is due to the artificially high price demanded, and unfortunately obtained, by the industry.

The only other vital accessory on the panel is the quick-release ring—a device which slips the towing cable at the end of the launch, and of this I shall have more to say later.

In the floor of the cockpit are two levers. One of them raises a slat in either wing, and has the effect of spoiling the lift, and so increasing the rate of sink when coming in to land. Without such a device, a high-efficiency aircraft would float for a considerable distance although only a few feet above the ground. The application of the spoilers destroys this otherwise advantageous characteristic, and makes landing in a small field simple and safe.

The other lever applies a brake to a small wheel which is recessed into the skid. Used coarsely, it will draw up the aircraft on a level field in a matter of 25 yards.

Between this and the primary type of trainer, costing in 1939 about £50, there is a gulf. As the price decreases, the cleanness of the design deteriorates. The open primary trainer is a poor-looking contraption, and, like all things ugly, is inefficient. Although its weight is not more than 200 lb. its rate of sink is about 10 feet per second, while, if the nose is depressed, this rate increases considerably without a corresponding rise in flying speed. On the other hand, it is cheap, easy to repair, and an ideal aircraft for the rough-and-tumble of instruction.

Intermediate gliders, such as the "Grunau" and the

Slingsby "Kite," combine a certain loveliness of line with quite a good performance. Costing pre-war about £140, they have nearly everything which the high-efficiency machine possesses except "penetration." That is to say, they are efficient at their best speed of about 33 m.p.h., but fall off rapidly, and at 50 m.p.h. develop an alarming rate of descent. Hence, for cross-country flying or flying upwind they cannot compare with such aircraft as the "Petrel," the "King Kite," the "Minimoa," the "Rhönsperber," the "Viking," and many others of the top class.

At their best angle of glide the rate of sink is between 3 and 4 feet per second. Their gliding angle is round about 17 to 1, while their weight empty is about 250 lb.

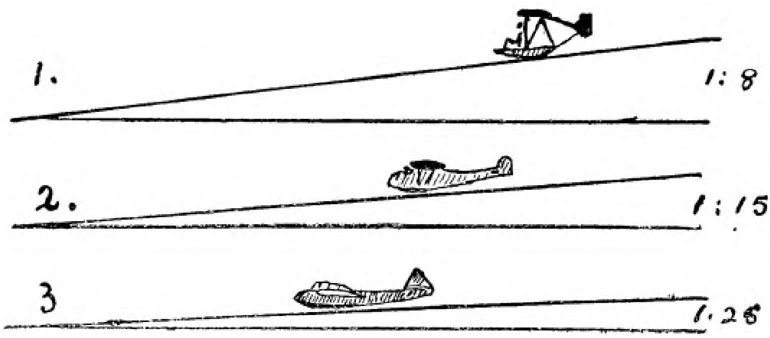


FIG. 3.—*The top drawing illustrates the approximate gliding angle of a primary. The "intermediate" shown in No. 2 has a considerably flatter glide path, while the high-efficiency type (No. 3) almost appears to be flying straight and level.*

All these aircraft are easy and quick to dismantle. The wings and tail planes are usually removed by the withdrawal of four pins, and smart work by a crew of three should dismantle an aircraft for packing in its trailer in 10 minutes. Equally smart work should rig it again in 15 minutes. The advantage of such simplicity after a cross-country flight, when the aircraft must be dismantled in order to be taken by road back to its base, is obvious.

Multi-seat gliders have been designed for troop carrying, but for sport and pleasure we have never gone beyond the two-seater. The best known of these is the Falcon III, which is a side-by-side machine with a span of 58 feet weighing

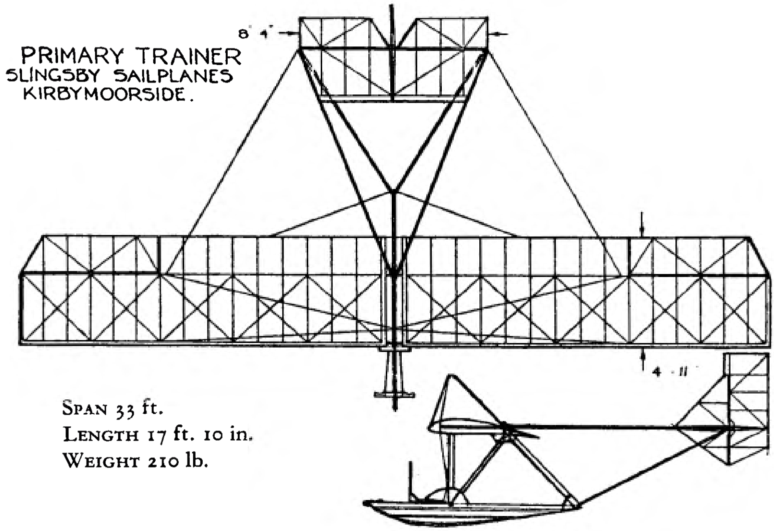


FIG. 4.—*The primary type of trainer in almost universal use. Its "vices" are nicely balanced, so that it will stall, spin, and slip when the controls are mishandled, thereby making it an excellent craft for learning. A glider which was completely stable would never teach a pilot anything.*

about 900 lb. with its passengers. It flies best at 35 m.p.h., but loses its efficiency at speeds of more than 45 m.p.h. The performance can be compared with intermediate types of sailplane. Just before the war new types of high-efficiency two-seaters were being developed, and the future will undoubtedly see multi-seat aircraft with the slim lines of the Petrel or Minimoa, and the same wonderful performance.

Most of these aircraft, whether single or two seaters, land on a hardwood skid mounted on rubber blocks beneath the fuselage. But the heavier types are often launched on a small undercarriage which is jettisoned as soon as the aircraft is clear of the ground, or on a single wheel of their own.

Troop-carrying gliders are a different proposition. They have been designed to carry great weights, and with the sole object of depositing them from a height as gently as possible on to the ground. Their soaring characteristics have been ignored, and from that point of view they are inefficient. The Airspeed Horsa, of which details have been released, is a typical example of this type. It weighs 15,000 lb. with 25 troops, has a wing span of 88 feet, and employs a tricycle undercarriage which can be jettisoned for landing on rough ground. A feature is the very large flaps which can be operated for a slow approach at a high rate of descent.

Such aircraft have little interest for the genuine glider pilot. It is another weapon of war, and an ugly one. While it may one day earn a place for itself in peace as a cargo carrier, it has no part in this book.

TECHNICAL

AFTER reading what I have written on the aircraft, a dormant conscience has arisen and stabbed me in the back. The panegyrics on sailplanes have the same brittle polish as their subject—good enough if you are writing fiction, but deceptive if you intend it for a background of precise knowledge. Conscience, therefore, inspires these further words on the aircraft and their efficiency, and in writing them I grow aware of the approach of a bogy which is a bigger menace than even conscience. It is the technical bogy which can lead the author as well as his clients into a bog of figures from which there is no escape inside a thousand pages—long before which his clients will have been lost. On the other hand, some sort of a technical background which is more mathematical than fine words will be most helpful, and in so far as this can be conveyed without a single formula, I feel that I must be momentarily scientific.

The word "efficiency," which has already been used and is likely to be used many more times, requires further explanation. Most of us know what it means when applied to office boys, but it should be elucidated as it applies to gliders. In the sailplane sense, it means the ability to fly "downhill" at a narrow angle while losing a minimum of height for the distance covered. It can best be expressed in terms of gliding angles, rates of sink, and speed. While reference to these qualities has been made, it is worth bringing them together again for a clearer understanding. Hence let it be repeated that a sailplane with a claim to efficiency will be capable of—

1. Flying for 25 feet in a forward direction while losing 1 foot of height (see Fig. 3).
2. Losing height in relation to time at the rate of 2 feet a second.
3. Retaining the first two qualities when the speed is increased by steepening the glide. Expressed in figures associated with the highest class of sailplane, this means that when the minimum flying speed is doubled the increase in the rate of sink is roughly proportional.

So far so good. Something very clever has obviously been achieved. An aircraft with a remarkable gliding angle which makes gravity look like a back number is an accomplished fact. But I have omitted the particulars of how so great an achievement was reached—how, in fact, the things fly at all. We have been progressing at a rare gallop, and it is time to learn to walk.

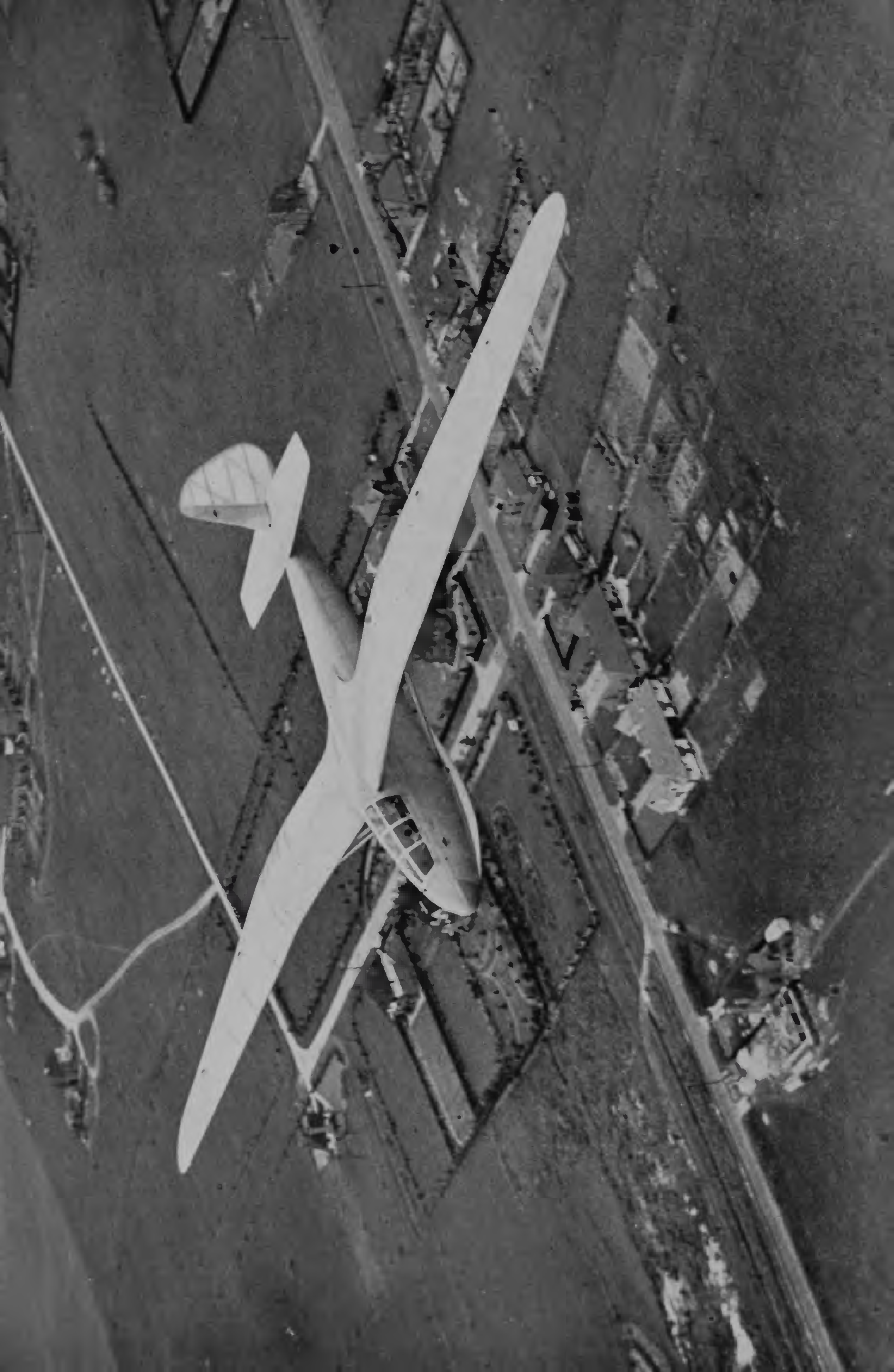
If one were to try to answer the implied question, the reply would be in two parts. The first would give a reason for successful flight and the second a fuller explanation of efficiency.

If you decline to have anything to do with mathematics, there remains the visual evidence of birds and their relationship to sailplanes. The clear deduction is that both fly because they have a wing suitable for the purpose. The fuselage or body, the control surfaces, and the other bits and pieces, are so much dross. The bird or glider flies because it has a wing, whether made of silver spruce and fabric or flesh and feathers. It is the passage of this wing through the air which provides the lift to keep the rest in flight.

As to the second part relating to efficiency, it depends chiefly upon the drag associated with the wing. There is the drag of the fuselage to which it is attached, and the bits and pieces such as the tail fin, struts, skid, and in the case of a power craft the engine, and to this is added the drag of the wing itself. Drag is the addition of all these factors and of others besides, including skin friction, and it is influenced by frontal area and by the extent to which the general design promotes the smooth flow of the air around it without setting up eddies. And, finally, it is a movable feast which changes with speed.

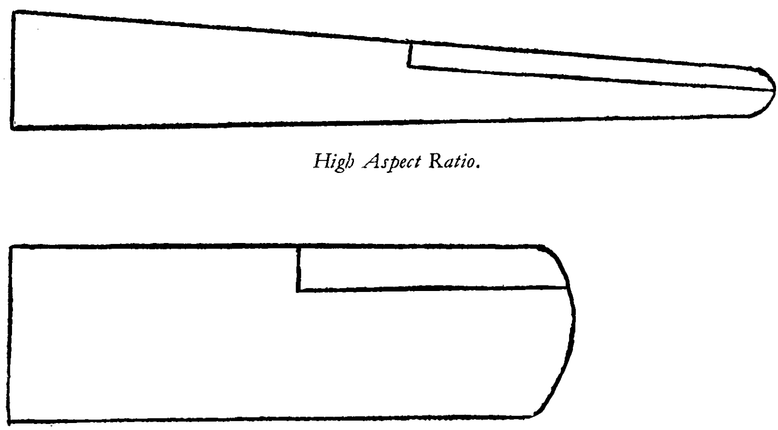
The photographs of high-efficiency sailplanes which are reproduced throughout these pages illustrate the best that man has so far been able to accomplish to keep it down while retaining a place for the pilot to sit and an adequate measure of control over the aircraft. They reveal two things in particular:

Opposite: Stceamline! A Kirby Gull in flight at Dunstable.



1. A streamlined shape for the fuselage—which is logical.
2. And long, tapering wings, the reasons for which are less obvious, particularly when one remembers the outline of an aircraft like a Spitfire which has comparatively short elliptical wings.

Let me for one moment dwell on this subject of "taper." Its degree is expressed by a numeral of what is called the "aspect ratio." This is the chord of the wing (or breadth) divided into its span. A short stubby wing will therefore be seen to have a low aspect ratio, while a long narrow wing a high aspect ratio (Fig. 5). This term will be used frequently.



High Aspect Ratio.

Low Aspect Ratio.

FIG. 5.

Now, before explaining why sailplanes have long narrow wings of high aspect ratio, it is necessary to mention briefly the shape of its airfoil. The airfoil is the cross-section which you would see if you sawed a wing through its chord. In all aircraft both the top and bottom surface is curved (see Fig. 6); the degree of the curve gives the airfoil special characteristics in flight, some being designed for the maximum lift at high

Opposite : "Only just room for a large man to squeeze. . . ." Mr. Philip Wills in the cockpit of his Minimoa. (See page 24.)

speeds, and others at low speeds. In the early days of aviation it was believed that a perfectly flat wing like a piece of board was the best shape to produce the maximum lift—a misconception to which I have referred again in the chapter on the development of soaring. It is sufficient to say for now that a curved surface provides a greatly increased lift, the suction built up over the top side providing three times as much lift as the pressure built up on the under side (see Fig. 7). From the foregoing it will be obvious that the design of airfoil will have as great an influence on the performance of a wing as its aspect ratio. To labour this point, let it be said that a wing suitable for a single-seat fighter designed to give its maximum lift at a climbing speed of say 180 m.p.h. will not be suitable for a sailplane with a speed range between 30 and 70 m.p.h. And even within this small range of some 40 m.p.h. there is a choice of many possible wing sections. It is actually impossible to produce a wing which will fly with equal efficiency at 70 m.p.h. and at 30 m.p.h., and the designer, consequently, seeks a compromise, often changing the section throughout its length.

FIG. 6.—*The curved airfoil showing the airflow around it. This gives much more lift than the flat wing.*

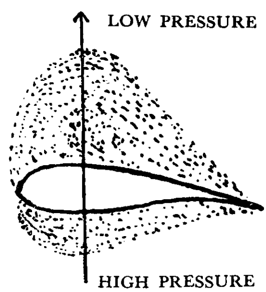


FIG. 7.—*Showing the pressure distribution over a wing.*

Now, the simplest form of main plane is of a rectangular shape with an aspect ratio of about 6. This is simple and cheap to manufacture, and it is the reason why it is fitted to primary training gliders. On the other hand, it is not efficient. The air load falls away rapidly towards the tips, and the pressure distribution is represented by an elliptical diagram. A rectangular wing has a second span known as its "effective span."

For this reason a tapered or triangular shape is substituted

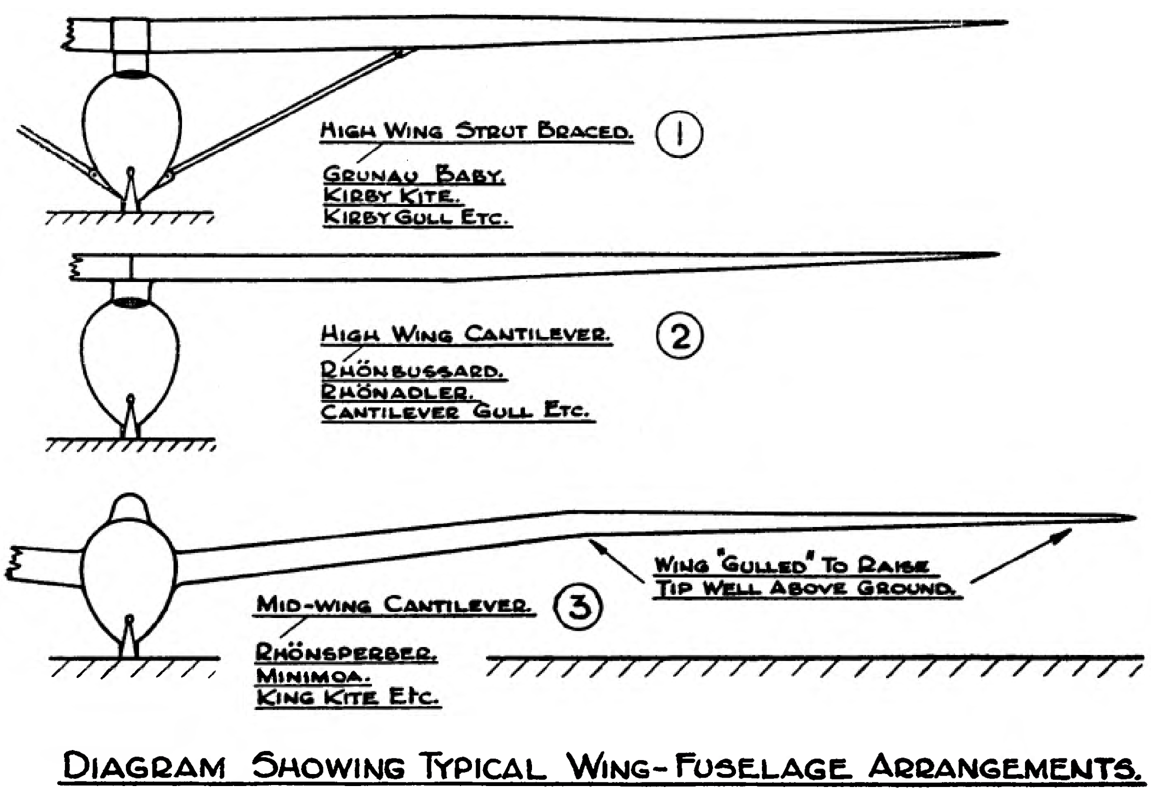
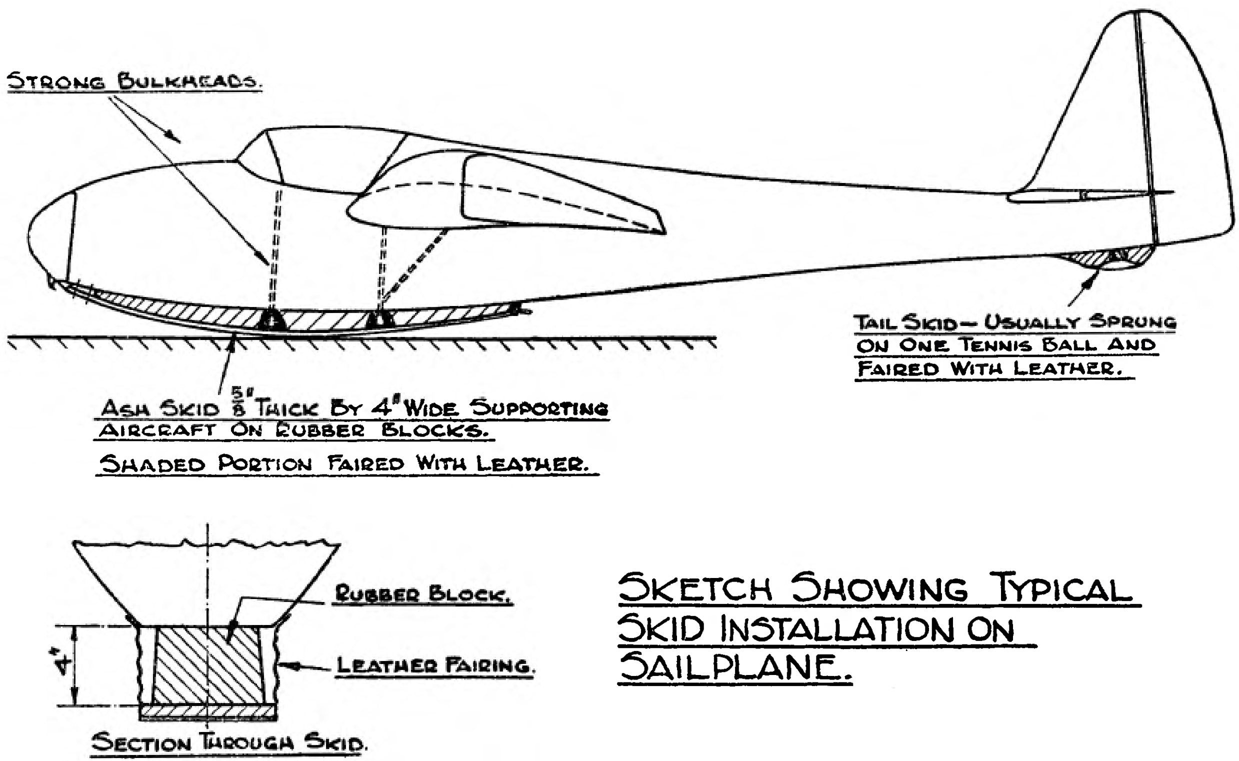

High Wing Strut Braced.
1
Grunau Baby.
Kirby Kite.
Kirby Gull Etc.
High Wing Cantilever.
2
Rhönbussard.
Rhönadler.
Cantilever Gull Etc.
Wing "Gulled" To Raise
Tip Well Above Ground.
Mid-wing Cantilever.
3
Rhönsperber.
Minimoa.
King Kite Etc.
Diagram Showing Typical Wing-Fuselage Arrangements.

Fig. 8.

in all types where efficiency is important, and the aspect ratio is thereby increased from 6 to as much as 20. This in itself carries with it new disadvantages. While the rectangular wing has been proved to stall in its middle section first, the stall spreading outwards to the tips, the triangular type stalls at the tips first and spreads inwards. There is therefore a tendency in such a wing to spin. This is dealt with by giving the wing tip "washout" or a negative incidence amounting to one or two degrees, and sometimes more. The wing tip stall is consequently delayed, and stability is restored at the expense of lift.

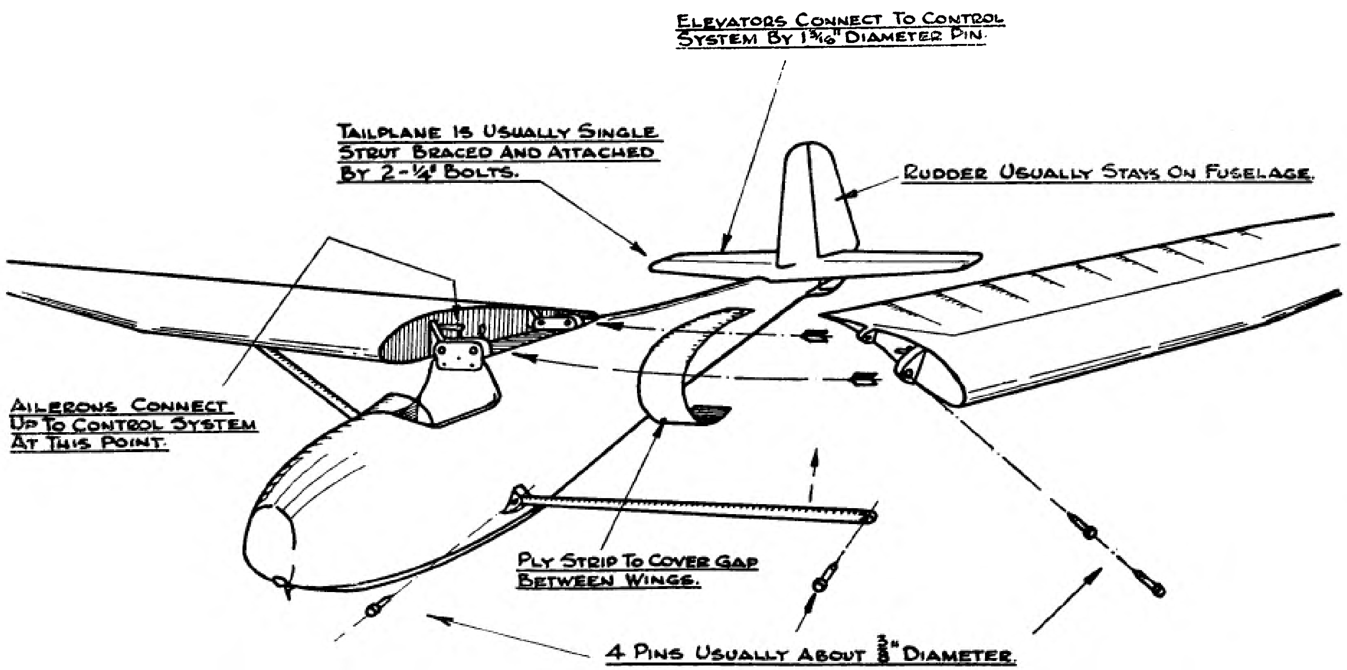
In order to obtain the same wing area in the tapered type, and therefore the same wing loading factor, it has to be of greater span. This involves much heavier construction in order to get the necessary margin of safety. As it is to be used for a high-efficiency sailplane, it must also be stressed for greater speeds. Now, this involves a consideration which has not yet been mentioned—the shifting of the point of load on a wing as its speed varies. In straight and level flight in which the wing has a small angle of incidence the centre of pressure is situated about one-third of the way back from the leading edge. When the angle of attack is increased, as it is in an aeroplane in the climbing attitude, the centre of pressure moves forward. On the other hand, when it is diving it moves right back to a point two-thirds of the way across the chord towards the trailing edge. So it will be seen that the forces for which the designer has to allow are movable.

In normal construction the main spar in which the greatest strength of the wing is vested lies one-third of the way back from the leading edge under the centre of pressure in normal flight. If this was all that the wing relied upon for strength it would be inadvisable to dive the aircraft, for as the centre of pressure moved back it would create a powerful torsion which might easily twist the wing. To deal with this the leading edge is either boxed in with a plywood skin which has a great resistance to torsional stresses, or a second spar is incorporated behind the main spar. In addition, the wing is sometimes fitted diagonally with a special torsion spar, and all these safeguards are sometimes used in combination. The net result is a safety



STRONG BULKHEADS.
TAIL SKID— USUALLY SPRUNG ON ONE TENNIS BALL AND FAIRED WITH LEATHER.
ASH SKID 5/8" THICK BY 4" WIDE SUPPORTING AIRCRAFT ON RUBBER BLOCKS.
SHADED PORTION FAIRED WITH LEATHER.
RUBBER BLOCK.
LEATHER FAIRING.
4"
SECTION THROUGH SKID.
SKETCH SHOWING TYPICAL SKID INSTALLATION ON SAILPLANE.

FIG. 9.



Typical Rigging Details On Medium-Performance Strutted Sailplane.

Fig. 10.

factor of about *ten*—which means that the weight normally supported by the wing (the fuselage, pilot, etc.) can be increased ten times before a fracture occurs. This is sufficient to provide against structural failure in the most tempestuous conditions if the speed is not excessive.

A wing of this type, in spite of its greater weight, pays a better dividend than a rectangular wing of the same area and airfoil design.

I have mentioned wing loading as entering into glider design. This is always expressed in lbs. to the square foot of wing area. The lightest thing which flies is probably the common gnat of a summer's day, which is loaded to only 0·02 lb. When you come to the birds you find that the swallow is 10 times more heavily loaded at 0·2 lb., but that the albatross is 16 times heavier again at 3·3 lb. The albatross is in the sailplane class—high-efficiency types being loaded to about 4 lb., while the intermediate types are usually in the neighbourhood of 2 lb. Heavy as such wing loadings appear to be, they are light compared with the 40 lb. and more which are associated with the highest speed war planes.

An ideal glider might seem to be one with the wing loading of a gnat, but its speed would be so low that its "penetration" would be insignificant. The tendency of recent years has been to increase the wing loading for the sake of its potentialities for speed.

Methods of attaching the wing to the fuselage reveal a war between the need for structural strength and efficient streamline, with a third contestant butting in and demanding simplicity of dismantling. The single strutted wing in which the struts work in both compression and tension has been found a happy compromise for most intermediate types; but it hasn't the efficiency of a cantilever wing in that the drag is higher. And, indeed, when a cantilever wing is built into the fuselage and faired off, its drag is about the minimum which can be achieved with our present knowledge. Moreover, ingenious design has provided for a central joint which can be made and unmade in a few minutes while retaining the greatest possible rigidity. A sailplane should be capable of being dismantled by a crew of three for packing into a trailer

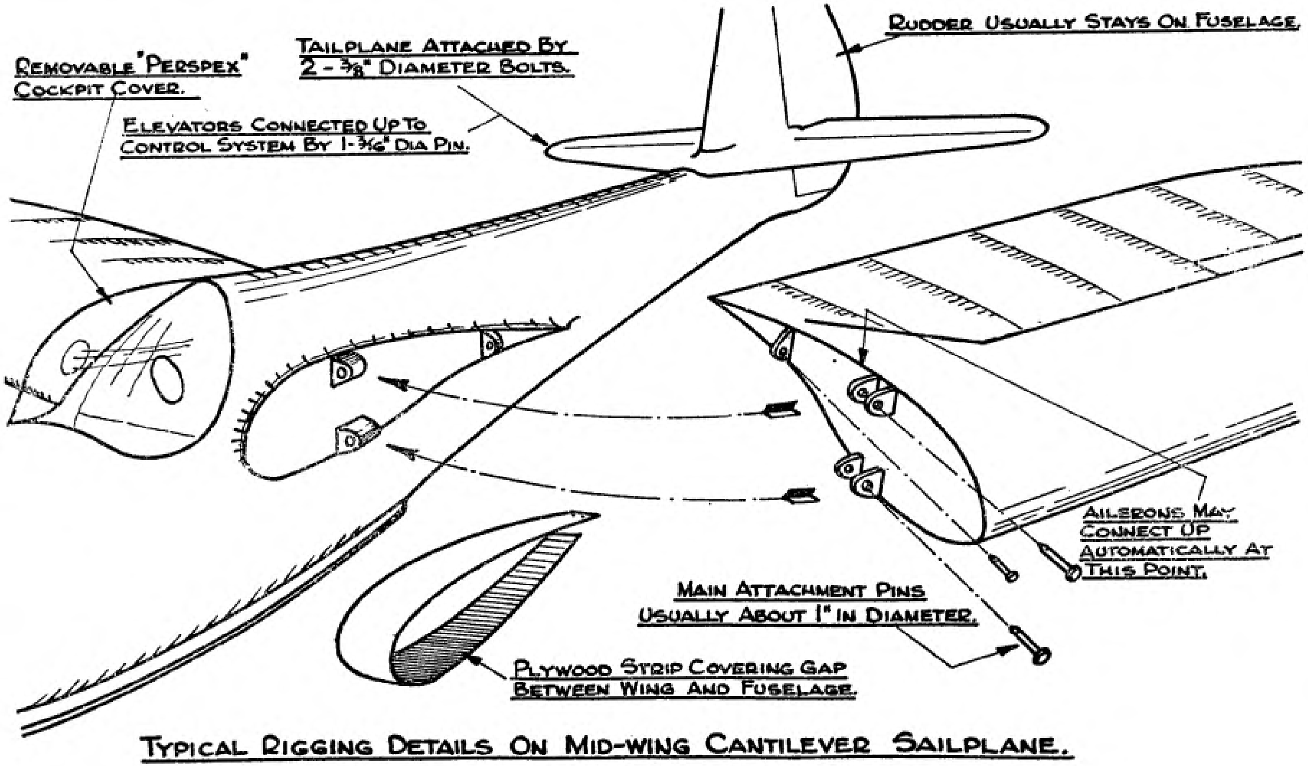

REMOVABLE "PERSPEX" COCKPIT COVER.
TAILPLANE ATTACHED BY 2 - 3/8" DIAMETER BOLTS.
RUDDER USUALLY STAYS ON FUSELAGE.
ELEVATORS CONNECTED UP TO CONTROL SYSTEM BY 1-3/16" DIA PIN.
AILERONS MAY CONNECT UP AUTOMATICALLY AT THIS POINT.
MAIN ATTACHMENT PINS USUALLY ABOUT 1" IN DIAMETER.
PLYWOOD STRIP COVERING GAP BETWEEN WING AND FUSELAGE.
TYPICAL RIGGING DETAILS ON MID-WING CANTILEVER SAILPLANE.

FIG. 11.

in less than 10 minutes, and most types now fulfil these qualifications (see Fig. 11).

The materials which go into the manufacture of sailplanes are high-grade woods, waterproof glue, linen fabric, and steel fittings. There is very little else. Those parts which take the greatest strain are built principally of silver spruce of the highest class obtainable. In effect this means that the wood must come from a tree which, after it is felled, shows not less than ten annular rings per inch. As an alternative to spruce, Oregon pine, Douglas fir, or even Deal are possibilities, although each is heavier. These woods are used in the spars, struts, longerons, and ribs.

Also used in quantity, as inspection of any glider shows, are various plywoods. The best is probably birch three-ply of Grade A quality, and it is almost invariably found boxing in the leading edge, and quite probably in the wing ribs and gussets. As an alternative a mahogany plywood is a possibility, and because of the exceptional finish to which it may be worked up it is often employed in the panelling. The only other wood of note is found in the skid, which is subject to wear far greater than any other part. It is usually made of the best English ash steamed into the right curve, and shod with a mild steel sole. Between the skid and the fuselage there are a number of shock absorbers composed of rubber blocks, fortified occasionally with tennis balls.

As for the metal parts, either drop forgings or fabricated mild steel is most common. There are too many well-known disadvantages in high tensile steels to employ them unnecessarily. Not only are the mild steels much easier to work, but their stretching qualities are such that excessive strain will usually be shown by slack fittings, whereas a high tensile material will fracture without any such warning. The few bolts required are usually of the same material, and are cadmium-plated to give anti-rusting properties.

Control cables are the products of specialists and are made of stranded steel wire with a breaking strain in the neighbourhood of five hundredweight.

Control pulleys are usually of duralumin and sometimes of special hardened fibre.

Wooden construction has been one which for general aircraft production was falling into disuse until De Havillands proved with the Mosquito that its era was by no means past. It has, in point of fact, very great advantages in sailplane construction, the chief of which is the ease with which damage can be repaired. Metal construction involving welded or riveted joints is usually beyond the amateur, particularly when grades of metal are used which yield only to specialised treatment. It is only in the most serious cases that sailplanes need to be returned to the manufacturers for repair.

Dope, shellac, oil varnishes, and polish are the principal finishing materials. Shellac is usually used when parts are to be varnished inside the fuselage, and where an oil varnish might weaken glued joints. An oil varnish capable of taking a high polish is usual for exterior surfaces, being pleasing to the eye and waterproof. The finished sailplane is a very high-class job, and the proof that craftsmanship is still alive in the land—if only in the hands of a few.

LAUNCHING

A HIGH wind was blowing up the hill. For the last fifty yards of the slope it was laying the stiff grasses low against the unyielding earth. Perhaps its speed was 35 miles an hour, perhaps a little more. A thousand feet higher it would be gusting up to 50, and higher still, under the steel-grey caldron of scudding clouds, the speed would be approaching a mile a minute. In the valley the smoke from the factory chimney was drawing a line parallel to the ground. The scrubby trees clinging to the lower reaches of the ridge moaned and creaked as though crying out for mercy.

At the head of the slope and facing the blast a dozen half-frozen men were standing by to launch a two-seater glider. Its crew were already in the cockpit, muffled with great scarves from which their tousled heads emerged like rag dolls. Two of the ground crew were hanging on to one wing tip as their fingers stiffened. Two others were draped over the sloping struts on either side, and yet another pressed down on the nose.

Harnesses were being finally adjusted in the cockpit, and as these preliminaries were completed the pilot held up his thumb and shouted something inaudible. On either side red faces looked up, grinned, and stood away clear of the struts. The aircraft rocked, shook itself, and shifted back a few inches under the force of the wind. Now the two inner crew put their shoulders under the struts and heaved. Although the dead weight above them was nearly 1,000 lb., the whole mass lifted, slid forwards, and took off like a great bird rising from some tide-washed rock. There for a few seconds it hung. Any one of us could have walked up and touched it, although it was in full flight. Then a gust, more savage than the rest, gripped the under surface of its wings. The mass rose vertically, swayed, and crabbed sideways with an accelerating rush. Within a few seconds it was a hundred feet above our heads and slipping down the length of the ridge like a great crab. Up there an enthusiastic pilot was wrestling joyfully with a control column which required the full range of its travel to correct the thrust of uneven airs. The launch was over. Another sailplane was in the sky.

There are few occasions on which such a crude method will suffice. Only on a day of high wind is it possible. A more orthodox launch of the same class is made with the help of an elastic rope. Instead of sliding the aircraft off the shoulders of the crew, the machine is catapulted after the fashion of a paper sling by a boy who uses a piece of rubber and his front teeth to grasp the missile.

For a single-seat glider two 30-yard lengths of $\frac{5}{8}$-inch rope are laid on the ground in the shape of the letter "V." To the apex of the "V" is lashed a short cable terminating in a steel ring, which in turn is placed over an open hook under the nose of the aircraft—a hook downturned, so that the ring is held in place only by the tension of the elastic. The ground crew—four to each side of the rope—pick up the ends and wait for the signal to walk away on a diverging course. Meanwhile, the largest heavyweight available lies on his stomach and grasps in a gloved hand the tail skid of the glider. It is his duty to hold back the aircraft until such a moment as the job is beyond his strength.

The ground from which the launch is made will slope down towards the steeper gradients of the ridge over which the aircraft is to soar (see the photograph opposite page 65). The place chosen may be as steep as the launching crew can run down without risk to their own necks. When the pilot gives the signal to "run," the walking crew will break into a double, and the last he will see of them will be their bobbing heads as they charge down the slope. Very soon afterwards—after the crew have covered a total distance of perhaps 30 yards—the man on the tail skid will no longer be able to resist the pull. The glider will be snatched out of his hands, and, accelerating with remarkable rapidity, will be airborne within 3 or 4 yards. This rapid acceleration will be increased still further as soon as the skid is free of the earth. The air speed will now be in the neighbourhood of 35 to 40 m.p.h., and the pilot will be in a position to pull back hard on the stick and climb at a sensationally steep angle.

During the climb the elastic is still exerting a considerable pull, and this will be maintained until a height of about 50 feet is reached. The pilot must then level out, when the ring at the end of the rope will drop off the hook. The aircraft is then in free flight, and the pilot will use his height to whatever advantage he can.

This type of launch is safe for a qualified pilot. It carries with it only one possible risk—that which is brought about by delaying the process of flattening out at the top. If the pilot relies only on the air-speed indicator to tell him when the pull of the elastic is nearing exhaustion, he will have a dangerously narrow margin between flying and stalling speeds. This is due to the lag in the instrument. The secret is either to rely upon the feel of the controls and the sound of the wind over the aircraft—absolute guides to the experienced pilot—or to commence flattening out two or three seconds before he believes it to be necessary. In this way he may sacrifice the last 10 feet of his launch, but he will be safe.

The same method can be used for training purposes on level ground (see photograph opposite page 272). Under the orders of an instructor, the elastic is only partially stretched and the man holding back releases his hold long before the full power available is stored up. The result is a short hop which may only just lift the aircraft off the ground, or even terminate in no more than a ground slide. It is a tedious and slow method of instruction, but it is cheap and achieves the results in the long run. Incidentally, a full launch over flat ground in still air will catapult an open training type for perhaps 80 yards, whereas the same launch of a high-efficiency type may result in a flight of 250 yards. One can produce a dramatic demonstration of the aerodynamic efficiency of different classes of aircraft by such a method.

A third type of launch which is usually more satisfactory is given with a winch and a wire cable. It is capable of producing a launch up to 1,000 feet, from which eminence a pupil has sufficient time to practise turns, or a qualified pilot has every opportunity for picking up a thermal.

The apparatus used in the bad old days was an ancient motor-car of high horse-power, a steel drum bolted to one of the back wheels, and 3,000 feet of cable. The differential of the car was locked and the rear wheels jacked up on wooden blocks. The driver, using second or third gear, depending upon the strength of the wind, let in his clutch and wound the wire on to the drum at such a speed as the aircraft at the other end was able to climb, after the fashion of a kite. In a high wind of 30 m.p.h. or more second gear and low engine revs. would be sufficient. On a calm day a wire speed of nearly 40 m.p.h. would be required, and full throttle on top gear. The experience and judgment of the driver play a vital part in a successful launch. On a day when there is a wind speed of more than 10 m.p.h. the launch can be continued until the glider is almost directly above the winch. At this moment the pilot pulls the ring on his instrument panel and releases the cable. On a calm day the maximum height will be reached before the wire is running directly up and down.

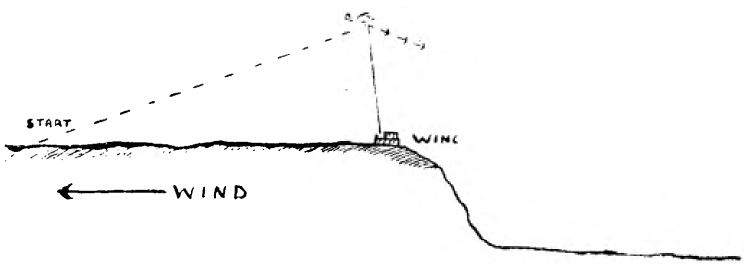


FIG. 12.—*This shows a winch launch from the top of a hill.*

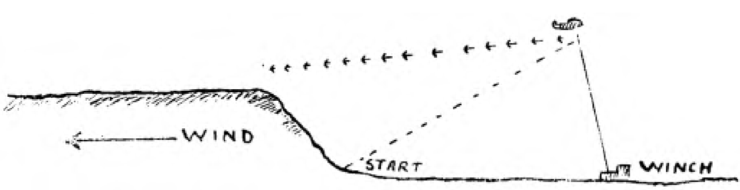


FIG. 13.—*A similar launch, but made from the bottom of the hill.*

The safety precautions are crude but effective. The cable itself has a breaking strain of not less than half a ton. A weak link with a breaking strain of about 600 lb. is often inserted at the aircraft's end of the wire. A second man is always standing by during the launch with an axe, and if the pilot fails to release the cable it is his duty to chop the wire on a steel block fitted close to the rollers through which the wire passes after leaving the drum. With the wire dangling from the nose of the aircraft, the pilot can still make a safe circuit and land again—unless it becomes entangled with an obstruction.

A winch launch is not only ideal for qualified pilots and for advanced training, but also for giving the initial ground slides by which the beginner is taught the use of his ailerons. It is, furthermore, a safe method. I have seen a pupil lose his head on the way up and clutch the stick to his stomach, pulling the aircraft into the steepest imaginable climb. The winch driver remains in control even at such a moment. By slowing down his engine the glider can be pulled back to the earth while retaining the attitude of a steep climb. In fact, the glider is in the same position as the naval aircraft which is hanging on its propeller as it comes in to make a deck landing.

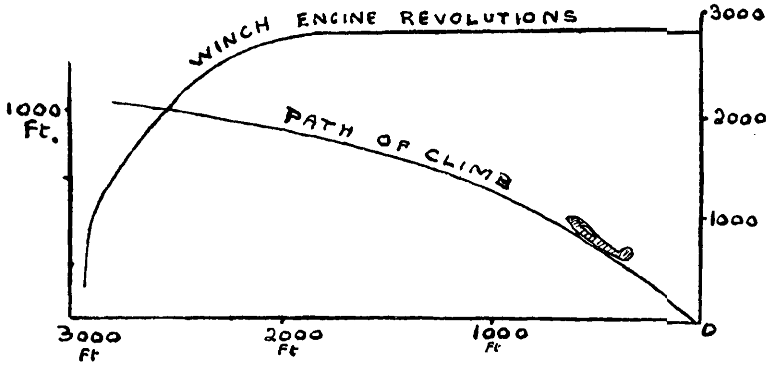


FIG. 14.—*A diagram showing a typical relationship between winch engine revolutions and the sailplane's climb.*

The apparatus of the future will no doubt put the rough-and-ready gear of the past to shame. There is in this country a vast and probably endless supply of good launching winches in the shape of barrage-balloon equipment which will, perhaps, one day be surplus to requirements. With slight alterations these winches may eventually be put to a constructive purpose (see illustrations opposite page 48 and reverse side).

As will have been gathered from earlier remarks, it is possible to tow a glider into the air. Either a motor-car or an aeroplane can be used, though not with equal results. As a member of a lawless band, I have towed with a motor-car from a public road, tempted by a long, straight stretch of highway and a fine mountain ridge which towered to one side of it. The deed was perpetrated in the Lake District after laying out the towing cable and holding up the traffic. Some six hundred feet

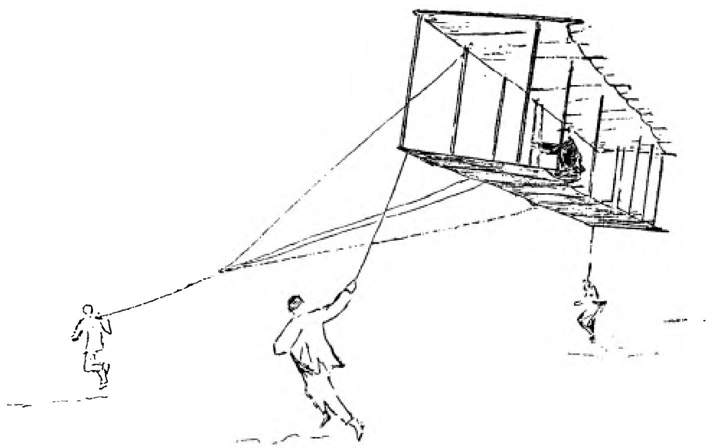


FIG. 15.—*An early glider which was not only launched by hand, but whose lateral control was provided by two other runners !*

of height was provided for the pilot, and everybody enjoyed themselves, including a very patient audience. But straight roads unfrequented by bordering hedges, telegraph poles, and policemen are rare.

The tow by an aeroplane is a better proposition, and this I think will be the almost universal method of the future. It disposes of nearly all the glider pilot's bugbears—the necessity for a hill site and the necessity for the right kind of wind.

Opposite.—Top : A winch designed and built by Messrs. Copeland and Hatcher as an independent unit. It gives the best possible view to the operator who stands facing the sailplane.

Bottom : In this case the winch, belonging to the Derbyshire and Lancashire Club, has its drum mounted on the driving shaft of a Chrysler car. It gives excellent results. The instrument on the top left-hand corner of the windscreen is a rev. counter.

Top : The latest type of barrage balloon winch.
Bottom : The oldest type of winch in which the drum is bolted to the rear wheel of a car.

Top: The first stage of a primary "bunje" launch. Bottom : The second stage. The rope is about to fall clear.

From the instructional point of view it will enable dual control in two-seaters to be given with convenience and good effect. The long process of starting with ground slides, graduating to hops, and thence to straight glides and to circuits, will be cut out. The time required for graduation will be reduced, and possibly reduced still further if the towing aircraft is fitted with dual control and used for teaching the elementary use of the controls when not required for giving launches.

The experienced pilot will find the aero tow less alarming than it sounds. With a 300-foot cable, preferably of silk rather than steel wire, he will be able to make a smooth take-off from any of the hundreds of aerodromes with which the country is dotted. The technique of holding the glider straight and level until the aeroplane is off the ground, and then flying out of the slip stream just above it, is essentially simple. The presence of a thermal, and therefore the moment to release the towing cable, is clearly indicated by the sudden rise of the aircraft ahead, which naturally enters the thermal before the glider behind it. On a good thermal day no launch need be extended beyond 1,500 feet. At such a height most thermals have attained plenty of acceleration, and the glider pilot has only to cast off and start circling in order to climb up to cloud base.

The advantages of such a method, as I have already said, dispose of the necessity for a special site and enable aerodromes in the vicinity of big towns to play a convenient rôle. If soaring achieves the popularity I believe it deserves, the importance of this convenience will be considerable. The cost of the tow will, of course, be higher than any other type of launch. But then all flights will be longer, even if they are restricted to a straight glide back to earth. If a towing aircraft with a low petrol consumption, and preferably a specifically designed aerofoil which will increase the rate of climb and lower the climbing speed, is used, the cost should not be more than a few shillings per launch. Wartime experience with troop-carrying gliders shows that more than one aircraft can be launched safely at the same

Opposite: Retrieving the Dagling at Dunstable after a ground slide. This is normally a two-man job—one man driving the car, the other holding the wing tip.

time. Apart from this, slight modification to existing designs of intermediate types of sailplane, which are at the moment too frail, or too slow to sustain the strains of an aero tow, will open this field to all owners.

With the knowledge that we have today about cloud conditions and their interpretation in terms of rising air currents, a wasted launch will be a rarity. The experienced pilot need not do much more than take a single glance at the clouds to determine whether soaring is possible. This, backed up by a weather report which includes information about the lapse rate, places the matter beyond reasonable doubt. I have no figures to show the number of days in a year on which thermal soaring is a possibility in this country, but from experience in flying over the British Isles I imagine that in summer-time it would not be less than one day in three.

SOARING SITES

PROGRESS was never a march of undimmed triumphs. In fact, it has probably robbed mankind of more genuine pleasures than anything else. So I shall regret the day when organisation and business efficiency have rationalised the sport of soaring. Books such as this are liable to do a disservice to a pastime enjoyed by a few, for if they are successful they popularise it and bring crowds to places which were once personal kingdoms. Yet it is a sad truth—or is it really a gay truth?—that the nation's place in world aviation probably depends upon people in all walks of life developing a personal love of the air. I do not believe that the plans of politicians can establish for us a high place in the merchant air navies—certainly not by making speeches. We did not become a great maritime power because a small number of men built a large number of ships. Greatness owed its growth to more subtle things. It owed it to something secreted in the blood stream of most Englishmen—a love of the sea. Without it, it is doubtful whether Drake would have sailed or Nelson had a crew worthy of his command. Press-ganged as the sailors were, they had an aptitude which went farther than piracy and a proficiency in battle. Nor would the men of the little ships in this year of grace 1944 be the scourge of the enemy if there was not within them that which made them adaptable to their wartime business.

So let us not delude ourselves into believing that it only needs an edict from Westminster to turn us into a great merchant air power. It may build aeroplanes and provide them with publicity for a send-off, but it won't found a future. Until we fly as a people as we sailed our small craft and even found pleasure in standing by the sea and watching it, we shall not be competent or worthy.

The world conflict which is ending as I write proved that our men had a great affinity for the air—as great as the men of any other nation. And I mean by this—no more and no less—that the thousands who buckled on their armour, their parachutes, Mae Wests, and oxygen masks, did so because they had discovered in themselves a love which mastered all other emotions, including fear. If peace should ground these crusaders, save for the few needed to fly the air lines, the future of commercial aviation will be gloomy. And peace will assuredly ground many of them unless one of two things occur. Either Parliament must vote a subsidy which will reduce the cost of private power flying from £2 an hour to about 5s., or vote a smaller subsidy (it might even be done without any subsidy at all) for the promotion of universal gliding. It is my opinion that the first choice would be a bad one as well as an expensive one, for the pilot who has flown a Spitfire in battle, or a bomber through the night watches to Berlin, will not be assuaged in spirit by flying a Tiger Moth round a local aerodrome. It would be too like offering a seasoned yachtsman a punt on the Thames. But give him the freedom of the skies in a sailplane—a sport with a challenge to his courage as well as his skill—and he will feel that he has a stake in the air.

This implies the abandonment of the old soaring sites in favour of convenient aerodromes near the big cities. As suggested in the last chapter, large numbers of pilots can best be catered for by aeroplane towing. This can only be done from well-organised aerodromes. Thus it is possible that the lonely ridges upon which pilots of the past pitched their camps may one day return to the state of undisturbed nature.

At the same time, I am sure that some of us, old and dim-sighted as we may be growing, will turn our eyes again to the hills, climbing their steep slopes to enjoy and endure the old rewards of motorless flight. And among the new generation there will be a few who will sacrifice efficiency for comparative inefficiency, just as there are fishermen who prefer the lightly stocked mountain burns, and the shooter a rough day on the hills in preference to the organised grouse drive.

Some great soaring sites have been discovered, and they will remain until the hills wear smooth in the earth's dotage. Principal among them (known to me personally) are Bradwell Edge in Derbyshire, Sutton Bank on a western spur of the Yorkshire moors, the Long Mynd of Shropshire with its view of Wales, and the chalk down at Dunstable, only 30 miles north-west of London. There are others, notably the proud ridge of Hartside which overlooks the lakeland mountains and offers a launch which makes even an aeroplane tow seem second-rate, and many heather slopes of lesser fame up which I have toiled and sweated as a member of a team prospecting for new experiences. Nor is this the end, for I have never flown from the well-known hills of at least a dozen other established centres. But each of them has a common characteristic—they are far from the petrol-reeking prairies of the aerodromes and the soot of cities, and in the most part are only reached by narrow lanes whose gradients discourage the traffic of others.

Hartside is perhaps the grandest and loveliest of them all, and if some philanthropist were to give £1,000 for its development (the cost of a modern aerodrome is £1,000,000) it would become famous, even in a world of aeroplane towing. The pioneers of the ridge, among whom I am proud to count myself, took every kind of liberty to put its qualities to the test. On a Sunday, when the motorists would roar across the moorland road from Newcastle to the Lake District via Penrith, a number of older and slower vehicles would follow in their wake. The later motorists would be stopped as we came to the mighty west face of the Pennines to be pressed into launching crews for our aircraft. It must be said to their credit that they bore the imposition with patience.

It is here, 10 miles beyond Alston—England's highest market town—that the road drops 1,500 feet into the Eden valley. For miles the moorlands have rolled to the west—Blanchland, Allendale, Alston, and Gilderdale Forest—to break at the crest of Hartside like a wave frozen into immobility. Looking outwards, the lakeland mountains rise a dozen miles away across the valley, and at sunset no blacker outline ever cast a silhouette across the evening sky.

The first attempts to soar the ridge were made in July, 1933, and they met with little success. The best flight only accounted for a gain in height of 200 feet and lasted for 35 minutes. It was not appreciated at that time that the main upward air currents were to be found some distance out from the crest and, apparently, at a greater height above it than was usual with lesser ridges. The policy of flying close in to the hillside

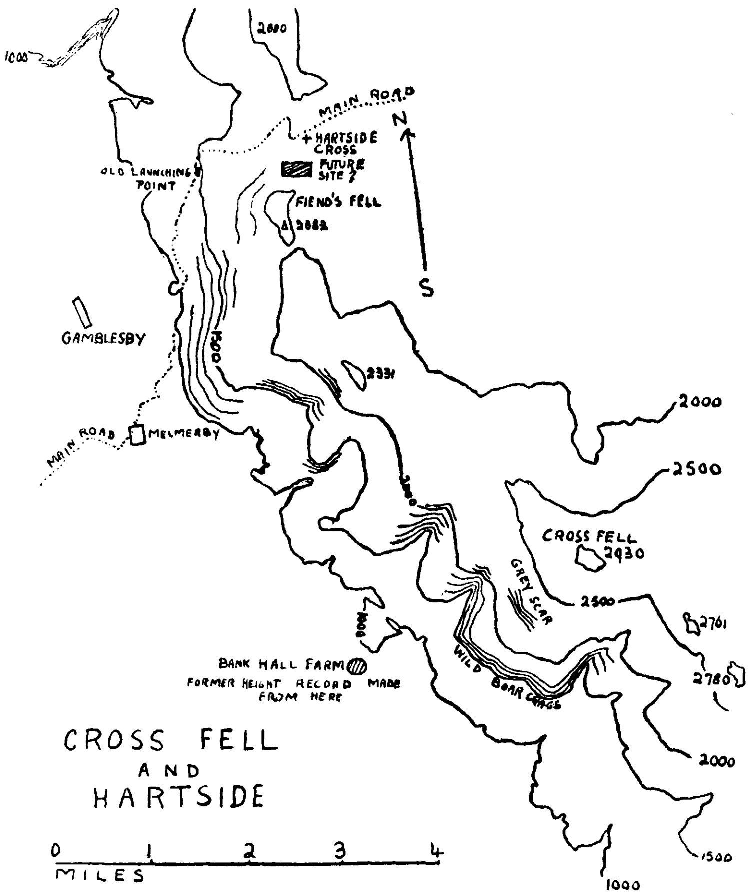
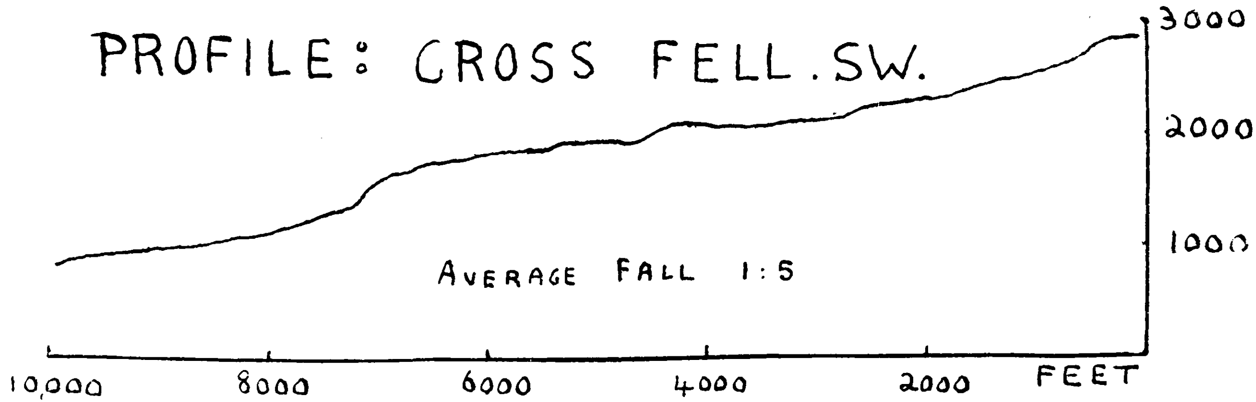
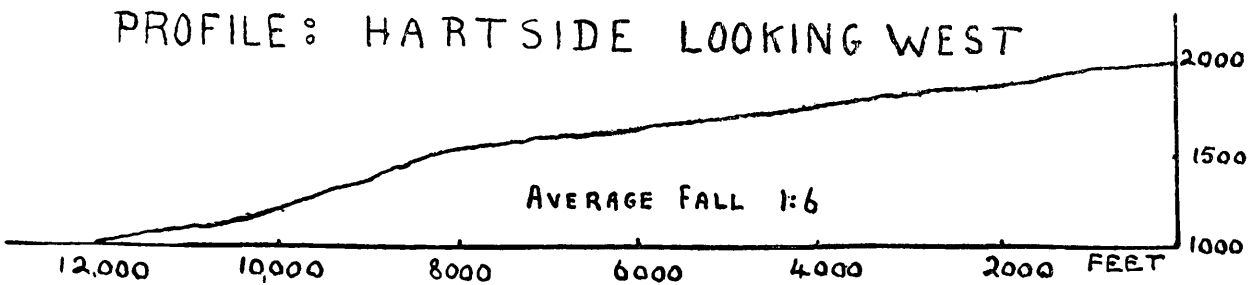


FIG. 16.—*The contours of the Hartside ridge show the broken nature of the face and explain the unreliability of the lift close in to its side. In Figs.* 17 *and* 18 *opposite it will be seen that the average fall of the ground even on the Cross Fell face is only* 1 *in* 5. *This is less than at most other established sites, although the total fall of more than* 1,000 *feet appears to create fine lift of the mass of air well clear of the ridge.*


PROFILE: CROSS FELL. SW.
3000
2000
1000
AVERAGE FALL 1:5
10,000
8000
6000
4000
2000
FEET
Fig. 17.


PROFILE: HARTSIDE LOOKING WEST
2000
1500
1000
AVERAGE FALL 1:6
12,000
10,000
8000
6000
4000
2000
FEET
Fig. 18.

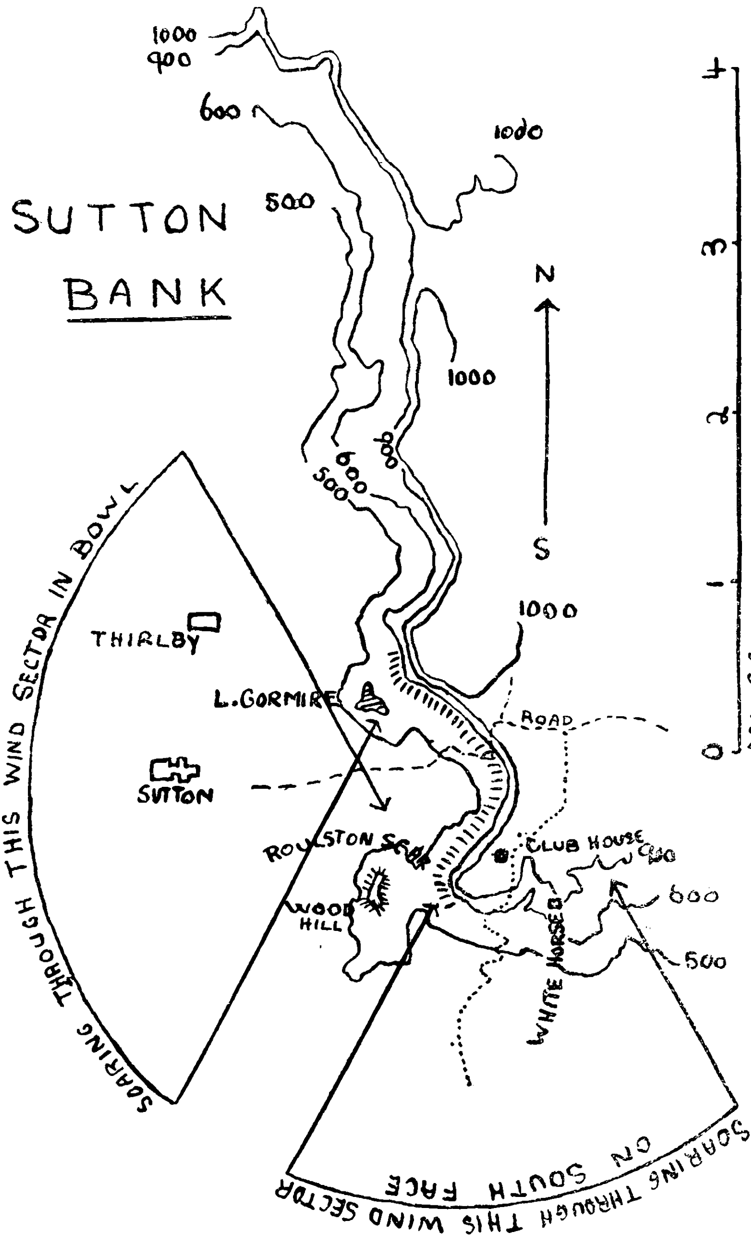

SUTTON
BANK
1000
900
600
500
1000
1000
900
600
500
1000
N
S
THIRLBY
L. GORMIRE
SUTTON
ROAD
ROULSTON SCAR
CLUB HOUSE
WOOD HILL
WHITE HORSE
600
500
0 1 2 3 4
MILES
SOARING THROUGH THIS WIND SECTOR IN BOWL
SOARING THROUGH THIS WIND SECTOR ON SOUTH FACE

FIG. 19.

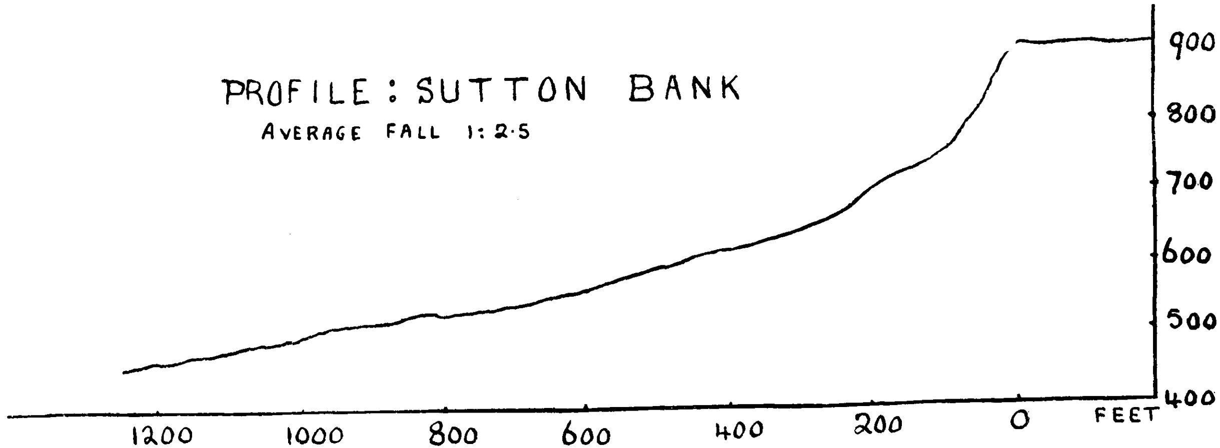

PROFILE : SUTTON BANK
AVERAGE FALL 1:2·5
900
800
700
600
500
400
FEET
0
200
400
600
800
1000
1200

FIG. 20.

never yielded any dividends, although it was necessary to adopt this policy in the experiments which came several years later, and in which I took part.

The difficulty of the ridge was always the launch, and we usually ended with taking the aircraft in their trailers halfway down the twisting road to a little step at 1,400 feet chiselled by nature out of the slope. Forty or fifty yards of rough grass offered a level platform close to the highway, and it was here that the burghers of Newcastle were coaxed from their motor-cars to man the elastic rope.

The pilot looking out from his cockpit had a view which was sensational. Immediately ahead was the road, sunk into the side of the hill, and beyond it the swaying tops of a belt of pines which fell away as the hill renewed its downward plunge. It was always problematical whether the pines as well as the road would be safely cleared, and the outcome was solely in the hands of the black-trousered gentlemen who were urged to run, and run faster, as the rope was stretched. Happily they never failed in their duty, and the keel of the aircraft would scrape the tree-tops to win out into free air.

From this moment the real struggle began, for there was 600 feet of hillside looming overhead, and every foot of it had to be flown with care if the pilot and sailplane were to emerge into the upcurrents, which only gathered their full strength over the lip at 2,000 feet. A right-handed turn seemed to pay, and then a tortuous course which followed the face of the ridge and was never much more than 50 yards out from its sides. Hartside is so big that the wind plays fantastic tricks in the little gullies which scar its face, producing purely local currents which have no reference to the surge of updraught which sweeps high over the main massif. It was a relief to emerge safely over Fiend's Fell and to see at eye level the moorlands rolling towards you from the east.

Now at last there was no doubt about the merits of the ridge. The lift was both smooth and steady, apparently extending for nearly 3 miles into the Eden Valley, while its ceiling was still another 2,000 feet higher up. One soon found oneself high in the eye of the sun, the valley 4,000 feet below, and the prospect of mountain and vale one to be remembered. Cross Fell itself

(2,930 feet) lay only 4 miles away to the south-east, connected by slopes extending in broad curves above the hamlets which nestled at their feet.

Flying south by Melmerby and Kirkland, one reached the Wildboar Crags which fall from the south-western shoulder of the mountain in a cataract of rocks. How far the Pennine line could be soared was never established, but there was evidence to suggest that the hill currents alone should extend for at least twenty miles to the southward.

When the infamous Helm wind was blowing we made our launches from a farm at the foot of the escarpment, and a later chapter describes how the British height record was captured from here. But much time was spent and many journeys made to explore the top of the ridge in the hope of finding a way through an apparently impassable bog for the winch car. Had we been able to get it on to a comparatively flat stretch of ground on the north-west side of Fiend's Fell—a stretch free from the grey boulders which strewed the ridge—our troubles might have been over. One day the money to drive a road through the brief swamp will be forthcoming—a hundred tons of stone should do it—and the site will be established. Thereafter we shall (with the blessing of the landowner) perhaps build a chalet for ourselves and a hangar for our aircraft. The British Gliding records can then look to their laurels!

I can already hear the ghost voices of criticism saying the Hartside is too high, that its crest is too often in cloud. But it is interesting how a westerly of soaring strength will lift the cloud base at this point and leave the ridge free from its toils. And for myself—I cannot help remembering how the path of the north-west wind blows straight for 230 miles to the Norfolk coast.

* * * * *

The considerations which go to the selection of a soaring site have standards peculiar to themselves. It is not the artistic eye which selects a crag which might be deemed more suitable for an eagle's nest, nor yet the difficulty of the rocks which might attract a climber. The glider is looking for a steep face over which vertical wind speeds of not less than 10 feet per

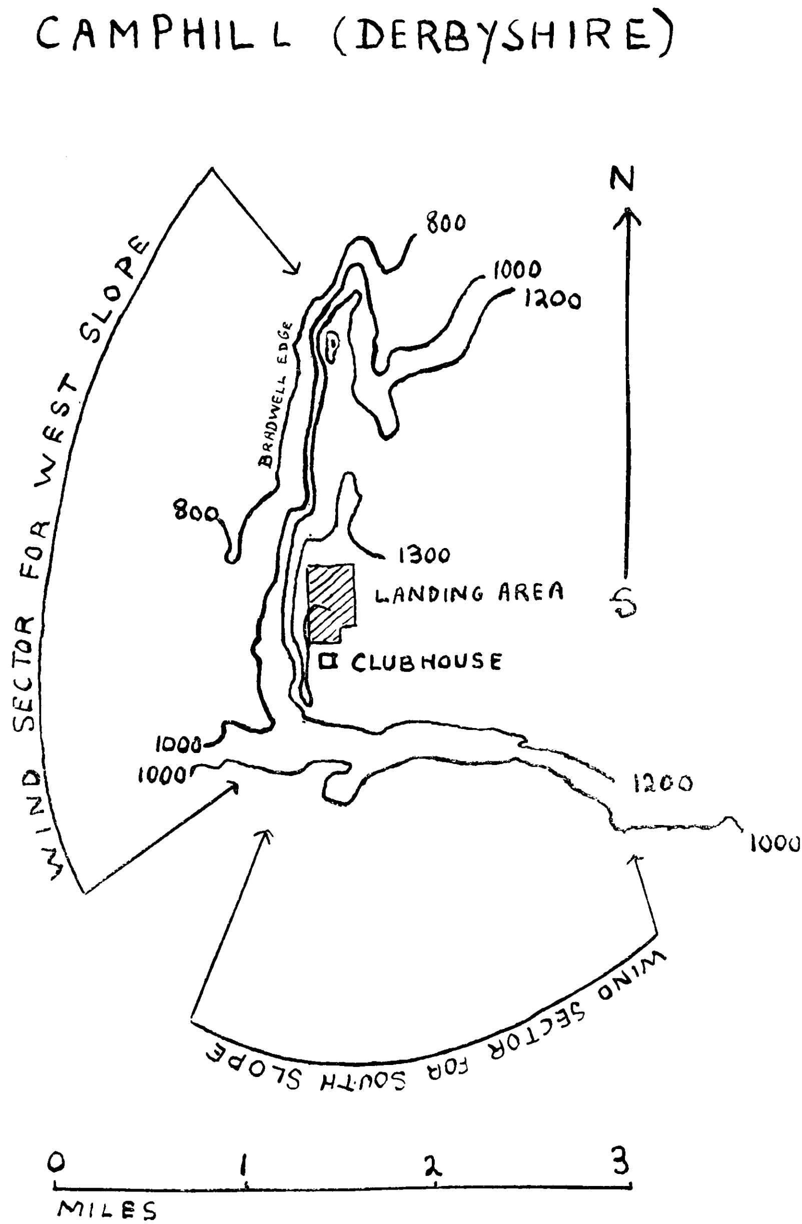

CAMPHILL (DERBYSHIRE)
N
S
800
1000
1200
BRADWELL EDGE
800
1300
LANDING AREA
CLUBHOUSE
1000
1000
1200
1000
WIND SECTOR FOR WEST SLOPE
WIND SECTOR FOR SOUTH SLOPE
0
1
2
3
MILES

FIG. 21.

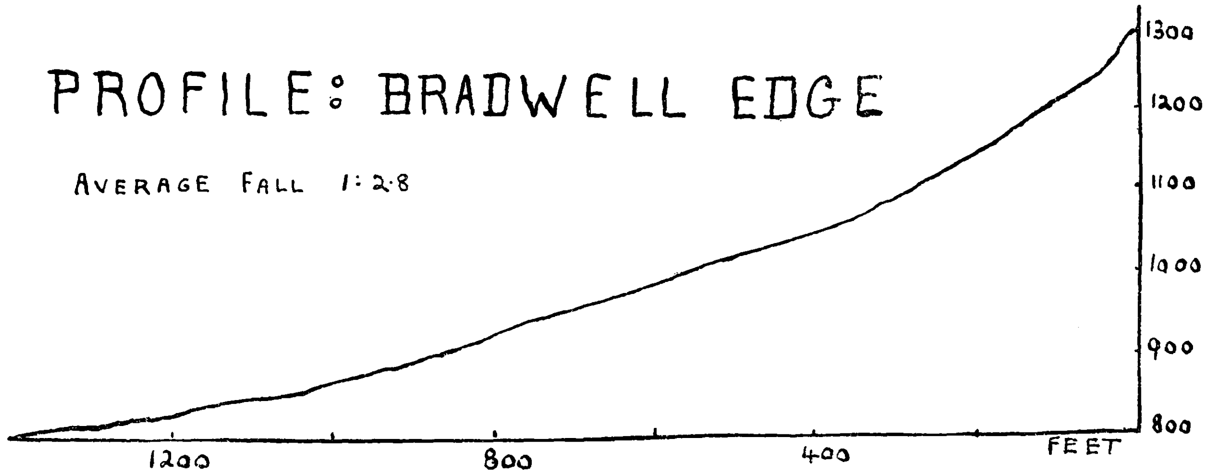

PROFILE: BRADWELL EDGE
AVERAGE FALL 1:2·8
1300
1200
1100
1000
900
800
FEET
400
800
1200

FIG. 22.

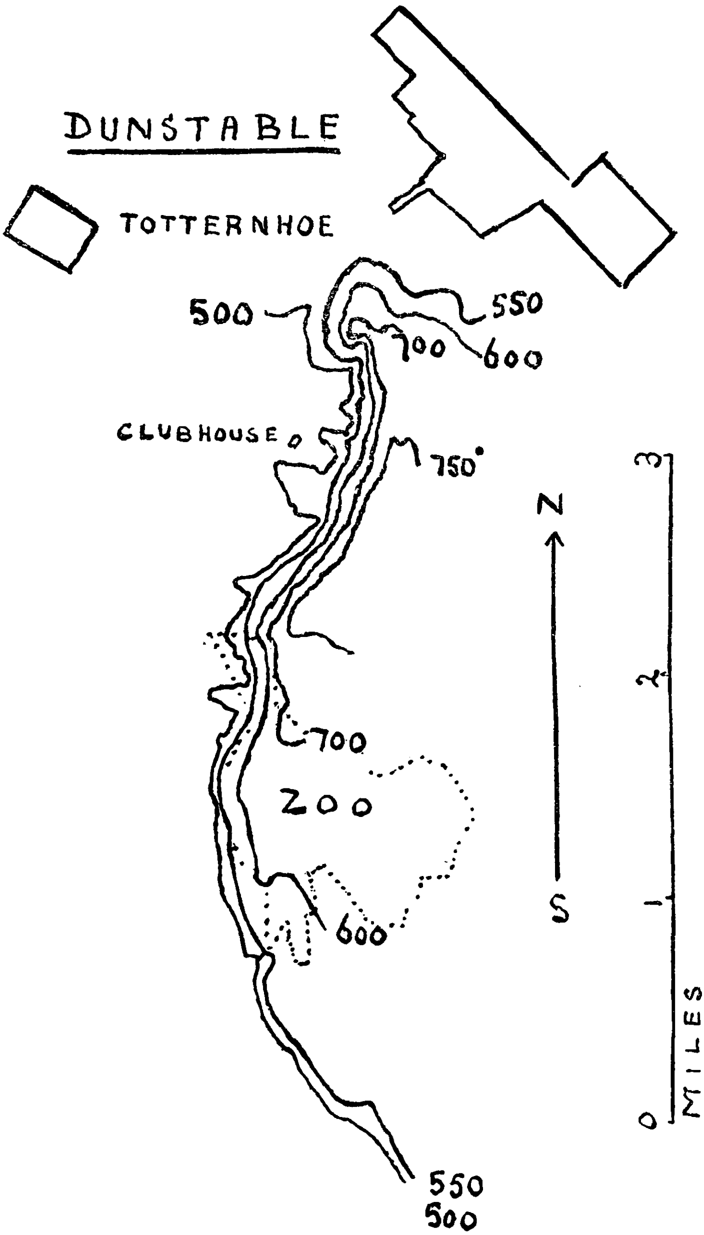

DUNSTABLE
TOTTERNHOE
500
550
700
600
CLUBHOUSE
750
700
ZOO
600
550
500
N
S
0
1
2
3
MILES

FIG. 23.

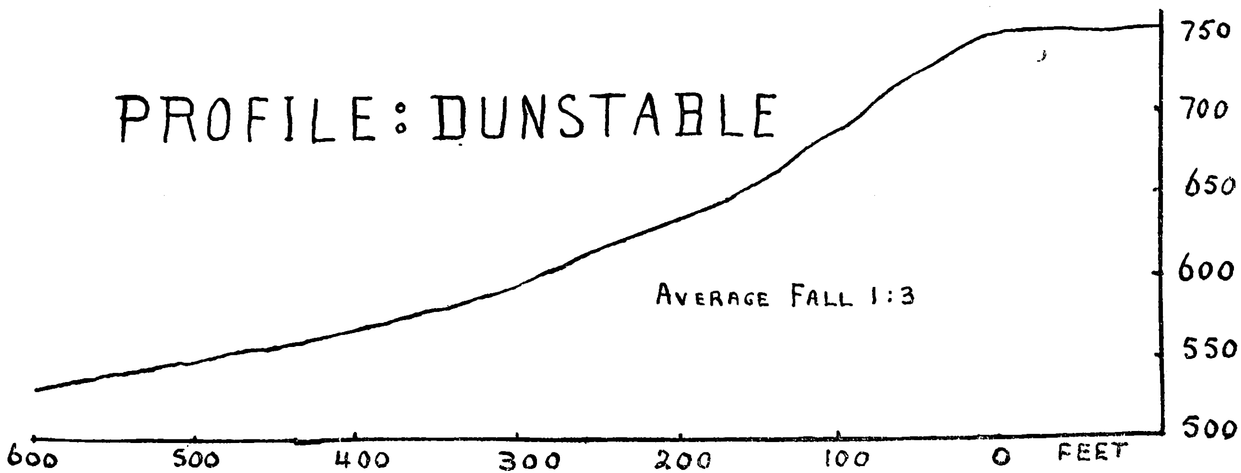

PROFILE: DUNSTABLE
AVERAGE FALL 1:3
750
700
650
600
550
500
600
500
400
300
200
100
0
FEET

FIG. 24.

second may be expected under favourable conditions. There are hundred of such places in the British Isles, but the majority are ruled out for one reason or another. The usual reason is because the ridge is facing the wrong way—and the wrong way is any way except west. Providence, abetted by other factors—of which more anon—has decreed that the wind over our island shall be westerly for about 300 days of the year.

Another good reason for discarding an otherwise suitable ridge is the lack of a road, or even a track by which it may be approached. And yet another is the essential need for a landing and launching area comprising at least 200 yards of level ground running back from either the top or the bottom of the hill. Lastly, but by no means least, is the unfortunate superstition held by many landowners that the presence of sailplanes disturbs such game as grouse, and consequently they withhold their authority. On this point it is worth mentioning that most varieties of birds take no interest in aeroplanes, and that when circling in thermal currents they get out of the way only at the very last moment.

At the established gliding centres all the preceding conditions have been fulfilled, and at some there is more than one soaring face. The great Bowl at Sutton Bank is a fine example, and any wind from north-west to south is usually soarable. The main western slope rises sharply for 600 feet from the floor of the Yorkshire plain, sweeping south in a broad curve before it suddenly breaks back to the east beyond the craggy nose of Roulston Scar. In a south wind the face overlooking the Vale of Mowbray is always worth a trial, and above the White Horse the hill lift is often good. I shall write more about this site.

The fine ridge in Derbyshire—it is really two ridges—deserves a chapter on its own. It would have been difficult to

Opposite : The steepness of the soaring slope at Sutton Bank is shown by this photograph taken from a spur of the Roulston Scar.

The Falcon III Sailplane in the picture is just completing a turn at the end of its beat—a beat which is restricted by the amount of south in the wind.

Dunstable Down. Although only 250 ft. high the ridge produces excellent hill lift up to 600 ft.

The Long Mynd. An exceptionally good soaring slope 6 miles long near Church Stretton. The Welsh mountains can be seen in the background.

select a more lovely place if the only considerations had been the upland prospect. Some three miles to the south-east of the Peak village of Castleton a massive shoulder of rock and heather rises from the banks of the Derwent in the north and stretches to the hamlet of Great Hucklow in the south, and then, turning east, runs sheer and forbidding for another two miles along Eyam ridge to Highcliffe and beyond. Its summit is 1,300 feet above sea level, and towards its southern boundary is a plateau of heather-clad turf offering a perfect area for training and for those long winch launches which give the pilot upwards of another thousand feet of height. An old farm-house and a good road, together with a highly competent committee of management, have blessed it with a reputation second to none.

Many otherwise suitable ridges are too short. They are long enough, perhaps, for a limited number of enthusiasts to soar, but when a dozen get together the impression is worse than the Brighton road on a Sunday. While two hundred yards is possible in an emergency, such as might arise after failing thermals have left the pilot on a cross-country flight thankful for any port in a storm, a ridge of two miles is not too long. I have been a member of a perspiring circus of fourteen sail-planes battling for lift along a ridge suddenly shortened (for soaring purposes) by a slant in the wind. Only too often a light breeze, or a wind which is not true against the face, will cut off the major part of what is normally a long and excellent slope, leaving only the briefest stretch of a few hundred yards for a dozen sailplanes.

I have digressed from the charms of sites to write of their flying characteristics, which properly belong to a later part of this book. At Sutton the surroundings made it seem worth while to cram the 67 miles from Newcastle into 75 minutes—not only proving that glider pilots can travel fast when they want to, but that Sutton has very peculiar attractions. The

Opposite : A Cambridge II is "bunje" launched from Bradwell Edge. This part of the slope is used for a catapult launch owing to its more gentle gradient. Winch launches are given over the steeper slope a quarter of a mile farther south.

yellow grit of that cliff-top lane, the changing shades of the heather on either side, and the streaming wind sock above the wooden clubhouse, were worth a hurry. I have tumbled out of bed in the morning and walked in bare feet to the head of the slope to watch the sun flood the Yorkshire plain, and when luck has been with me, to feel the soaring wind straighten out my hair. In Derbyshire, too, although it is a longer walk from Camphill farmhouse, I have watched the same sun noose the peaks—Mam Tor first and then the lesser giants one by one—until the light poured down into the valley itself.

And at Dunstable I have watched the hill mist retreat up the morning hillside as though making ready for the sailplanes which were being rigged below. Here launching is done by winch from the foot of the hill, and the clubhouse faces the chalk down and the morning sun. It is a more gentle prospect than either Sutton or Bradwell Edge, and infinitely removed from the majesty of Hartside. But it has character, and the 250-foot slope produces greater lift for its height than any other I know. The flying characteristics are further enhanced by the Whipsnade Zoo at the southern end, an emergency landing park which is enlivened by beasts whose attentions have proved vastly entertaining—for those on the right side of the fence.

Finally, and this is a point which is becoming increasingly significant as the performances of sailplanes improve, the site should be as far away from the sea as possible on the downwind side. Dunstable in a north-west wind offers the longest distance for a cross-country flight in the direction of Dover, rather less than 100 miles away. In a south-west wind, in which the Totternhoe end of the ridge is just soarable, the obvious direction is towards the coast of Norfolk, whose farthest point is some 110 miles away. At Sutton Bank the chances of making a really long flight are considerably worse. Scarborough is less than 40 miles distant, and although many pilots have paid it a visit, such a flight is short by modern standards. The small size of our island, in fact, is a perpetual drawback to the ambitious expert, and the long-distance records of the Continent (over 400 miles) are out of reach, unless the Channel is crossed and the flight continued across France. While this is by no means an impossibility (it was soared in a sailplane for the first time in 1939), twenty miles of open water is not a hazard to be tackled lightly.

* * * * *

The people who inhabit the gliding world are popularly rated as cranks. It is time justice was done them, for though they are prone to look like tramps, cranks is a hard word and quite unjustified. They are, of course, individualists, and it has always surprised me how they have ever come together to give each other mutual support.

Co-operation and unselfishness, and the other virtues of better men and women, are not expected in people of character who have a touch of fanaticism about them. Yet high qualities of selflessness are necessary on every hilltop where sailplanes have to be rigged, hauled and launched, and hauled and launched again, while newcomers have to be instructed. A gliding club on a Sunday morning presents a bewildering picture, and is about as near to being a communist cell as ever caused a conservative shudder. It is not as though there may be anything bizarre in a professor of mathematics borrowing a sheet of toilet paper from the shock-headed garage mechanic by whose genius the winch car works, or the rather frail-looking schoolboy with the fair hair telling the stockbroker where he gets off in the matter of thermal soaring. But it is remarkable how, when the toilet paper has served its purpose and the schoolboy has had his say, they work together as though they were agelong members of the same team. Boots clatter on the cobblestones of the yard leading to the steading where the winch cars are housed. Grunts and imprecations proceed from its recess as the world's most reluctant engines are persuaded to give tongue, and finally, without spoken orders, two steaming juggernauts will rumble from under the eaves, bump up the lane beneath the trees, and steer out across the open moorland towards the ridge.

Meanwhile two sweatered hulks, belonging perhaps to an insurance agent with an important clientele and the village schoolmaster, will clash in the same narrow doorway.

"Coming to rig the Grunau?"

"Yes, surely."

"Flying this morning?"

"No, there's a big list. I'll do a bit of instructing." And off they go across the short wire grass to where the hangar stands on the boundary of the heather.

When the Grunau is rigged and the daily inspection sheet signed by the insurance agent, the other drifts back to the old barn, where he rakes out the ashes of the stove preparatory to putting on a pot of glue. The Falcon's wing tip was smashed the previous week-end and he has appointed himself its physician. Another occupant is already in this converted workshop. He's a lightly built man of early middle age, and if it wasn't for his stained grey trousers and his wild-looking hair you would place him a trusted clerk in the service of a shipping company. As a matter of fact you would be right, but he stands now with his hands in his pockets and a blackened pipe in the corner of his mouth contemplating the fuselage of a sailplane which he has been building for the past eighteen months.

"She'll be flying before Christmas," he says, and the schoolmaster looks up and replies: "A nice job, George, but why give her an R.A.F. 32 wing section? Now, a Gottingen 652 . . ."

And the argument starts.

Out on the hilltop figures move like ants in small groups. One lot drags the Kite to the launching position under the stone wall farthest back from the ridge. Behind it, like a chain gang, come another group hauling the primary trainer to the north end of the field where the pupils will be out of the way. Over the hangar a spectacled young man is coaxing the fuselage of a Gull out of its trailer. He's a visitor, but half a dozen willing hands are helping him. When the wings, fuselage, and tail unit are laid out on the grass, they will help rig it, and if necessary haul it 500 yards to the launching point, although there is no chance of any one of them flying the aircraft. The winch driver for the morning comes up and looks on. His car is already in position.

"You've flown from here before?" he asks the visiting owner, but the latter shakes his head.

"Any advice for me?" he inquires.

"Difficult to say," replies the other, "though we ought to be able to give you a launch to 600 feet in this wind. You'll have no difficulty in staying up."

"What's the north end of the ridge like?"

"Not so hot this morning—I shouldn't go beyond the clump of trees." The newcomer looks up from inserting a strut pin with a note of inquiry on his face. He has already walked over the site, being wise for his years, and the north end looked good to him.

"There's a bit of south in the wind," says the winch driver, "and there's a gully just there which seems to break the lift. It'll be all right if it freshens."

The other nods and asks about thermals. The winch driver gives him an appraising look.

"I'd try the factory chimney in the valley any time after 11 o'clock. Do you intend to go away?"

The visitor shakes his head. He hasn't got a retrieving team, and, anyway, the weather report was not sufficiently promising to risk it. It is a poor business to be grounded in a field miles away with no prospect of being collected.

An hour later there are a dozen aircraft soaring the ridge and every sign of aggressive individualism is being shown. Now it is every man for himself—not that this means jockeying for positions that are better than others, but a restless search for thermals as far out over the valley as the pilots dare strike without losing the chance of regaining the hill if they are unsuccessful. Some find the magic bubbles of rising air and soar to the newly forming clouds as they drift back over the slope. Others land, exasperated at their own ill luck, or, more shrewdly judged by others, through their incompetence.

Meanwhile the ground hoppers toil and sweat at the northern end of the field, led by the honorary instructor, who has given up his own morning flight. The instructor knows by this time that his own chances during the afternoon, when he will be relieved, are deteriorating. The weather report speaks of a warm front expected during the evening. A layer of low stratus cloud will probably stop soaring for the day.

Yes—they are an unselfish, aggressive, incomprehensible lot. They would make good guerillas, but a shocking line regiment—and the longer you live amongst them the more certain you are that it must be a strong bond which holds them together.

An odd thing to find among so many individualists is the way the conversation at night round the smoke-filled bar veers to "shop." In a company whose interests cover the field of human progress no word escapes of their private lives.

In the war which is closing many of them begged or bullied their way into flying jobs. Some were graded physically unfit, or too old for first-line squadrons, but within a year of the end of private flying in 1939 there were glider pilots flying bombers over Germany, Spitfires in the battle of Britain, Swordfish for the Fleet Air Arm, and yet others of every conceivable type on ferrying duties for the A.T.A. And now, nearly five years later, it can be claimed that they have done well. As was inevitable, many have been killed, but there are sufficient of us left to re-establish a sport which has its own contribution to make to our future in the air.

FIRST LESSONS

A MAN or woman can learn to fly a glider in about the same time as they learn to drive a car. Some will have a more natural aptitude for it than others, but there are very, very few who will ever feel so inept that they will give up once they have taken their first lesson. It is something to know, too, that a high-efficiency sailplane is about the easiest type of flying machine to pilot and certainly the safest. Of the aircraft I have flown, I would put three sailplanes at the top of the list for ease of control—the Kite, the Gull, and the Rhönbussard. (The Minimoa is more stable than any of these.) The secondary and elementary types have just sufficient natural vice to make them suitable for teaching, and they stand in the same position as the Tiger Moth and the Gladiator, or the Miles Master and the Spitfire—the Gladiator and the Spitfire being the easier machines.

But before you are strapped into the seat of your primary glider for the first lesson it is well to understand clearly the nature of the wind currents for which your brief preliminary training will qualify you. The chapter on soaring sites will have given an indication of the winds used in the simplest type of sail-flying, but they are sufficiently important to be re-stated in the plainest language.

First of all, it is obvious that to maintain height in an aircraft without an engine a rising current of air is essential. Most winds over the land, and nearly all winds over the sea, blow on a horizontal plane. But under certain conditions they deviate from the straight and level path, and even, as in thunderclouds, blow directly up and down. The sailplane pilot in a good machine can make use of any wind which is rising at a speed greater than 3 feet per second, regardless of its horizontal velocity. The intermediate type of sailplane at its best gliding angle has a rate of descent of just about this speed, so that if it is flying in a current rising at, say, 5 feet per second, its net gain will be 2 feet per second, or 120 feet a minute.

Many vertical currents achieve a velocity far in excess of the bare minimum. The greatest of all are to be found among those majestic masses of cloud which pile up into Himalayan ridges, whose undersides are a deep purple and whose flanks bear the stain of livid yellows. Vertical air speeds up to 60 feet per second may be found within such masses, velocities which will tear the wings from the strongest aircraft. Losses among night bomber squadrons have been known owing to just such formations. Even the geodetic construction of metal fuselages, backed by the power of thousands of horse-power, have succumbed before the onslaught. Few pilots of Bomber Command but would prefer to face the known hazards of "flak" than the unknown terrors of a fully developed thunderstorm.

Between such conditions of great violence and the quietude of complete calm there is a range of airs which may be ridden with joy and safety. Most elementary of all are the gentle winds

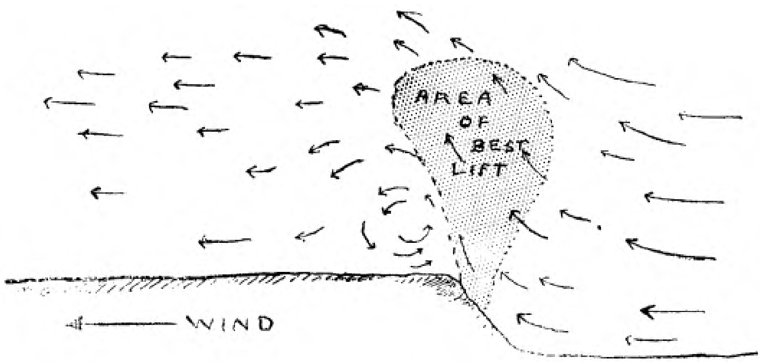


FIG. 25.—*The airflow over a ridge when the lapse rate is high. For further comment on this see page* 84.

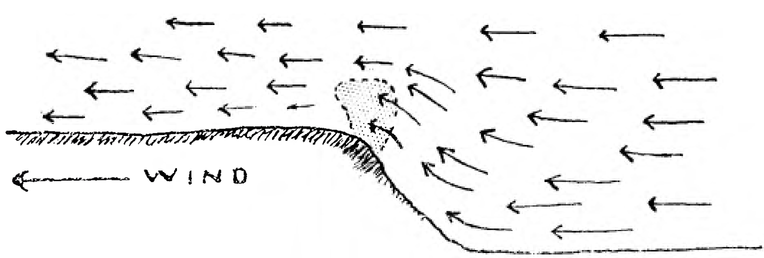


FIG. 26.—*The same ridge, but in conditions of a low lapse rate.*

which strike a hill face and are deflected over it as they flow onwards across the countryside. Along the sides and above the crests of such hills it must be clear that an upflow is created which might support the burden of a sailplane. As a matter of history, the vertical speed acquired by a wind which strikes the face of a hill may be anything from 3 to 15 feet per second. At Bradwell Edge in Derbyshire, or at Sutton Bank, where the characteristics are similar, a west wind of 20 miles an hour may produce an upcurrent of 7 feet per second immediately over the crest, and perhaps 12 feet per second for the ensuing 300 feet. Beyond that, the wind will begin to flatten out again, its vertical element dying away, until at 800 feet the pilot is neither climbing nor sinking, but held suspended in an upcurrent which exactly matches his natural speed of descent (see Fig. 25).

Other ridges show quite different results. I have described a catapult launch off that forbidding face which falls from the shoulders of Cross Fell. Here, as I have said in the last chapter, the contours are on the grand scale, the slope falling fifteen hundred feet from the lip which spews the Alston road into the Eden Valley. One is fired like an arrow from a bow into an area where updraughts of the most potential kind are to be found and avenues opened to more ambitious journeys.

With such an elementary knowledge one can begin one's training. For the first few weeks there is not the slightest chance of finding oneself fighting for height along the precipices of Hartside or anywhere else. The nearest the pupil gets to such places is the flat training field either at the top or the bottom of the club ridge. The training at Camphill, for instance (the Derbyshire and Lancashire Club), is given on the comparatively smooth plateau which runs for 800 yards parallel to the soaring slope. It is bounded on the eastward side by a dry stone wall which guards the sacred precincts of a grouse moor, and here there is no cliff over which to fall, or savage eddy which calls for instantaneous action to avoid disaster. Instead, there is this reassuring moor, an open "Dagling" trainer, a towing car, and a hundred yards of wire rope. Over on the west side one admittedly notices that the earth suddenly ends and the sky begins, and that in slow majesty the shapes of the *maestros'* sailplanes swing leisurely to and fro above the edge. But all this is 400 yards away and perhaps 30 minutes' flying time. (There came a moment which was 15 minutes' flying time after my first lesson when I certainly did find myself looking down between my knees through 400 feet of space at the callous faces of friends below. The fact that I rejoined them safely is testimony for 15 minutes well spent and for the quality of glider instruction.)

My first flight was no flight at all. It consisted of an invitation to the bucket seat of the "Dagling" (illustrated opposite page 49) and ten minutes' "stick" practice in which we never moved at all. There was a nice breeze blowing, and by heading the aircraft into it it was possible to balance the machine on its skid by use of the ailerons. For this purpose another pupil held the wing steady for a moment until I was ready, and then by pushing the control column to one side or the other as a wing "wobbled" in the gusts, I very soon learnt the elements of lateral control. The average pupil could balance the stationary "Dagling" on the ailerons after 3 minutes. I will guarantee to teach anybody's grandmother to do the same in less than five.

The next lesson, costing sixpence, consisted of being dragged along the ground by the wire cable attached to the motor-car. The shock of starting was absorbed by a short length of rubber rope between the wire and a hook in the nose of the machine.

The driver went ahead, and my monster and I lurched forwards, keeping company by virtue of the broad strap which encircled my middle. The speed never rose beyond 10 miles an hour, which, in spite of the head wind, was not fast enough to lift me from the ground, whatever I did with the control column. It was, however, fast enough to give me lateral control. I could still keep the wings parallel to the ground, moving the stick hard over one side whenever the opposite wing tended to drop.

The initial fault of pupils at this stage is, of course, to make their corrections too late. If you have ever tried to teach anyone to drive a car, you will have noticed how slow they are to anticipate a swing to one side of the road, and you itch to grasp the wheel. It is exactly the same with the controls of a sailplane—or for that matter of an aeroplane. The practice which I was putting in during half a dozen runs across the field was not so much to learn that left stick pulled the right wing up, but to anticipate the drop of the wing and to correct it before it happened.

After about a dozen runs, between which I did a vast amount of hauling and recovering for the benefit of other pupils, I could anticipate the eccentricities of the aircraft (which were due to the unevenness of the wind) with reasonable speed. It was really ridiculously easy, and the corrections which had to be made were becoming automatic. The moment had arrived, in fact, when I was to be addressed in stern tones by the instructor.

"We are now going to pull you over the ground a few miles an hour faster. If you ease the stick back you will fly."

This is a big moment. You suddenly realise how little you know. How far must you pull it back? and what about the rudder, which hasn't even been discussed? Fly? Good heavens! —and then the inexorable voice of the instructor breaks in again.

"Ease it back gently, but quite firmly, and then when you feel yourself off the ground ease it forward again. That will bring you back to earth—perhaps with a bump. Never mind—just let the machine settle down and then if you feel like it ease her off again."

Yes—ease her off again and then push it back, ease her off and push her back. An exhilarating panic is sweeping over you by this time, but at least you have the presence of mind to ask about the rudder.

"The rudder," says the instructor. "The less you have to do with it the better. In fact, I'd forget about the rudder if I were you."

He doesn't feel very certain, but he looks a nice chap, and you can't believe that he is sending you to your death deliberately. You are wondering about this when the instructor waves an arm slowly above his head, the signal to the car driver to take up the slack in the cable. Before you realise it you are moving. You are off on your first flight!

I saw the heather bow and crush beneath the skid, and for a moment watched fascinated the curl of the blue exhaust from the car ahead. Faster and faster, till I knew that if I pulled back on the stick I should fly. Gently I pressed back—oh, so gently—and then without any warning the earth and I parted company. I was flying—flying! I wanted to shout it to the heavens. Three feet above the heather I was consuming space with the freedom of a dragon-fly.

Stick forward . . . mind the bump . . . steady . . . steady . . . a savage jab on the rudder to correct a yaw (curious how instinctive it is), and then once again the brief ecstasy of smooth air beneath the skid for a dozen yards. I was hardly airborne for the second time when the car stopped. The flight was over.

I can never hope for another thrill quite like it. I thought perhaps that it might be vouchsafed to me when I made my first solo in a real aeroplane. Then I thought I might recapture it when a Service pilot offered me his Hurricane for a joy ride, and later still when I grasped the controls of a four-engined aircraft for the first time. But no! That flight which never took me more than four feet from mother earth was a thing on its own.

Once you have been in the air in sole charge of a flying machine you feel a very different fellow. You walk into the bar at the end of the day without any of your previous modesty, and, forgathering with brother aviators at about the same stage as yourself, you "shoot your line" as vigorously as that other group over in the corner who have been slope soaring. But be careful not to get into the wrong group. The withering contempt of a seasoned aviator as you describe the tasty way you saved yourself by a jab on the rudder of the primary as you were neatly spinning in from ten feet is most rankling.

After two or three week-ends of hard labour helping to rig, haul, and launch the aircraft, with nights spent in the crowded bunkhouse of the converted farmhouse which served as the club's headquarters, I was promoted "to the wire," which meant that when my turn came to fly I was no longer conducted by a wheezing motor-car, but attached to the end of a 2,000-foot cable and "wound up" to a winch in a series of long hops. In the course of these hops I reached colossal heights—sometimes 10 feet, and once nearly 50 feet—from which I glided down in a straight line to the heather.

Every ascent was made with a decreasing quota of terror and an increasing sense of pleasure. It is extraordinary how readily the dull-witted adult will react to the swishing melody of a glider a few feet above the earth. And in this connection it should be stated that the pilot is unconsciously learning something which he will use throughout his soaring career. He is learning to use his ears, which in a primary takes the place of an air-speed indicator, and in advanced soaring is a guide which, owing to the lag of the instrument, is, under rough conditions, far more useful.

Gliders each have a sound of their own. No two machines are quite alike, and as their speed varies, so does their note. The training primary is more shrill than the organ-like song of the advanced sailplane. It has one particular sound for its best flying speed, and this is the first sound which it is important to recognise. At a higher speed new noises are added to the other whistles—perhaps the trill of another flying wire and certainly a deeper note for the main body of wind passing over the leading edge behind your head. At a low speed near the stall the sound sinks to a gentle sob, unmistakable in its warning, so that even if the sloppy feel of the controls fails to tell you what is happening, your ears should come to the rescue.

And being further blessed with eyes, one learns to associate the sound of the aircraft with its attitude to the horizon. The absence of instruments is no disadvantage. It is, in fact, intentional, because it forces the pupil to take note of the things which matter in sail-flying—the sounds in his ears and the feel in his hands. The idea has always horrified professional power-craft instructors.

It is during these pulls across the field that one grasps these essentials. The winch driver will sometimes stop his winch if you are climbing too high, leaving you to glide down on your own account. So the words "gliding angle" take on a real meaning. Sound and feel prove what you already know theoretically—that a primary trainer has a glide path of about

1 in 12, and flies best at about 26 m.p.h. The subsequent landing, which takes hours of practice to be even "safe" in a power craft, presents only minor difficulties to the glider pupil. He may, of course, continue his glide path straight into the ground and suffer shock to his posterior accordingly. But he is unlikely to do any serious damage, while the instinct to hold off is such a natural one that he far more often finds himself flying parallel to the earth, the actual landing being safe—if not polished—in the hands of old man gravity.

Looking back through my log book, I find that I had three pulls across the field before being passed out as ready to try for my "A" certificate. This meant that I had to accomplish a free glide of 30 seconds, entailing an ascent to the unprecedented height of 400 feet. At this height the winch driver would stop his motor, the towing cable would fall off the open hook of the aircraft, and I should be left to fend for myself. So far I had done no turns, and what use of the rudder I had made had been of the gentlest variety. Nor was I encouraged to use it now. The rudder is a dangerous control under the feet of a hard-kicking enthusiast, and all the alterations of course required at this stage of gliding can be achieved principally on the ailerons.

The test was staged one fine Sunday afternoon, and, as was usual when a new pilot was about to dice with death, a group of friendly ghouls gathered round to offer advice.

There was a southerly veer in the wind that afternoon, which meant that the take-off was parallel with the ridge and we had the longest available stretch of flat ground for the flight. My instructions were clear. As soon as I felt the strain come off the cable I was to push the stick forward and get the nose down. Then, assuming a safe gliding angle, I was to return to earth in a straight line. On no account must I attempt to make a turn.

This sounds simple, but to a pilot who had less than 15 minutes' air experience, it had its disturbing side. Four hundred feet must be about the height of the Nelson Column, and the idea of being perched on what seemed no better than a kitchen chair without the protection of any sort of fuselage was almost as unattractive as an invitation to walk the "high wire."

I listened carefully to my instructor and was strapped in, my head resting against the leather pad beneath the leading edge. The ring on the end of the cable was slipped under the glider's hook; the wing tip was held steady by a willing hand; the signaller began slowly to revolve a flag round his head. The cable began to tighten. I looked nervously down its length, across vistas of heather to its far distance, where nearly 700 yards away the other end of the wire curled over the winch drum. Then we jerked forwards a few inches. The wire was taut. The signaller dropped his flag, and I can hear the whistle of it now as he cut it to his side. It was the signal for the winch driver to speed up his motor.

With a savage tug the wing tip was snatched out of the helper's hand and I was charging forwards across the heather. I held the machine down for a moment by keeping the stick forward, and then eased it back for a sudden leap from the earth. This was to be the longest climb I had ever made, and I had time to think about it. First of all came hurried thoughts about keeping the wings level and the nose not too steeply pointing at the sky. A glider which is on a winch launch has an unbelievably steep angle of attack, far steeper than an aeroplane climbing on full throttle. But it can be overdone, and the dangerous sign is a snatch of the cable like a fretful horse on the end of a halter.

But I made no mistake that day. The ridge and then the valley below opened up on my right, the clubhouse with its ring of flat-topped trees floated above my toes, while to the left the moorland bounded in successive waves to the horizon.

There was just one moment of panic when the towing cable dropped. Then the instinct of self-preservation took a hand. I had to do something, and do it quickly. I had to push the stick forward and get back my flying speed. I did it, and as the wind mounted in my face and the firmness came back to the controls, I recovered the feeling of stability. I could even lean sideways over space and look down into the upturned faces without feeling sick.

Before I was halfway down I remembered that I had to stretch the flight to 30 seconds. So with gentle tugs at the stick I eased the nose up till the wind was no more than a playful breeze, and descended for the rest of the way less hurriedly for a total flight of 34 seconds.

Within twenty-four hours I had sent off a signed form and a cheque for 5s., which would enrol me as a certified glider pilot.

SECOND LESSONS

LANDINGS . . . more landings . . . and still more landings. I made scores of them. An early entry in my log book reads: "Must get out of the habit of landing 10 feet up." It was a common fault. Many pupils created for themselves an invisible platform of solid earth several feet above the ground. Very few tried to land below the ground, although they would have been safer if they had made the attempt. Years later I found the same difficulty in adjusting my perspective to Service aircraft in which the pilot's seat was anything up to 12 feet above the deck. The tendency now was reversed—instead of holding off too high, I found myself flying into the ground and bouncing off again, swallowing up long stretches of the runway in gigantic leaps. I have already said that there is nothing difficult about landing a sailplane. Of the world's aircraft it is the easiest. But nothing in everyday life calls for good judgment in vertical distances. The quality is undeveloped in the human being and the eye needs training. Even the driver of a racing car finds himself in difficulties in a sailplane—his estimation of distance in a horizontal plane may be perfect, but his opinion on a matter as to whether he is 3 or 6 feet above the ground is worth nothing.

You fly a sailplane all the way back to the earth, and it is this which makes it so easy. The three-point landing which follows a stall 6 inches above the deck—a trick which takes the pupil of a power craft several hours to master—is unnecessary and undesirable in a glider. As soon as I had exorcised my first bad habit, I began to hear the short heather rustling the underside of the landing skid for 20 yards or more before the aircraft touched the solid earth.

But whenever the wind was blowing at more than 10 m.p.h. every pupil discovered a new factor entering into his consideration—the factor of decreasing wind speeds immediately above the ground. It was this which retarded my progress more than anything else, for I took time to realise that I might be flying through air moving at 12 m.p.h. at 12 feet above the ground, but that 6 feet lower down the wind had dropped to a mere 9 m.p.h. This slowing down of the air currents, due to friction between the uneven surface of the earth and the air, made it easy to stall a glider if the approach was made too slowly.

While exact figures cannot be given for the drop in wind speed near the ground, partly because it varies with the lapse rate, the temperature, and the unevenness of the ground itself, the following table from a height of 300 feet down to 3 feet is representative of daytime conditions with a medium lapse rate and comparatively smooth ground such as a grass field.

Height in Feet.	*Wind Speed in m.p.h.*
300	25
75	19
30	16
15	14
9	13
3	11½

Another early difficulty which was only disposed of by constant practice was an accurate estimation of the flying speed, a point not only linked up with landing, but with the long glide back to earth from the top of a launch. I had successfully overcome the tendency to fly too slowly—or I should never have been allowed to take the "A" certificate. But it was now necessary to learn with a nice degree of accuracy the precise speed which gave the longest glide. When a difference of approximately 5 miles an hour represents the gap between stalling and flying too fast, and the pilot has only his untrained ears to rely upon, the need for practice is clear. I began to use my ears more and more—to listen to the song of the wind in the bracing wires and to translate it into terms of air speed. And my hands began to grow more sensitive. I began to interpret better the feel of the controls and appreciate the nice differences which existed immediately before the stall. A sense of touch was developing which ultimately enabled me to assess the flying speed as accurately as any mechanical instrument, a quality which was not without its value on many future occasions.

The time eventually came when I was ready to be introduced to the magic airs which lay beyond the edge of the cliff. The first time I felt the surge of the rising currents and saw below the giddy depth of the valley I knew that at last I was face to face with the real problems of soaring flight. I had been pulled up to a height of 500 feet and had been given permission to include a segment of that hitherto forbidden ridge in my circuit back to earth. As we crossed the lip I felt the sudden assault of the vertical wind, an instability which up to that moment I didn't believe could exist. It was a desperately thrilling moment, perhaps with a kinship to the feeling of a helmsman who steers his yacht out of harbour for the first time to experience the toss and heave of the open sea.

I found myself gripping the stick a little harder, thrusting it against the unsteady air-flow, and keeping the nose low as I had been taught. And in that brief passage I realised that I was no longer sinking, but at last riding the updraught in the true fashion of a sailplane.

This initial step between the quiet training field and the heady air of the ridge need only be a short one. The new pilot may have made a mere half-dozen ascents for wide circuits of the field, but he will have practised gentle turns and will be sure of his landings. Nor is it likely that he will cross the cliff for the first time in his original training machine. He will have been promoted to something more efficient—probably a nacelled Dagling, his old friend with a fuselage built around the seat. It is wonderful what a sense of security a sheet of plywood will give him, and even more wonderful how it improves the flying characteristics of the craft. Instead of a rapid sink, there will now be a feeling of buoyancy and, in spite of the additional weight, a more gradual descent. Although it is only the flying bedstead in a new guise, it will now soar if the wind on the cliff is a good stiff one (see illustration opposite page 256).

Introduction to the new craft itself means that flights lasting more than a minute are possible without crossing the cliff edge. One of these, plus the payment of another five shillings, earn the aeronaut his "B" certificate and the right to attempt his first soaring flight. If he now succeeds in maintaining height above the starting point for five minutes, he will obtain the final endorsement of competence—the magic "C" certificate, corresponding in dignity to the "A" licence of the power pilot.

As far as I was concerned, I passed the "A" and "B" tests in successive week-ends. But I was balked of my "C" for over three months, to say nothing of nearly breaking my neck in the interval.

I never missed an opportunity to fly, for the new love was in its first flush, and though I was ham-handed and never even guessed the fun which was to follow as practice brought a measure of skill, I exerted myself to the extent of getting up at dawn, motoring 30 miles, and making another attempt before driving yet another 30 miles to the office. But to no purpose. During those weeks the wind blew either from the south, in which only a skilled pilot could soar (and that in a high-efficiency machine), or else from the east—a wind which would have grounded a Fulmar on this site—the most brilliant exponent of soaring flight among the birds.

Perhaps it was well, for the disappointment not only gave me the opportunity to practise landings, but taught me something more about the meteorology of soaring, without which no pilot is ever any good. I learnt, for instance, that even when the west wind was blowing I should have no chance if it was rustling the tree-tops around the clubhouse. Such isolated items of knowledge were proved by hair-raising scrapes over the wall which lined the edge of the cliff. They provided food for thought. Why should a west wind one day permit a pilot to climb to 600 feet, and the next confine him to within a few dangerous feet of the ridge?

So I made the discovery that it was necessary to be an interpreter of the sky and not only an admirer of its beauties. I had been like a man who had been taken to hear a great piece of music and was suddenly confronted with the necessity for composing a piece himself. Some of the first great truths which govern soaring flight were being dinned into my thick head—truths which every new pilgrim into the by-ways of the sky must learn for himself.

The wind in the trees around the clubhouse was not heard on good days because it was passing overhead, leaving a calm below. On bad days it came tumbling over the cliff to rush among the trees a few hundred yards from the edge without rising. In the first instance the air stream leapt into the sky from the ridge, while in the second it clung lifelessly to the contours of the ground. It would have been possible to have discovered what the wind was doing on any day without going within a hundred miles of the site by ringing up the Air Ministry and inquiring for the lapse rate. The lapse rate, which is the temperature by which the air falls for every thousand feet of height, has a profound influence on soaring. When cumulus clouds are in the sky—the towering castles of a summer day—the temperature may drop by as much as 6 degrees for every thousand feet of height. Thus, if the temperature is 60 degrees in your garden, it will be only 42 degrees at 3,000 feet, and freezing at about 5,000 feet.

On the other hand, when a roof of flat grey cloud covers the sky the fall in temperature may be only 1 degree per thousand feet, or it may even be warmer than at ground level, and what is known as an inversion exists. Translate these conditions into terms of two 20 m.p.h. winds striking the foot of Bradwell edge, and see what happens. Both winds are forced up the hill for 500 feet. One of them enters an air layer which is 3 degrees colder, and the other a layer which is ½ degree colder or less.

In the first case the rising stream will be accelerated, for it is appreciably warmer than the layer it has entered. In the second case it will have much less acceleration imparted to it for this reason, and will consequently tend to resume its course laterally over the landscape. The latter wind will rustle the trees round the clubhouse. The former will pass overhead, leaving a calm area beneath (see Figs. 25 and 26).

As a matter of fact, under good soaring conditions, with a 20 m.p.h. west wind on the face, I have found a dead calm when standing on the ground 30 yards back from the edge, and a slight breeze which veered from the north into the east 40 yards back. After yet another 20 yards the wind has begun to resume its westerly trend, very gently, but not for many hundreds of yards regaining the impetus with which it struck the cliff.

Hence it can be stated that any upward trend in a current of air, for whatever reason, will be accelerated by a high lapse rate. It follows that under such conditions soaring should be good.

The quality of the hill lift doesn't, of course, depend only on the strength of the wind and the lapse rate. A third factor—the angle at which it strikes the slope—is of importance. It is obvious that the greatest effect will be felt when the wind is at 90 degrees to the slope, but as no ridge runs in a straight line over its whole length, the lift will be stronger in one place than another. It will, moreover, be variable and capricious above gullies and faults.

The more interesting aspect of the problem is how far the wind can veer towards the general line of a slope and still remain soarable. Like many other gliding problems, there is no straightforward answer. Given a high lapse rate and a wind speed of not less than 25 m.p.h., it would seem that an angle as small as 30 degrees does not always stop flying. When a straight face curves round to form a bowl, the bowl itself appears to form a gathering ground for the air stream, providing excellent lift at this point.

Experience of flying different ridges in narrow slants of wind suggests that there is a critical angle for each set of conditions. In other words, the air stream continues to flow up a hillside until the critical point is reached, after which any further increase of the slant causes the flow to bend, creating a local veer in the wind, which then commences to flow parallel with the hill. At Hartside this factor always seemed to be specially marked, probably owing to the great bulk of the Pennine mass having a capacity for deflection greater than lower and shorter ridges.

THE BREATH OF SOARING FLIGHT

IT is now time to introduce other great air currents which make glider flights possible. Although we shall come to know each of them more intimately as my theme develops, a nodding acquaintance at this elementary stage will help to form a background to the world into which we are moving. The most important of them is the current known as a "thermal," which is born as the result of a patch of ground warming up more rapidly than the ground round about it. A piece of chalk country, a stretch of bare rock like that provided by the White Horse in Yorkshire, a wood, a newly ploughed field, the roofs of a town, all warm up on a sunny day more rapidly than grass-covered soil. On the day which I wrote these words I was flying over the outskirts of London, and above nearly every fresh suburb was smacked hard by a thermal. Above them a bubble of warm air will accumulate under the influence of the sun, and like a soap bubble will finally drift away, overcoming the stiction which held it to the ground. These thermals are the principal link between the ground and the clouds for the glider pilot (see Fig. 27).

It doesn't matter whether it is winter or summer. The temperatures of the air and the ground are of no account so long as they differ relatively. Admittedly, the greatest variations occur in summer when the sun is stronger, but the thermals of a winter afternoon are often strong enough to take a pilot to the clouds.

The lapse rate is important just as it is on the home ridge, for the speed with which the thermal rises will depend largely upon a rapid fall of temperature as height is gained. On a good day a pilot may achieve a climb of 3 or 4 feet per second over the first few hundred feet, increasing to 5 feet per second after a thousand feet, and rising to as much as 15 feet per second near cloud base. The evening thermal encountered in Derbyshire is a mass effect of the same conditions—the rising, not of an isolated bubble, but of the air filling a whole valley. (I have dealt with it in some detail in a later chapter.)

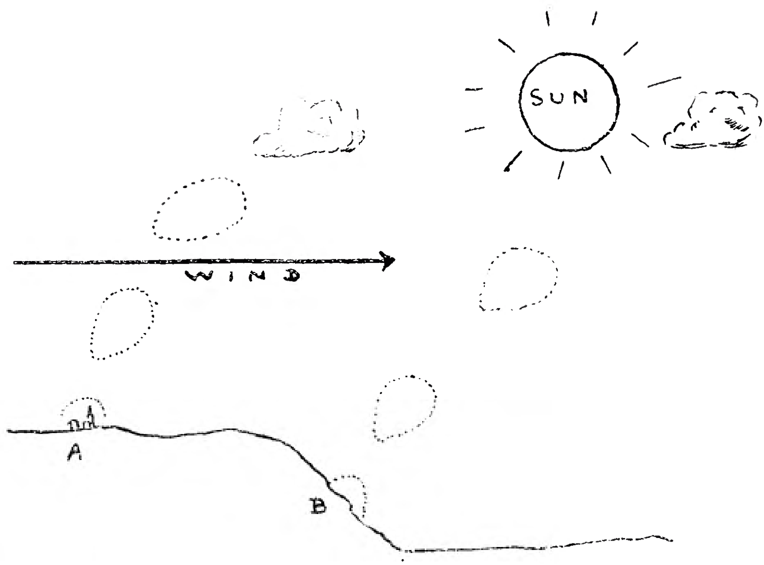


Fig. 27.—*Two typical conditions under which thermals will form. On the left the sun is beating down on the roofs of a hamlet, and on the right the thermal is forming on the wind-sheltered slope of a hill. The dotted figures represent the path of the thermal after release, in each case condensing into a cloud when the dew point is reached.*

Two other kinds of rising currents can be mentioned briefly. A third—the sensational phenomenon known as a standing wave—will emerge in another story. There is, first, the important effect of a cold front. Under these conditions a mass of cold air advances across the country, cutting beneath the warmer air ahead of it and forcing it upwards. Local cold fronts are often to be met with in spring when squalls advance across the sky, bringing with them furies of rain or hail. Along the forward edge of the storm the warm air is violently thrust out of the way, as though by an enormous snow plough which shovels it over the top of the advancing air mass. Its effect is violent even close to the ground. I have been whipped upwards in such a front for a thousand feet in half a minute. It is a good vehicle for a cross-country flight, for by riding the currents ahead of the storm you may travel with it until it blows itself out.

Lastly, there is the lift to be won from the clouds themselves. Every cloud casts a shadow, and the air immediately beneath its base tends to cool, the warmer air around it filtering in and rising into the cloud. Its effect can often be felt for 1,000 feet beneath the base.

Horizontal air currents are ostensibly of little use to the glider pilot beyond the lift they provide for ridge soaring. But in practice they play a bigger part. Their influence on cross-country flying is a governing factor, not by virtue of the wind speed and its direction on the ground, but by its speed and direction at the height at which the flight is made.

I was looking at the weather report at a fighter station one day, when I noticed that the wind speed at 30,000 feet was 100 miles an hour. This is nothing unusual, although at ground level such a gale doesn't occur in this country once in 10 years, and then only as a gust.

Today there was a breeze of 15 m.p.h. on the ground. At 2,000 feet it had increased to 30 m.p.h. and altered its direction by 30 degrees. At 3,000 feet it had risen to 50 m.p.h. Such conditions are quite normal. I have frequently found a wind more than 40 miles an hour to be blowing at 3,000 feet when there were only light airs at ground level. As a general rule the wind speed at 3,000 feet is likely to be three times its speed at 10 feet. If the indicated air speed of a sailplane is 35 m.p.h., the ground speed is 75 m.p.h. with a 40 m.p.h. tail wind—or, conversely, −5 m.p.h. in the opposite direction. So the influence of the upper air currents both in speed and direction matters a great deal in advanced soaring. It can even matter in power flying.

On one occasion, when carrying out an exercise for the Fleet Air Arm, I crossed the coast and flew out to sea for 20 minutes at an indicated air speed of 120 m.p.h. I then turned through 180 degrees and flew back. Had there been no wind, I should have crossed the coast again in another 20 minutes. In point of fact, it was 1 hour 14 minutes before I sighted an island in the Forth, nearly 30 miles to the south of my starting point. The wind on the ground that day was not much more than a stiff breeze, but at 2,000 feet, the height at which I was flying, it was in the neighbourhood of 70 m.p.h.

On more than one occasion I have gone down to sea level in an aircraft in order to cheat the winds blowing in the upper air. Nine times out of ten they are nothing like so strong close to the earth—a fact which may make the difference between getting home and making a voyage in a rubber dinghy when petrol is short.

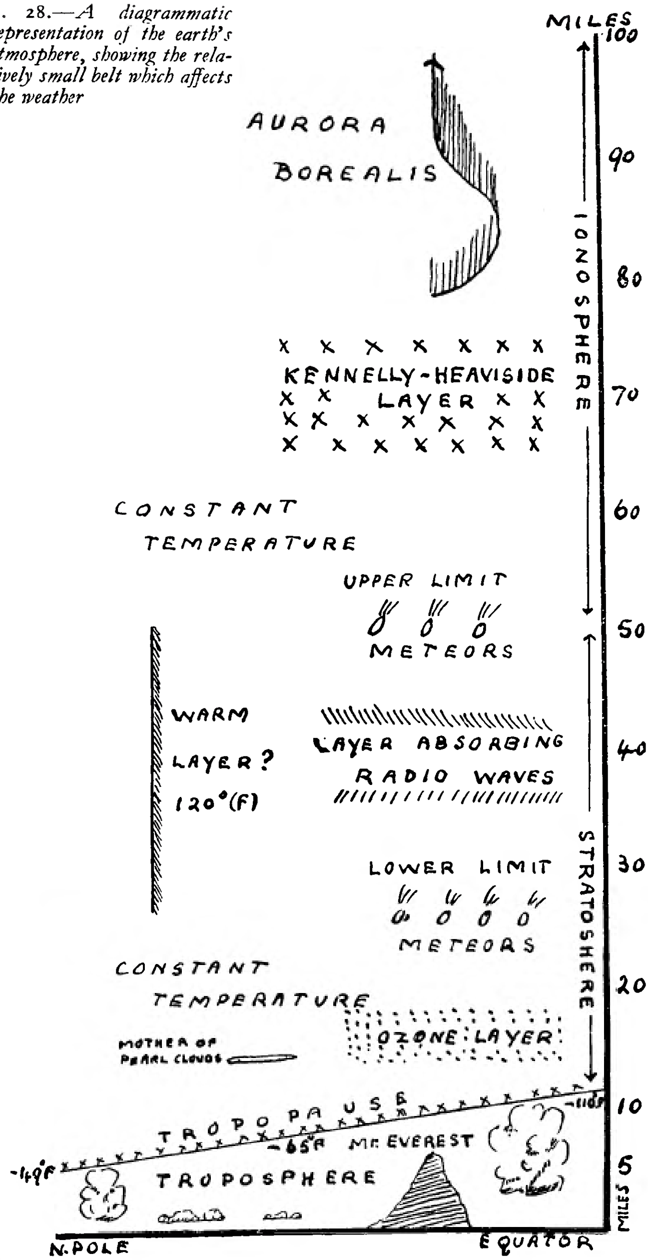
The highest wind in which I have soared a sailplane was a mere 45 m.p.h. It was once again on the Derbyshire site, and to maintain a position over the edge of the cliff it was necessary to hold the nose down and sacrifice efficiency for speed. The technique of landing in such a wind was amusing. It entailed reducing flying speed to 30 m.p.h. by raising the nose, and flying backwards across the plateau until in a convenient position to land. The sight of the ground passing the wrong way beneath the aircraft was upsetting. But there was no alternative. In such a wind any attempt at making a normal circuit would have whipped me away on to the moor. The retreat was, of course, halted by putting the nose down again, and holding it down until it was necessary to flatten out just before touching the ground. The wind was less here, and it was just possible to put the machine down and keep it down by continuing to hold the stick forward. The actual landing run was not more than 6 feet!

Lest this dissertation becomes tedious, let me be done with it by saying that horizontal wind speeds are governed by the fall of air pressure between two points. If the fall is sharp, the wind will be high. If it is gentle, it will be light. In "met" parlance, the wind will be high when the isobars are close together.

When you reach heights of the order of 30,000 feet the same rules apply in principle. If the pressure at the top of two columns of air 200 miles apart is radically different, there will be a high wind between them.

Everything of which I have written here belongs only to a fractional part of the earth's atmosphere. In gliding one's interest over the 16,000-foot level is academic, for it is largely below this height that the world's weather is manufactured.

FIG. 28.—*A diagrammatic representation of the earth's atmosphere, showing the relatively small belt which affects the weather*



On the other hand, some understanding of the atmosphere's structure helps to paint in the background without which no complete picture is possible.

It is because 90 per cent. of the moisture in the atmosphere is held in suspension within the first three miles that the weather is made or marred within this compass. But above it, terminating about 1,000 miles above the surface of the earth, is the first trace of the air which we know and by which we live at ground level. Observers have fixed a flicker of the Aurora Borealis at 4,000,000 feet, proving the existence of the molecular construction of the atmosphere at this height. Below it there are vast banks of strata, each of them with strange and little-known characteristics. Diagrammatically they are represented in Fig. 28 on the previous page.

It will be seen that the stratum in which we human beings are interested is a narrow one, a little deeper in the tropics, but all of it lying below a height of 12 miles. On the top of it lies a roof which we call the Tropopause. It can be bent by depressions into the shape of a wave, but for all practical purposes it marks the boundary of our world. Above it lie the icy deserts of the stratosphere, a cloudless oasis of air, structurally the same as the air at ground level, but infinitely thin, constant in temperature, and as stable as a duck pond. At these levels, perhaps at some 70,000 feet, our children's children will fly in safety and certainly in comfort. Successive layers above it have their own individual characters—for instance, the layer at some 40 miles above the earth which absorbs radio waves during the daylight hours and has no effect upon them at night, a phenomena which suggests that the temperature of the icy void momentarily gives place to a mysterious heat at this level, a stratum capable of assimilating the sun's heat and creating a barrier to the radio wave. And higher still there is the Kennelly-Heaviside Layer, reflecting radio waves like a mirror and making long-range transmission from point to point on the earth a matter of course.

This fascinating kingdom of the upper air does not belong to the sailplane pilot, but it is meet that he remembers it and is humble in his triumphs.

The roof over our own special world is about 60,000 feet high at the Equator and 25,000 feet at the North Pole (see Fig. 29). In the middle latitudes the ceiling is about 35,000 feet, and it is at this height that airmen over the British Isles finally leave behind the last of the thin cirrus clouds.

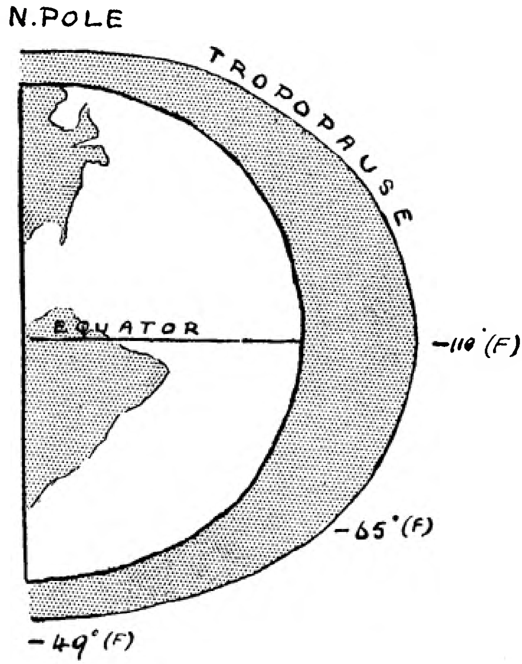


FIG. 29.—*The weather belt lies beneath the Tropopause, which is seen to be deeper at the Equator than at the Poles.*

To understand the reason for the elliptical shape of the weather belt it is only necessary to explain the action of the sun on the earth's surface. Forgetting for the moment the light waves and remembering only the heat waves emanating from the sun, the latter pass through the atmosphere without being absorbed, with the result that the great majority of these waves reach the earth's surface. Unlike the atmosphere, the earth absorbs this heat energy, which it releases again as radiant heat. Above the Equatorial belt much more radiant energy is received than over the Polar regions, so that the tropical air is warm, and in this condition expands and rises to far greater heights than the cold, dense air over the Poles.

With an understanding of this effect it is easy to go on and visualise the differing currents which will arise above the big sea and land masses. It has already been stated that thermals are the result of uneven heating of the earth's surface. In the same way the great air currents such as the Trade winds are due to the same cause on a bigger scale. The continents are mirrors of the sun's heat waves, while the oceans are radiators to a lesser degree. Hence we have the same temperature variations present to create the world's wind system as we have for the local thermals and local winds in our immediate neighbourhood. No more need be said at the moment on this subject, save to mention that the rotation of the earth itself puts a curve into all the great winds.

From the foregoing it can be readily understood that the air beneath the Tropopause must not only be in a state of permanent movement, but must have a tendency to be unstable.

Uneven heating of the earth's surface, creating air masses of different temperatures, will lead to their drift from cold regions to warmer regions, and *vice versa*. Such movements are the harbingers of the weather systems—of storms which sweep in from the Atlantic in winter, of fogs, and equally of the clear skies and the bright sunlight of the anticyclones. More of these causes and effects anon.

Meantime, there is one more factor of immense importance to the manufacture of the glider pilot's weather. It is the moisture suspended within the air masses of which we have been speaking. It has already been stated that 90 per cent. of all the moisture of the world's atmosphere is contained in a three-mile belt next to the earth's surface. Its influence upon the development of clouds within the belt is profound. It is associated with such factors as the lapse rate, whose importance has already been stressed, and which in the following pages will be demonstrated to have a decisive effect upon gliding.

Let us for a moment consider the thermal bubble which on a summer day breaks away from the surface of a newly ploughed field. It will rise in the first place because it is warmer (probably a minimum of 2 degrees F.) than the surrounding air. It will depend for its acceleration upon remaining warmer than the air through which it passes, but as it rises it will have a tendency to cool. When its temperature has fallen to the same as that of the air about it movement will cease and, like some wreck which has plunged beneath the surface of the ocean, it will be held in equilibrium.

Much can happen, however, when there is a large content of water in suspension. Firstly, as the air bubble rises and cools, its capacity for holding its moisture will be reduced, and there will come a moment when the moisture must condense into a cloud. Secondly, there is the expansion to consider of the bubble itself while it rises into areas of increasingly lower pressure. This particularly contributes to its cooling, since the heat within it is becoming distributed over a larger area. If it was unable to obtain some heat from another source it would the sooner acquire the temperature of the surrounding air. It is at this point that the moisture content makes a special contribution. As it begins to condense, heat is released—the latent heat of condensation—and thus the temperature is partially maintained and the instability of the mass preserved. In such a manner does the development of cumulus clouds continue.

It is only a step from here to conditions which can give rise to the precipitation of rain. The minute water drops of which the new cloud is formed cannot in themselves produce a shower, but they may be present at a sufficiently low temperature and in sufficient quantities to combine with particles of matter which are always in suspension in the atmosphere. Such "nuclei" will form the base for the future raindrops, and as turbulence within the cloud circulates them, so may they grow until they have sufficient weight to fall out of the cloud. Were it not for invisible salt crystals picked up from the surface of the sea and blown into the atmosphere, and for sulphate particles which are the products of combustion finding their way into the air through factory chimneys (both salt and sulphates having an affinity for water), the earth's rainfall must be drastically reduced.

This elementary picture of the weather belt in which glider pilots seek their sport is not intended to be more than a sketch. There are local circumstances which can affect the weather over any particular place. Mountain ranges, warm sea currents, and, above all, the clash of air masses of differing temperatures and pressures, can create a confusion which even an expert forecaster may find difficulty in diagnosing. But I have, perhaps, said sufficient not merely to introduce more advanced gliding, but to whet the appetite for the more precise knowledge which is introduced later.

Opposite : Hushaby Grunau Baby. (*See page* 106.)

Top: The Rhönsperber picks up a thermal and begins to circle.

Left: The southern 400-ft. spur of Bradwell Edge. The Derbyshire hamlet of Hucklow lies out of sight just round the corner. (*See also Figs.* 21 *and* 22.)

Opposite: Sutton Bank from the bowl looking south. Roulston Scar is the rocky outcrop in the distance. The Club House is just over the lip of the cliff to its immediate left. (*See also Figs.* 19 *and* 20.)

LEARNING THROUGH FAILURE

IT was a high, wild day in spring. Over Cheviot, and the waste of crag and heather around it, the clouds raced like a cavalry charge to the coast. It was twenty-two miles from the peak to the sands of Beadnell Bay, and they embraced as representative a stretch of Northumberland as is to be found.

A flying party was perched on the intervening ridge between Cheviot and the sea, on an 800-foot step nearly 10 miles long, which jumped from the green pastures of the Breamish valley to create the second wilderness of heather in a few miles of travel. The breeze in our faces cut straight from the shoulders of Northumberland's bravest peak, whipped our hair into tails, and left the coast 10 miles at the back of us a line of yellow sand and creaming water. A day for soaring if ever there was one! This was the day I was to collect the "C" endorsement of my licence.

I settled back into the cockpit of the sailplane, slipped the safety pin into the harness, and was ready. I was flying an "intermediate" type of aircraft of moderate efficiency, and expected little difficulty in remaining aloft above the starting point for the necessary 5 minutes. In fact, I had made up my mind to stay up for at least an hour.

The elastic rope spread out in a wide V from the nose of the machine, its extremities manned by eight stalwarts—four to each side—who were the human crew of the catapult. They were waiting the signal to flick me over the edge of the step. I could see ahead the waving tree-tops of the upper edge of Hepburn Wood, thin branches holding out their arms in doubtful welcome.

"Take the strain!" came the voice of the instructor in charge. "Walk!"

The crew walked away from me. The white rope stretched, growing thinner. Then came the shout: "RUN!"

The eight stalwarts broke into a brisk double. They dis-

Opposite: Roundway Hill, near Devizes—a favourite site of the Cambridge Club.

appeared down the slope until only their bobbing heads were visible. Behind me, out of sight, a prone figure on the ground clung grimly to the tail skid of the aircraft, holding it back against the mounting strain. Then the aircraft moved an inch —the friction between the skid and the ground was suddenly broken: 300 lb. of aircraft and 200 lb. of pilot were snatched out of his hands as though they had no more weight than a walking-cane.

With the surge of a racehorse at the starting gate I jumped across the heather, was airborne in a dozen paces, and sped smoothly in a rising curve over the heads of the crew. I saw them out of the tail of my eye as we passed, a mass of arms and legs precipitated head-first down the slope as the strain suddenly came off the launching rope—a laughing bunch of enthusiasts who heard the whistle of my wings above them and knew that they had done their job well.

I was above the waving boughs of Hepburn Wood. I could see them receding below me down the slope—down and down in serried ranks of tossing green to the walls of Chillingham Castle at the bottom. The needle of the A.S.I. stood at 35 miles an hour, and we were still climbing. The wild air which sprang from the crest caught the wings, and another mighty surge bore me farther aloft. It was like being tossed by an invisible giant and left hanging above the earth on silken cords.

If I had had more experience I could have made use of those heady draughts to great purpose that day. I could have climbed into the eye of the sun and become a speck to the watchers on the ground, and, had I wished, I could easily have flown across the moorland, over the coastal plain, and landed on one of the yellow beaches of the sea-board. But instead I crashed, a smother of splintered plywood and remorseful humanity, in a bank of heather twenty minutes later.

It was a sad ending to a flight which had promised so well. This was to be the day of days when I would earn the magic endorsement to my licence. Indeed, as I climbed away from the ridge, and saw even the brow of Cheviot across the valley growing lowly, I felt certain that the prize would be mine. After 5 minutes I had only to land quietly and respectably and, after paying another 5s. to the proper authority, collect my laurels.

Instead, ambition got me by the ears, and after showing me what a fine flier I was, left me suddenly to my own devices and my startling incompetence.

I had climbed to 900 feet, rising steadily along the ridge on a northward course. Half a mile up the step thrust forth a rocky nose into the valley, and here the air roughened and I rode the gusts in hovering flight. It was a perfect sensation for a novice. The prow pointed outwards across the valley into the wind. We neither advanced nor retreated, but hung like an eagle, hunting gently from left to right as though looking for a prey on which to pounce on folded wings.

Tiring of this, I looked behind me, and saw the wild coast of Northumberland spreading northwards—Bamburgh, Budle Bay, Holy Island, and the smudge of smoke from Berwick-on-Tweed. Nearer, on my own ridge, was the rounded crown of Ross Castle hill, a mere step away across a cleft which carried the moorland road down through the woods to Chillingham. That cleft might cause a break in the rising winds which held me up, but the noble brow beyond it would burble with rising eddies. Once across the little gap, a bare mile wide, and the whole proud ridge for as far as Lowick, seven miles to the north, could be soared. This was going to be my red-letter day!

I was at 1,000 feet above the rocky promontory when I made my dart across the wooded bowl behind it. I flew straight for the crest of Ross Castle. What happened I can scarcely realise even today. Instead of the strong thrust of rising winds, I was snatched by all-powerful hands that pulled me down. The needle of the variometer swung violently and held a rate of descent of between 10 and 15 feet per second. The woods leapt up towards me, the brow of Ross Castle sank, the whole earth came up to meet me. Instead of having a margin of four or five hundred feet above Ross Castle, I suddenly realised that I would only just clear the top of it. And then, when it was too late, I realised that I wasn't even going to do this. I was going to hit it. I had just time, by a savage thrust at the rudder bar, to yaw the aircraft to the left and put one wing into the side of the mountain, instead of meeting it face to face. There was a rending and a tearing, and a dozen pistol shots of dry wood bursting, and then I was sitting in a little clump of heather, trying to make myself believe that this terrible thing had really happened to me.

My friends afterwards told me that they had heard the crash a mile away, and never expected to find me alive.

I got up and felt myself all over. I was not even going to be an interesting invalid. In fact, I was unscratched. On hitting the slope the machine had slewed round, wiping off first the starboard wing, then the skid, then the fuselage, breaking its back, and finally the port wing as 180 degrees were completed. I had been pitched gently out of the remains of the cockpit.

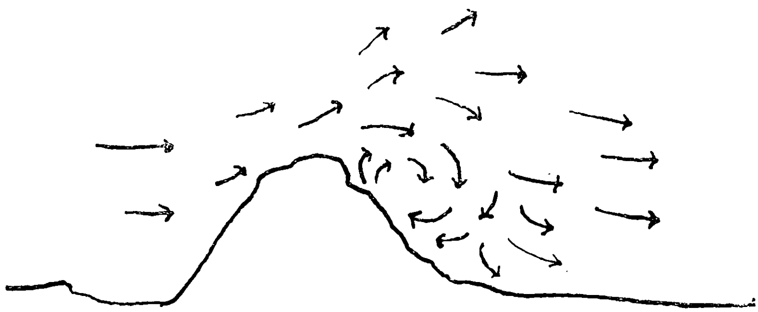


FIG. 30.—*The downdraught on the lee side of a hill.*

So I sat on the heather and waited, and wondered what I should say. Looking upwards behind me, I saw that I had only needed another 20 feet to have cleared the top of the hill. Then, looking outwards over the cleft, I saw the opposite promontory from which I had come, and wondered how it was possible that I could have lost so much height in such a short distance. I stood up, and felt the direction of the wind on my face. It was coming directly from the opposite height, striking the run of the ridge at an angle, and not on its face as I had supposed. There was the answer to my question. There was more south in the wind than I had believed. It had given good lift as long as it struck the level face of the step, but the gap across which I had flown was shielded by the cliffs on its southern side, and I had encountered a powerful downdraught as it curled over the rocks. Alas, there was no excuse for me whatever. I had committed the unpardonable sin of ignoring the flow of the wind, and, what was worse, failed to take the escape road into the bottom of the valley while there was time.

* * * * *

As an example of the kind of mistake which an inexperienced pilot can make this stands out because of the wound inflicted on my personal vanity. There are other common errors which may have similar results. On the principle that experience is cheaper when purchased in book form—even if it is not so effective—a warning against the evil spirits which haunt the soaring ridge is worth consideration.

Until the pilot is sufficiently advanced to cross the lip of his cliff and enter the updraught over its edge, he will have no experience of flying in rough air. It is certain that he will be momentarily frightened and quite probably will be convinced that he is about to meet his Maker. He need have less cause for anxiety on this score if he makes up his mind before he takes off to put the nose of the aircraft down as soon as he flies into the turbulence. This sounds a simple resolution to make, but the first flight over the ridge is so bound up with the pilot's determination to soar that his ambition to fly at the best possible gliding angle—that is to say to fly slowly—is in conflict with his physical misgivings. It is better to allow the latter to triumph, and the results are not likely to suffer. An extra five miles an hour on the flying speed will not prevent him from soaring unless the wind is light, and in such conditions his instructor will not send him for the first time into the hill lift.

So immediately after the launch the first consideration is to establish a predetermined flying speed and to maintain it accurately, whatever the qualities of the updraught. After settling down on a course parallel to the ridge and a few yards out over its lip, this speed should be constant. The best distance from the edge will vary, depending upon the character of the slope, the strength of the wind, and the initial height of the launch. But if the pilot has been catapulted he will only be some 50 feet over the crest, at which height the lift will be concentrated into a narrow band directly above and perhaps 20 yards out from the edge. The pilot's mind will be closely concerned with climbing away from what he considers to be a dangerously low altitude. It would be better, as I have already suggested, that he should concern himself more with his flying speed and have at the back of his mind a resolution to turn outwards over the valley and force-land at the bottom of the hill should he find himself below the crest. Under no circumstances should a pilot who is not an expert attempt to climb back up the slope once he has sunk below the level of his launching point. Following on this it should be the rule of every pilot, novice or expert, to discover, before taking off, the best emergency landing field below. Better still, a wise man will walk down the hill and prospect the field for himself.

In the rough airs along the cliff top big movements of the control column will be required to correct the buffeting. In the calm air of the training field only the gentlest movements were required, but now it will seem as though the aircraft is often nearly out of control.

The novice should always be ready to push the stick forward and to get the nose of the aircraft down whenever he believes he is in danger. If he does this an accident is virtually impossible

During the anxious moments of this first soaring flight there will be one other tendency which can be dangerous if carried too far. There is an instinct to combine violent use of the rudder with violent use of the stick. In a sailplane it is possible to fly for hours without using the rudder at all. It is, in fact, a control which is best forgotten by the beginner. The same truth holds good for most power aircraft. While giving dual instruction to pupils I have frequently demonstrated that turns can be accurately made on bank alone. Indeed, it is only for high rates of turn that the rudder comes into action at all—and then in the opposite direction to hold up the nose. Too great an application of rudder can, under certain circumstances, accentuate the stalling characteristics of the aircraft and lead to a spin. Without use of rudder a spin is almost impossible.

A measure of confidence after two or three soaring flights will give rise to the temptation once again to fly slowly. A speed of two or three miles an hour above the stall is safe enough for the experienced pilot, but even he will require to keep very much awake in order to counteract the probable consequences. A sailplane is only maintained in flight by the speed of the wind over the wing surface, and when there is a sudden drop in this speed, such as can be caused by a gully in the soaring ridge, or merely by the tail-end of a gust of wind, a wing may stall and instantaneous action be demanded to restore the situation. Under these circumstances there is no warning. One wing of the aircraft drops and the pilot perhaps finds himself looking into the face of the cliff. The instinctive reaction is to put on opposite aileron and pull up the nose. If the instinct is obeyed the stall may be accentuated by increased drag and the flight terminate after the fashion of a butterfly on the windscreen of a motor-car. When a wing drops the correct action is to ease the stick forward and apply a touch of opposite rudder. The first lowers the nose in order to regain flying speed, the second yaws the aircraft away from the stalled wing, and so increases its speed through the air that it will regain its lift.

Two final points should be remembered during the early stages of soaring. The turn at the end of the ridge should be made outwards and at a slightly higher speed than that for cruising, and, furthermore, it should not be skidded. A table of figures which show how the stalling speed of a sailplane increases during a turn is given in a later chapter, and from this it will be seen that the extra two or three miles an hour are accompanied by so small an increase in the sinking speed that they are worth-while insurance. So far as a skid turn is con-

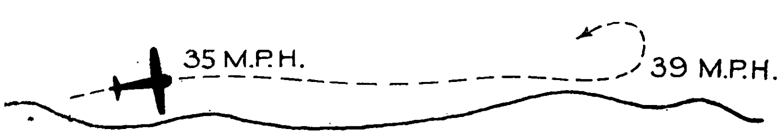


FIG. 31.—*This shows the correct way a turn should be made at the end of the soaring ridge. It will be noted that the speed is increased from 35 m.p.h. to 39 m.p.h. during the actual turn. The importance of this cannot be overstressed to new pilots.*

cerned, I would say that a bad habit has grown up among glider pilots of using the rudder instead of the ailerons, in the belief that the aircraft better maintains its efficiency. This is not true. Every turn should be made with the requisite degree of bank—that which will keep the top needle of a turn-and-bank indicator on the zero mark.

Lastly, the circuit for a landing should be made without hurry; the point of the field to be aimed at is not immediately over the boundary, but at least one-third of the way inside.

There would seem to be many "dos" and "don'ts" associated with the first attempts at soaring, and on paper the risks appear considerable. In fact, the number of accidents which occur at this stage are few and far between. Just as in power flying, the first solo is almost invariably safe. It is when the pilot has a little experience and believes that he is already an expert that the possibility of his damaging an aircraft is a real one.

I am not the only concessionnaire of errors in the gliding world. The fraternity has many leaseholders—starry-eyed hopefuls who have "got away with it." Sooner or later they will all graduate into the class who don't make mistakes and the sport will be the tamer. We had a colleague at one club whose delight it was to spin off the top of a launch. It was an evolution which he repeated time after time, but he was

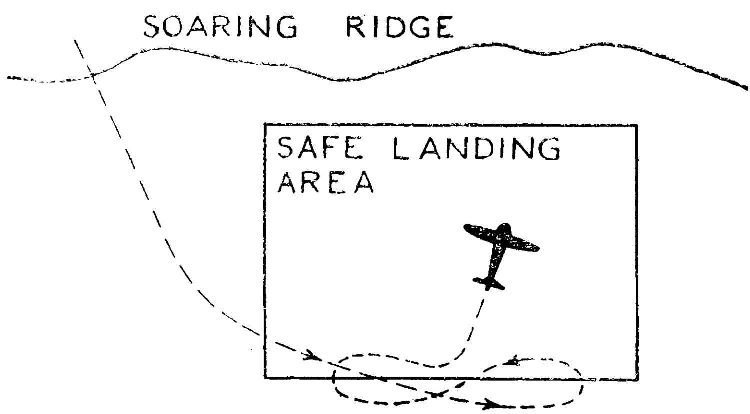


FIG. 32.—*The box shows the safe landing area behind the soaring ridge. Excess height should be got rid of by making beats over the rear boundary—and not behind it.*

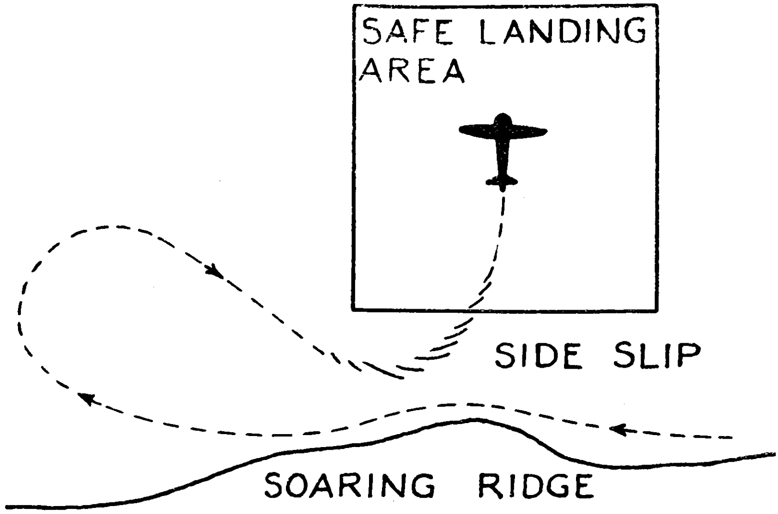


FIG. 33.—*When landing at the bottom of the soaring ridge it may be necessary to make the type of approach illustrated here. Excessive height is slipped off immediately after the final turn in.*

blissfully unaware of what happened and refused to believe it when he was told. He would say that the aircraft had seemed to stall and the nose and one wing had unaccountably dropped, adding that a touch of opposite rudder always put it right—and that he wasn't worried. If he had known how some of his friends perspired on the ground he would have had more consideration, and perhaps paid a visit to a doctor for examination of his middle ear.

Another was the classical performance at Camphill which led to the christening of a pimple which grew out of the almost vertical slope halfway between the top and the bottom. It started one day when a certain pilot took off in the hope of winning his "C" Certificate—entailing a flight of five minutes above the launching point. No names, no pack drill; the story is second hand and it has probably improved with age. Anyway, this candidate disappeared into a low cloud before he reached the top of the launch and found himself with no more visible connection with the earth than sight of the winch cable disappearing into the fog a few feet below. In due course he decided to release the wire, whereupon he was flying completely blind. He appeared to do well considering that he had neither experience nor instruments and he remained airborne.

His account of the next few minutes describes his search for the lost ground. For a time there was no sign of it. Then, just as he was beginning to despair, he suddenly found it, at a point above and to the side of him. Then almost immediately afterwards another piece of ground materialised beneath—so immediately and surprisingly that he stalled the aircraft on to it in a perfect landing. So far so good. In fact, it couldn't have been better until investigation proved that he was placed on a knob halfway down the cliff—a position from which experienced climbers took several hours to rescue him and his machine. I believe that the author of this feat is today a Service pilot with a deserved reputation for sound pilotage.

Another popular error of judgment is a close relation to the one which left me sitting in a pile of wreckage on Ross Castle. The gliding angle of a sailplane is so good that it sometimes persuades pilots that they can reach any desired landing field within sight. Sooner or later one learns the fallacy of this—and usually at the cost of equipment and dignity. I remember watching a hopeful pilot flying across the wooded slopes of a soaring ridge below the level of its crest. I have already suggested that this is a hazardous position for one who has not already made up his mind to make a forced landing at the foot of the hill. But this pilot clung to the hope that he could claw his way back into the stronger upcurrents higher up, and he put up a remarkable performance in completing a beat of the ridge just above the slanting woods. As he passed the position where I was standing in the company of others, shouting myself hoarse with imprecations for an immediate retreat into the bottom of the valley, we looked down into his cockpit not 50 yards away.

The end came a minute later, just after the pilot realised what the rest of us had seen to be inevitable long before. In sudden desperation he alighted with a dreadful sound of rending in the top of the biggest oak tree in the district. The subsequent efforts to disentangle the aircraft developed into a circus act which would have rocked the big top. About half a carpenter's shop had to be carried to the top of the tree, and the subsequent felling operations from the top downwards were encouraged by a crowd who not only offered advice, but in one instance a pair of draught horses. I last saw the broken pieces in the club's hangar, where the penitent pilot was spending the umpteenth week-end trying to make a repair. As far as I know he is still at it.

The charm of such exhibitions is the regularity with which the author walks away from them unhurt. A similar performance in power craft almost inevitably ends in hospital or even farther afield. Difficult though it may be to credit, I have seen a pilot spin into the ground from 400 feet in an open primary and get up and walk away. It would hardly be possible in anything fitted with an engine. Nor is there a risk of fire—the greatest threat which awaits the unsuccessful aeronaut who sits on top of a hundred gallons of petrol.

SOME MORE FAILURES

THE soaring site at Sutton Bank is a little piece of England which will live for ever in my memory. It is lovely, with a gentle grandeur, and yet for those who yacht among its airs it possesses a power more usually associated with greater hills. I found it first many years ago when I essayed a journey in an ancient motor-car from Thirsk to Reivaulx Abbey. A stern warning of the steepness of its gradient had caused me to turn my car about and present her stern to the climb. "Fanny" always climbed better in reverse, so I made the ascent between the rugged scar of Roulston and the Whitestone Cliff in as unorthodox a manner as ten years later I made the same journey by air in the opposite direction.

The descent by air was the sort of mishap which could have easily ended up as a crash. It was possibly even more hazardous than the first journey by road.

The Yorkshire Gliding Club have rented a smooth patch of heath on the summit, a few hundred yards south of the point where the road heaves itself over the lip of the ridge. That craggy scar of Roulston, with its sheer drop into space, marks its southern limit. Over the steep slope to the north of it the club's sailplanes are launched. They can best turn north, and follow the long curve of the horseshoe bowl, crossing the road and heading for the dark wood crowning the Whitestone Cliff on its opposite horn. If the wind is in the south-west, a sailplane can hang there in suspense, its pilot looking down into the black pool of Gormire created by some fault in the rock stratas below. Bottomless by popular superstition, Gormire is a sinister eye that bodes no good. But the prospect beyond it is so lovely that the threat never lingers. You are pinned to the sky a thousand feet above the cliff, with the whole Yorkshire plain spreading ahead into the limits of hazy distance. On a clear day the rim of the Pennines will lift itself round the edges of the horizon, but more often the blue smoke of Thirsk and the isolated wisps from the hamlets of Sutton and Balk will mark your boundaries.

Here on my first visit I proved that I still had much to learn about flying. I was launched by the winch to some 400 feet, and left to fend for myself along the ridge. Light airs tugged feebly at the wings; every yard showed a small loss of height, and gradually we sank lower and lower until the edge of the bowl was almost level with my eyes. I should have turned in quickly, but a moment's hesitation lost me my chance, and suddenly I knew that I was doomed to make a forced landing at the bottom. Fortunately, I had prospected the only convenient field—one close to the road—which was comparatively safe. It necessitated a side-slip over a tall tree which guarded one corner (unless good management placed you in exactly the right position at the right moment).

On the way down, a journey which took fully five minutes, for puffs of gentle air still delayed the descent, I ranged close to the heady slopes over which the road twisted and turned, saw the red roofs of Sutton grow larger, and knew suddenly that I was going to make a perfect landing.

And so it turned out. The big tree slipped beneath the wings, and a sharp thrust to the stick with plenty of top rudder brought me with a sure swiftness to the smooth grass beyond. We bumped to a standstill 50 yards from a gate leading into the road.

* * * * *

Very shortly after this I made an attempt to stay in the air for five hours. There is, in the gliding world, a merit to be acquired by this feat of endurance. If a pilot can remain airborne for such a time, and subsequently make two other flights on which he reaches a height of 1,000 metres and a distance of 50 kilometres, he becomes entitled to a "Silver C" certificate. This is an international honour, and there were at the time only a handful of British pilots who had won it.

I don't think that I shall ever again make the attempt. Gliding is a leisurely sport in which finesse rather than endurance is the prime factor. To mortify the flesh, as I did from the crest of Sutton Bank, was too like making an attempt on the London-Brighton walk.

I did, however, remain aloft for 3 hours 45 minutes. During that time I ploughed up and down the ridge from Roulston

Scar to the Whitestone Cliff a score of times. A strong, gusty wind with frequent rain squalls didn't help to make the flight a happy one. It is extraordinary how raindrops driven against the bare flesh can, after a time, give the impression that one's face is being pulped. In spite of the discomfort, however, I hung on, and only surrendered when a particularly heavy shower began, literally, to fill up the fuselage with water. It was no doubt an unusual reason for abandoning a flight. But a waterlogged aircraft is no more healthy than a waterlogged boat, and there came a moment when it undoubtedly behoved me to land. I was really glad to do so, although the surprised faces which greeted me as I entered the clubhouse bore in their expressions a trace of scorn. However, when I persuaded one of them to help me bail out the "Kite," they realised that it had been raining harder than they had supposed.

* * * * *

Lest these trifling experiences fail to do credit to a sport which at times has been classed as "tough," I should like to record the more spartan story of a German pilot and his failure to break the world height record. The flight was a chapter of miscalculations from beginning to end, but there was something more glorious about the failure than most of us are likely to achieve.

Herman Seele took off in a Rhönbussard on June 3, 1936, from Hirzenhain during the eliminating trials for the Rhön contests. There had been fog until 10 a.m., when it cleared and gave way to cumulus clouds. At 2.40 p.m. Seele was aero-towed to 1,000 feet, where he cast off in a thermal in which he reached cloud base. He entered a cumulus, which he twice tried to leave, but on each occasion found so strong a down-draught as soon as he came out of its side that he thought it wiser to return to it.

"The cloud," he says, "had a milky-grey colour, its edges were smooth, and it did not hang downwards"—from which he deduced that it was not dangerous. Moreover, from its base at 4,600 feet it did not look very big. In view of the circumstances, he decided to be satisfied with what he had, and he proceeded to climb in the regulation circles.

His forward speed was 37 m.p.h. and the variometer showed a climb of 4 metres per second. Everything, indeed, was going well, and the altimeter slowly swung round until it registered 2,500 metres (8,200 feet). At this point the air became rough and the rate of climb more than the variometer could register. The altimeter meantime moved up to 3,200 metres, beyond which it was not calibrated. This, however, was a small matter in itself, for the barograph was in the pilot's line of vision, and from this he saw that he had climbed to 16,400 feet. He was now feeling thoroughly frozen, not being dressed for the occasion. He complained that he found difficulty in holding the stick.

Now things began to happen. A jar threw his face against the cockpit front. He pushed up the speed to 56 m.p.h. to get out of the cloud, but didn't. Hail began to fall. His air speed became erratic, and during a dive the windscreen bent out of shape and then flew off. Immediately he was bombarded with hail, and in a few minutes his face, chest, and hands became iced up. He began talking to himself in quiet distress. One moment he was being forced down into his seat and the next he was hanging in his straps. He tried to make the aircraft spin, but it wouldn't. He tried again and met with no success. The hailstones were hurting his eyes so much that he could no longer see—his friends think they must have been as big as hen's eggs, and meteorologically it is not an impossibility. Then in the middle of another dive there was a loud noise. He was thrown against the right side of the cockpit, and saw the left wing break off and disappear upwards into the mist.

It was time to get out, but Seele found that his hands were too frozen to undo the straps. Fortunately they were loose, and he managed to extricate his legs and left arm and climb out. Then there was another violent bump, and he found himself hanging outside the fuselage—that is, all except his right arm, which was held inside by the straps. Part of the right wing then broke off. The new holder of the world's unofficial height record then tried to make it official by grabbing his barograph; but he couldn't get hold of it in his awkward predicament, and soon found that his right arm came away (from the cockpit, not from himself).

He was now free, and hanging from his parachute. The latter, however, was invisible, for the cords disappeared into the mist overhead. His wrist-watch, keys, and knife dropped into the mist. Then something appeared from below, sailed up past him and disappeared above. It was a wing from the Rhönbussard. Snow was falling, his arm was hurting, his face was burning, his eyes were so swollen that he could only see through a slit under his lids.

The snow now changed to rain, and before long he was out of the cloud, although he was still too blind to recognise details of the ground below. A dark shape appeared. He raised his legs and covered his face; his back hit something, and then he found himself in a sitting posture. He put his hand out to discover what sort of ground he was on, but there wasn't any ground. He was sitting in the top of a tree. It took two hours to get him down.

Opposite.—Top: Four sailplanes begin to circle in a thermal beneath the base of a cumulus cloud. The up-current is moving in the neighbourhood of 8 ft. per second. (*See page* 113.)

Bottom: Here five sailplanes are soaring over the Dunstable ridge. The cloud in the background is one of a street producing strong thermal currents.

The Kite gets away to a good launch. Note the steep angle of climb.

Top: Mr. Wills takes off in his Minimoa.
Bottom: The actual cumulo-nimbus cloud in which Mr. Wills reached a height of 14,170 ft. *(See page 117.)*

ADVANCED SOARING

ABOVE Dunstable Down, on an early summer day, thirteen sailplanes beat along the ridge from Whipsnade Zoo to Totternhoe. They were like yachts jockeying for position at the start of a race.

The highest of them was flying at perhaps 700 feet, and the lowest at 300 feet. Several were at the same height, and hunted up and down the ridge in packs. Every now and then one would swing out of line, do a brief circuit of the landing field, and, slipping off the last hundred feet, come gently to rest on the chalky field at the bottom. In a few minutes a new pilot would have climbed into the cockpit, and the launching cable would be once again singing its whistling song as it pulled him up to five or six hundred feet. At the top of the launch he would turn quickly over the ridge, pick up the rising air currents, and take his place with the throng.

Occasionally one of the craft would fly out from the lip, nose its way over the hamlet of Totternhoe, crab sideways over the ploughed fields behind the hangar, and then make a quick rush back to the crest of the hill without landing. It would clear the summit by the barest of margins and then laboriously climb aloft again on the wings of the ridge currents. If you watched this particular sailplane, you would see that it would make another exploratory voyage over the valley as soon as it had won back its height. The next time, perhaps, it would stop suddenly in its circuit, and begin to make tight turns as it drifted eastwards with the wind. Instead of sinking steadily, it would climb away, while the wind brought it gradually back over the ridge. But now the ridge had no interest for it. The circles continued, while the wind carried it back and back over the down, over Kensworth, across the London road, and on towards Luton. And, climbing all the time, it would

Opposite.—Top : Mr. G. H. Stephenson in the cockpit of the Kirby Gull in which he crossed the English Channel. (*See page* 132.)

Bottom : Mr. Kit Nicholson and the cockpit of his Rhönsperber. (*See page* 124.)

gradually become a speck, to be absorbed in the folds of one of the great cumulus clouds which were continually drifting across the country. Another pilot has said goodbye to Dunstable.

Once during the day, shortly after lunch, four sailplanes began to circle within a few hundred feet of each other. They were soon at twice the height of the common herd which beat up and down the ridge; and they, too, moved eastwards, to be lost shortly afterwards among the steepling clouds.

Each of these sailplanes was flown by a pilot who was a master of the art. You can pick out such men or women at any soaring site. They leave the ruck and, nosing outwards, search for the unsteady air of a thermal which breaks away from some ploughed field or wood. If they have no luck the first time they will try again, and sooner or later a quick turn and an endless succession of circles will denote that they have found their heart's desire, and that their variometers are showing a climb instead of a sink.

Between each unsuccessful attempt they will return to the ridge to win back lost altitude before expending it again in a second search.

In such a way nearly all cross-country flights are started. The contact with the home ridge has to be broken. Those who are left behind are limited to the airs immediately above the crest, perhaps only a hundred yards wide and a few hundred feet high. Their soaring is bounded by the length of the hill face, and they are like prisoners within an invisible fence. The few who escape have the world at their feet.

Late this day the wind dropped and moved into the north. The big clouds gradually dissolved, presaging a calm evening. It meant that the thermals would be weaker and would die away altogether within the next hour. At this moment I took off in a Gull which a friend, in the kindness of his heart, lent me for the occasion.

There was no hope of even soaring the ridge by this time. All other aircraft had landed. What wind remained was already blowing at too fine an angle on the hill. The best I could hope for was a wide circuit, lasting perhaps three minutes—unless, after all, I managed to find one of the afternoon's dying thermals. I had already made my plans, and the Gull, one of the best sailplanes ever designed for circling, gave me my chance.

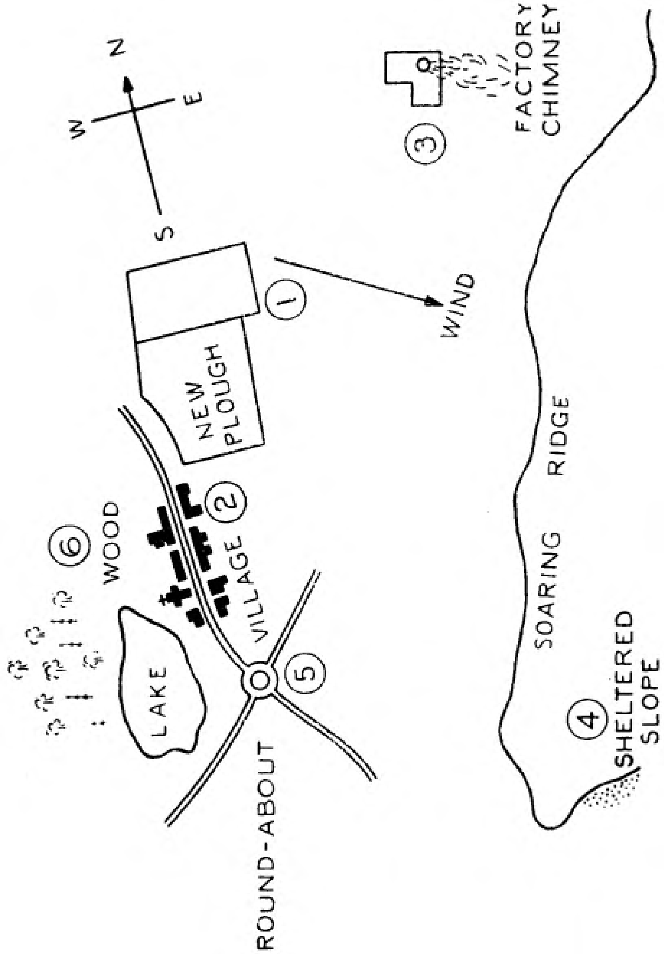


FIG. 34.—*Six possible sources of thermals which might be within reach of a pilot from his soaring ridge. The sheltered slope (4) should not be overlooked when the wind is light and the sun hot.*

The winch launch provided 650 feet, and I began to use it to explore a newly ploughed field to the west of the hangar. Time was important. I was losing 3 feet every second. The air above the field was smooth, and my hopes sank as fast as the aircraft. I had just time to try the next field, and still leave myself with 200 feet to reach the landing ground if it failed. This time a small burble in the air rocked the wings. I counted three, and then put on bank and rudder in a medium turn to the left. A smooth patch of air followed, but hopes rose again with another burble, and then another. I tucked my head into the cockpit and went on to the instruments. The needle of the variometer was no longer steady. It was kicking across the dial in spasmodic jerks, rising from a loss of a few inches per second to a trifling gain. I took a quick glimpse out of the cockpit and saw that the ground was no nearer. For the moment I was neither losing nor winning height. The altimeter stood at 220 feet.

After half a dozen circuits the oscillations of the variometer's needle had moved a little in position. Their mean travel was at last a little beyond the centre of the clock face. The thrusting airs beneath the wings were outbalancing the smoother patches, and very slowly I was drawing away from the ground. The first sign showed on the altimeter—a gain of 50 feet. When I looked out the field appeared to be very little farther away—but the instruments couldn't lie. I continued to circle, smoothly, steadily, varying neither speed nor altitude. In a weak thermal it is fatal to move even a dozen yards out of the pattern which you have elected to trace. It is almost certain that you will fly out of the edge of the rising air and ruin your chances.

That afternoon, by dint of adherence to the instruments, I slowly climbed from 200 to 500 feet, and then, as the bubble accelerated, reached a peak rate of climb of 5 feet per second. It was, in its little way, a small triumph. Then when I was at 1,100 feet I either flew carelessly or, as I prefer to think, the thermal petered out. Anyway, I suddenly found myself in still air, flying with the smoothness of silent tyres on a perfect road. Below me was the Zoo, and I could hear the snorts of animals and see the backs of some bisons in their park. I knew the game was up, and in leisured peace I turned back towards the landing field, put the nose down until the speed mounted to 70 miles an hour, pulled it up into a steep climb, peeled off the top, and swept back to earth well satisfied. I had been airborne for 25 minutes.

Such a flight as this was notable only for the low height of 220 feet from which the thermal was caught. At this time no cross-country journey was exceptional unless it extended for more than 100 miles, and no height less than 8,000 feet was worth a description in a log book. Prodigious performances had been put up by sailplanes. The world height record stood at over 22,000 feet. It had been made by a German pilot in Silesia with the aid of oxygen, and was concluded in a temperature of minus 40 degrees F. The distance record stood at 466 miles and was held by a woman Russian pilot. The British distance record was more than 200 miles; the Channel had been crossed in a glider.

While I myself was neither sufficiently skilled to accomplish such performances nor had the inclination to attempt them (for every cross-country flight entails dismantling the aircraft and hauling it back by road), I had great admiration for others who did so.

I know all too well what it is like inside the heavy cumulus clouds from which the best lift to the greatest heights is obtained. The qualities of resolution which amount to forthright courage are not to be belittled. Some examples of them—which I cannot provide myself—is a just acknowledgment of the problems which confront the record-breaker. The following account by Mr. Philip Wills of his British height record is a fair sample of advanced flying.

He took off in his Minimoa sailplane from Dunstable on July 1, 1939. Ninety minutes later his altimeter was reading over 14,000 feet. He writes:

"It was 3.30 p.m. when I left the ground. Just overhead the sky looked stable, but there were obvious possibilities. A front containing a number of cumulo-nimbus clouds had come into view from the north, moving slowly towards Dunstable, and at right angles to the prevailing W.N.W. wind.

The policy was to keep going, to reserve an eye for the distant front, and to take any opportunity of bridging the seven-mile gap between the club site and the clouds.

Right off the winch launch I struck a thermal which took me up to 1,500 feet, and it might have been more had I not wanted to go north-east, instead of E.S.E. with the prevailing wind. I abandoned it and returned to the hill.

Then a local patch of stratus obscured the sun, and for 20 minutes a height of 600 feet above the hill was the local ceiling. The returning sun first struck on the Zoo end of the slope, and flying that way thermal currents commenced again, and for half an hour height varied between 800 and 1,500 feet. Then I saw a newly forming cumulus drifting over Dunstable town about halfway towards the front, which was now over the far side of Luton and developing mightily.

I abandoned the slope and flew northwards at about 1,500 feet. Over Dunstable I struck a large area of gently rising air. No amount of manœuvring could work the lift up to beyond 2 to 3 feet per second. So in this gentle fashion I climbed to 3,500 feet, and then set off for the big stuff.

As the wall of cloud ahead got nearer, it grew in size and blackness, and I battered through an area of downcurrent into a gloom enhanced by contrast with the brilliant sunshine I had left. Underneath a large and extra black patch I struck lift. At 6 to 8 feet per second I circled up into the concave bell which is formed by the rapid upcurrent in the otherwise flat base of a cumulus.

Once inside, the lift increased rapidly until the rate-of-climb indicator jammed against the top at 20 feet per second. My rate of turn I kept between two and three on the Pullin electric turn-and-bank—which means a circle of about 30 seconds. How fast I was climbing I did not know until afterwards, when my barograph dotting at 30-second intervals showed two dots over 1,100 feet apart—a rate of climb of 2,200 feet a minute, which would make even a Hurricane feel respectful.

The air was in general smooth, with the taut smoothness of a stretched violin string. One expected it to break violently at any moment, and every now and again the machine would suddenly give a number of violent but small shudders. The speed would creep up from 42 to 50 m.p.h., and I would straighten up momentarily, ease off the surplus speed, and put her again into the turn.

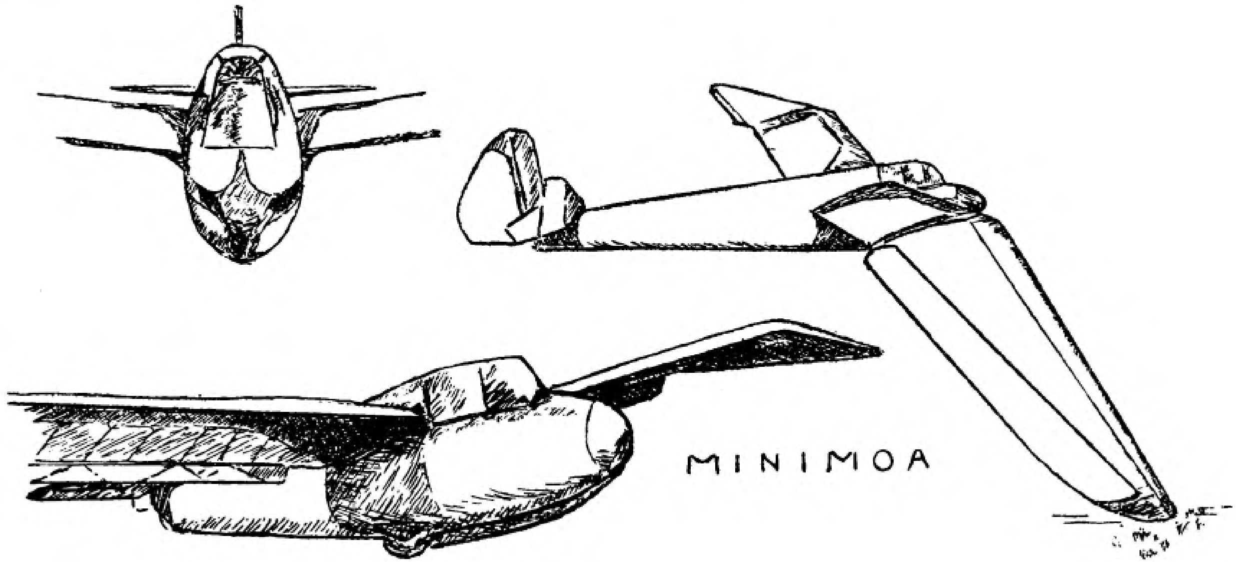


FIG. 35.—*A sketch showing the general lines of the Minimoa with which Mr. Wills broke the British height record in* 1939. *A plan of the sailplane with data relating to its performance is given on page* 296.

The barograph shows that the last 10,000 feet of the climb took only 7 minutes—although it seemed more. I have a theory that the dangerous part of these big cumuli is near the top, where a rising fountain of air turns outwards and downwards, like the water at the top of a fountain jet. Consequently I determined to leave immediately the turbulence noticeably increased, even if this meant throwing away the last thousand feet or so.

At last the variometer needle unstuck itself from the top of the dial and returned to a beggarly 15 feet per second, and suddenly the roughness of the air increased. My altimeter showed about 15,000 feet above take-off. I straightened up and with some difficulty held her straight until the compass needle settled down at N.W.

Now before entering the cloud I had noticed that the front ran from north-west to south-east. Hence the quickest way out was north-east or south-west. I turned on to the N.E. mark and struggled out in torrents of wild air.

The bumps increased and a dazzling glare flooded the cockpit. Behind billowed the mountainous cloud from which I had come, and I estimated its crest at least another 1,500 feet above me. Right and left behind ran further mountains in the chain created by the front, separated by deep valleys. In all other directions was a tumbled vista of cloud-tops about 7,000 feet below. Far to the N.E. ahead I could see the peaks of a parallel range of cloud mountains, evidently a second front following on mine.

A broad ribbon of ice decorated the leading edge of the wings. It was about the width and had precisely the serrated surface of one of those rubber nail brushes. It looked most un-aerodynamic. Long icicles pointing forwards decorated the pitot tubes and all minor excrescences.

I did not know where I was. I felt muddled and rather exhausted. If I flew west back to where I thought Dunstable was I should have to go through the next Everest on the line, and presumably suffer further undesired gymnastics. I could not see the ground except when directly above the few holes in the floor, and then in the shadows of the clouds it only looked a dark blur. Finally I cut south-west through the valley between my mountain and the next, and flew along the wall of cloud which was then on my right. I noticed that my sinking speed at 42 m.p.h. was 4 feet per second as against the normal 2·4 feet per second. No doubt this was the combination of height and ice.

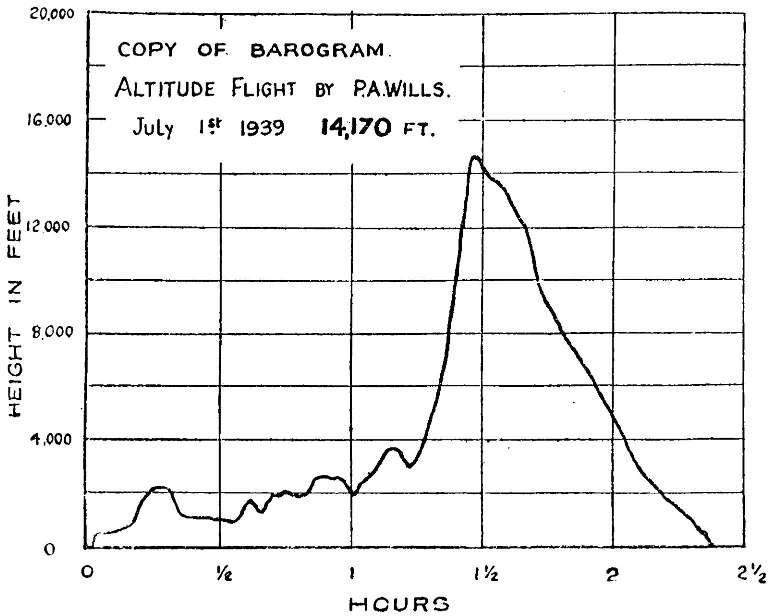


FIG. 36.

At about 12,000 feet I spotted a town below, a faint network of white lines which were new concrete roads showing through the haze. I went round and round, studying it and my map until a railway showed up running nearly north. At 10,000 feet I saw the roof of a cathedral—St. Albans.

Dunstable was about 16 miles to the north, on the other side of the front. So I turned north-east and hugged the cloud on my left. About now I began to feel a severe pain between my eyes. It was a kind of nerve pain along the forehead, with an ache behind each eye. I rubbed my brow, took off my spectacles, shook my head—and it got worse. I began to feel really worried for the first time. I had never heard of such a thing. Assuming that it was due to increasing air pressure as we descended, I flattened out the glide as much as possible.

My enforced north-east course brought me over Welwyn, and then I edged north along the railway to Stevenage. We were now down to 6,000 feet, so if we were to get home it was high time that we got on our course.

So we turned west, and entered unwillingly into the cloud. After a few minutes a fine drizzle set in, and simultaneously "Mini" stalled on me—or at least the A.S.I. dropped back to 30 m.p.h. This was puzzling, for she felt all right. Then the A.S.I. sank back to 15—to 10—to zero, and I spotted it. Its icicle had melted and blocked the pitot. I applied myself feverishly to the artificial horizon, an instrument I had never previously honoured with much attention. But with my various aches this was too much, and I turned east and came out of the cloud.

At 5,000 feet it looked as though I might get west under the cloud base. So I turned again and scurried along in semi-visibility. Under the retreating front visibility was surprisingly poor, and I was relieved some time later to see Luton airport appear out of the mist about a mile to the north-west.

I reached Luton at 1,500 feet, and it seemed hopeless to try and get back to the club, six miles away. Then I noticed that the smoke from the chimneys was blowing from the north-east! The front had passed over and brought a change of wind. Having lifted me on high, it now arranged kindly to blow me home.

I turned and followed the ridge of low hills that runs from Luton to Dunstable, and managed to reduce my rate of descent appreciably thereby. Dunstable drew nearer, passed a bare 600 feet below, and as the back edge of our hill came nearer, it was going to be touch and go whether we cleared the power wires which run so thoughtfully along the top. The golf course slid underneath, the power wires ditto. Glory be! We cleared the hill by 50 feet, circled the clubhouse, and landed.

Subsequent examination of the barograph gave the following figures. Time spent in the final upcurrent was 14 minutes. The climb during each two minutes was:

	Feet.
1st two minutes	800
2nd " "	1,100
3rd " "	1,200
4th " "	2,000
5th " "	2,650
6th " "	3,000
7th " "	700

The last figure is unreliable, as the pen of the barograph went off the top of the chart.

The final computation of the height above the starting point was 14,170 feet."

CROSS-COUNTRY SOARING

WHEN cloud soaring ceased in September, 1939, there were not more than fifty active British pilots who really understood the secrets of cross-country flying. There were more than 600 who were practical exponents of simple ridge soaring, but the gap between the ridge and the clouds was one which comparatively few could "step across." Many were learning and many more will learn in the future. I have already suggested the lines of country which the pilot must explore, and it will be deduced from this that more than half the difficulties can be overcome by recognition of the sky-signs—the shapes, formation, and movement of the clouds.

I am indebted to Mr. Kit Nicholson for an account of a cross-country flight which in a practical way shows the problems faced by the pilot. He flew from Dunstable to Lympne, a distance of 88 miles, piloting a Rhönsperber—a high-efficiency sailplane of German design. His course took him from Dunstable 30 odd miles to the north-west of London on a south-easterly track which cleared the main built-up areas of the city and passed over Romford on the way to the Thames. The river itself was crossed a little nearer the sea than Gravesend, and it was over the arm of land between the river and the estuary of the Medway that he was forced down to 600 feet. When he had won back his height by courtesy of a last-minute thermal he flew across Kent in conditions of varying difficulty, and finally landed near the coast some 20 miles or so to the west of Dover. It was a competition flight in which the goal had to be stated beforehand. The goal was Lympne.

After an aero-tow to a point 2,000 feet above Dunstable, Mr. Nicholson dropped the cable.

"I cast off over the bowl under an ideal-looking sky in a westerly wind. My first thermal faded after a patchy climb of 800 feet, leaving the clouds still 2,000 feet overhead, and I would have gladly turned back to the hill had the competition rules allowed. As it was, I was precipitated into the first of the day's struggles. It took an hour to reach cloud base, and by then I was just beyond St. Albans.

During those sticky sixty minutes I was forcibly reminded of a day a little less than a year before when Philip Wills went to Dover, whilst I, under precisely similar conditions, scraped into Hendon. I encouraged myself by remembering his remarks —something about ' slipping over into the Thames valley to find square miles of upgoing air.'

The reservoir near Waltham Abbey passed slowly 4,000 feet beneath. The conditions seemed to be getting better and better. In the really active stratum stretching from 1,800 feet below cloud base every thermal was of generous size, and a little positioning would give me lift of 10 feet per second or over. But a few minutes later, over Romford, I ceased telling myself that this cross-wind goal-flying was easy, that I was already halfway to Lympne, that I was about to 'slip over into the Thames valley '—over the river which was invisible a few miles ahead. As I turned on to a more southerly course, having rounded London, the air lost its few remaining signs of turbulence, and the 'Sperber started sinking at a determined 7 to 10 feet a second.

By this time my optimism (which is unquenchable above 3,500 feet) had cooled off sufficiently to let me think. I found myself in the thick of the murk which was drifting off the city; the horizon had disappeared, and the blue cumulus-strewn sky had given way to a dull, formless uniformity.

A flat monotone arm of the Thames detached itself from the dim landscape as the machine surged towards it; the Medway followed a little later. We now seemed to be going down rather faster than along.

The discouraging thing about this sort of situation is that one has nothing to go for—no reason to turn to one side or the other, and every reason for kicking oneself for not turning back a quarter of an hour earlier.

Gravesend was 10 miles upwind and Eastchurch the same distance downwind. In the vain hope of reaching the latter, I abandoned all cross-wind ambitions and began turning east. As I did so the machine shivered and the variometer partially recovered itself. A little later, at long last, I persuaded the green ball off its seating for at least part of a circle. High time, too, for the ground was less than 600 feet below. My circling was terrible. The horizon was still missing, and in an effort to steady down I switched on the electric turn-and-bank. As my eye followed the long tapering lowered wing, the steel grey of the leading edge toned exactly with the water, and reappeared as it swept across the cut-up land bordering the Medway.

I dared not shift the position of the machine by more than a microscopic amount on each gyration. Searching for a datum mark below, I spotted a man and a bonfire on a tiny peninsula. Each correction took the machine nearer the smoke until eventually, as we entered it, the variometer, for the first time for hours and hours (anyway, half an hour), showed rise all the way round. The next time I looked down the ground was 2,000 feet below. Right on the edge of a cone of vision, bounded by mist, a pigmy figure still tended its fire.

I could now start to distinguish cloud forms above. The machine gave a proper heave, and in a matter of moments I had her well on her side again and going up at 5 feet a second. It was good for the soul to swim out into clear air somewhere just south of Faversham. One's change of attitude on these occasions has to be experienced to be believed. After 3½ hours in the air, downwind of my course, with few clouds about and those of rather doubtful intentions, none too high, and sinking in a healthy downdraught, I admitted to feeling grand!

The thermals I managed to find in this third and last stage of the flight were, as the barogram confirms, widely spaced. What clouds there were always seemed to lie in the wrong direction. A series of cross-wind struggles landed me at 1,500 feet over a white crown carved into the side of the North Downs. I tried feverishly to find it on my quarter-inch map. I've since located it close to Wye.

The sky was now entirely clear. No, not entirely! A mile out over the Weald of Kent I think I can detect against the intense blue the first mists of a forming cloud. I take all the trouble I know how to approach the cloud from directly downwind, and in no time 'Sperber is singing round in by far the easiest, smoothest, and most opportune thermal ever. At 2,300 feet I am in the midst of its thin, untroubled vapours.

I could see the sea, and obviously beyond reach something suspiciously like an aerodrome. There was no going higher;

every turn took me farther east, so I must go on. It was now only a question of how far short of it I should land. The thrills of the next few minutes are reserved by the gods for the inexperienced.

The town a bit to the left, the foreshortened curve of the bay, that aerodrome—it might be Lympne—it might not. How misleading is a barogram! Looking at it afterwards, its ridiculously short descent from the last peak tells nothing of the misgivings I suffered.

The variometer showed a descent of just over 2 feet a second at 40 m.p.h. I put the speed gradually up to 55 m.p.h. and the sink hardly increased at all. I checked up on the second variometer in the cockpit, and it told the same story. We were covering the ground fast, even in the cross-wind. I could just see the lie of the hangars, and it was unlikely to be an R.A.F. aerodrome, for they were in line. I think we're going to make it—I'm pretty sure we're going to make it. The next time I look at the A.S.I. we're doing 70 m.p.h. I let the stick go forward a little as I turn right and then gently left on to the regulation circuit. The A.S.I. is calibrated up to 90, but the hand is well beyond it as the 'Sperber, with her usual lack of fuss, rounds Lympne at about 110 m.p.h.

I landed at 4.35 p.m., after 5¼ hours in the air for an average speed of 16·3 m.p.h. Over Lympne I had 2,000 feet in hand, which made the performance of the 'Sperber in the stable evening air seem astonishingly good. The run into Lympne was the first time that day I had held a steady course, except when flying through downdraughts, and it may account in part for the wildness of my miscalculations at the end of the flight."

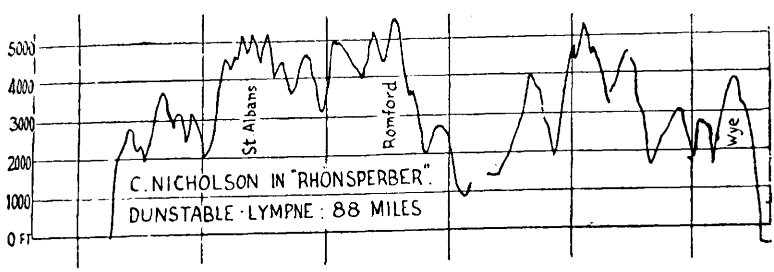


FIG. 37.—*The barogram of Mr. Nicholson's 5¼-hour flight described above.*

The flight was a difficult one because the convection currents on which it relied were not only weak but spaced widely apart. Once the towing rope of the aeroplane had been cast off, there was neither slope for ridge soaring nor front which could assist. Every climb had to be made within bubbles of air which had broken away from unevenly heated patches of ground. This was, however, a pleasant type of cross-country flying in comparatively smooth air, and anxious only on account of the threat of being let down at any moment.

Another type of flight made in cold-front conditions gave its pilot a very different kind of ride, and it is of special interest by contrast with Mr. Nicholson's effort. The pilot once again was Mr. Philip Wills, and his track was not dissimilar to that of the Rhönsperber's. He started from Aston Rowant, which lies to the south-west of Dunstable, and, flying by High Wycombe, Rickmansworth and Heston, crossed the Thames near Kingston and continued on a south-easterly course which took him over Croydon and eventually left him at Westerham. Here he turned almost due east, and after passing Sevenoaks eventually landed at Hothfield, only a few miles to the north-west of Lympne—a total distance of 83 miles (see Fig. 38).

A feature of this flight was its more or less accidental occurrence. Its author, attracted by the large cumulus clouds which were forming after the passage of a cold front, had his eye on the altitude record. A long spell of north-easters had given place to a frontal belt of violent rain and a shift of wind into the north-west as the front passed. By early morning the cumulus were developing to 8,000 feet and the Air Ministry reported the likelihood of secondary cold fronts during the day. This was ideal weather for the achievement of height. In pursuit of this, Mr. Wills flew from cloud to cloud, exploring their battlements and hoping for something which would

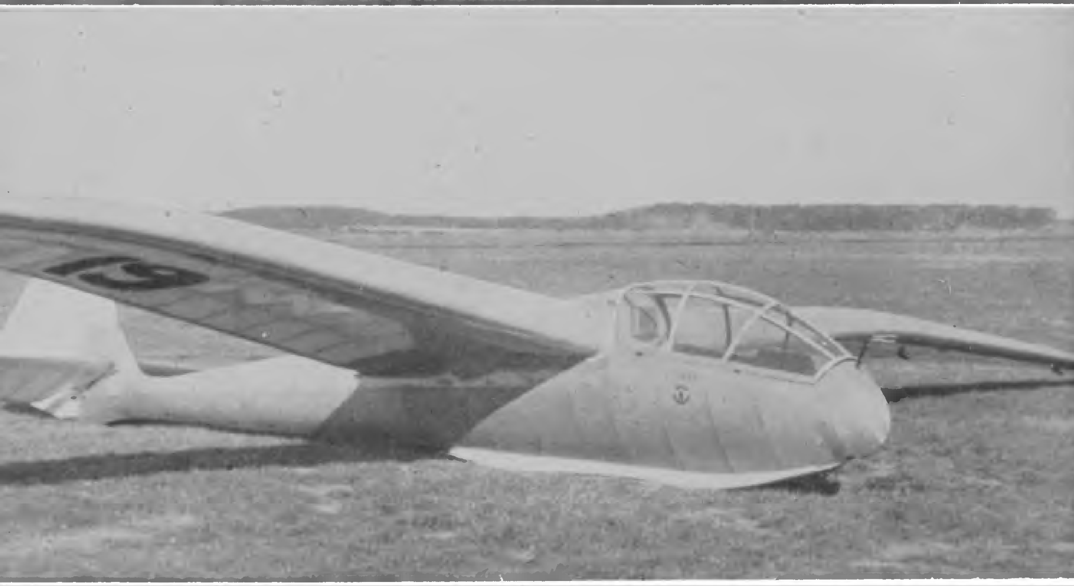
Opposite.—Top: How the cable release is operated by the pilot. A firm pull will open the jaws of the catch. (See also Fig. 63.)

Bottom: The instrument panel of a high-efficiency sailplane—in this case Mr. Nicholson's Rhönsperber. The instruments include a compass, turn-and-bank indicator, two independent variometers, altimeter and air-speed indicator.

L
R
AIR SPEED
50
40
60
30
70
20
10
80

The cross-country flight of the future may be made largely from aero-tow launches.
Here an Avro 504 is towing a Cambridge which flies just above the tug out of its slipstream. The sailplane is yawing to take up slack in the cable.

A Kirby Kite against a background of convection cumulus which has formed in spite of the stratus clouds which will be observed at a higher level in the background.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eventually take him really high. He was finally left at 8,000 feet over Sevenoaks, when he abandoned his original project and came down in a long, straight glide of 30 miles which terminated at Hothfield.

"The lift inside the clouds was nowhere very great," he writes. "I soon found out one unexpected fact: that the easiest way into a big cloud is from underneath. Approaching from below, the most active part is fairly readily guessed as the darkest portion, usually a concave area in an otherwise flat base."

For 2¼ hours the pilot spent much of his time inside big cumuli searching for the most turbulent parts. Several times he came out for a few moments to rest his eustachian tubes. He climbed to 6,000 feet, found mild icing conditions and general instability which produced anything from 3 to 10 feet a second lift. He observed that one of the most noticeable features was that strong lift was nearly always to be found in a narrow band at the extreme edge of the cloud. Flying blind, the air would suddenly become rough; up-and-down gusts of 3 feet per second either way would hit him, and then for a moment the lift would increase to 10 feet per second before he burst out of the cloud into sunshine.

"I tried circling for some time half in and half out of a cloud, but it was rough and not very successful on balance. In some of the larger clouds," he continues, "I experienced considerable vertigo, and after I had found the undesirability of leaving the cloud for a rest I tried various other methods. Singing to oneself is good, a shake of the head may help, and so may swallowing."

Opposite : Three sailplanes suitable for advanced cross-country flying.

Top : A Rhönbussard with Hartside Fell in the background. The narrow platform for the cantilever wing will be noted—in spite of which the aircraft has great structural strength.

Middle : A close-up view of the Petrel showing the clean lines and the excellent pilot's view.

Bottom : The Kings Kite, the heaviest and fastest of British high-efficiency sailplanes. Here again the clean lines will be noted.

At one point the vertigo, which is so upsetting to one's sense of balance that one is inclined to disbelieve the instruments, caused Mr. Wills to push the nose of the aircraft down and down in the belief that it was standing on its tail. Finally convincing himself that the instruments were not lying, he let go of the stick, and, as he remarks, "freed from my asinine interference, 'Mini' comfortably settled back to her usual 38 to 40 m.p.h. gait."

These explorations took him beyond the Thames, where he climbed into what he supposed was a very small cumulus, but which turned out to go on and on in a vertical direction for an unexpected length of time. It finally spewed him forth at 7,200 feet over the hills round Nutfield. This point is not without interest, for many pilots before him have failed to recognise the extent of a cloud when flying close beside it. What appears

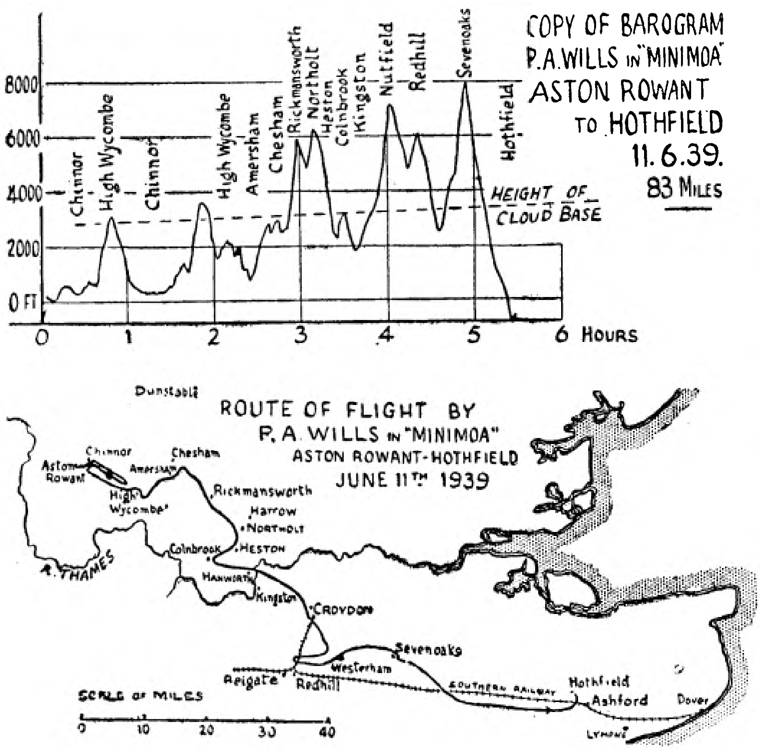


FIG. 38.—*The barogram and map of the flight referred to on this page.*

at first to have only a few hundred feet of vertical development turns out to rise to really great heights, the foothills of its lower slopes giving one the impression that they are in fact the peaks. Unless one gets a view of a cloud from a distance, a pilot on a level with its base may easily misjudge its proportions.

With over 7,000 feet in hand, the flight now became a cross-country rather than a search for mere altitude. The opportunity was too good to miss, and when Sevenoaks was reached at 8,000 feet the pilot looked beyond into clear air, and had the interesting prospect of seeing how far he could travel by a straight glide from such an eminence. The answer was 30 miles.

"The wind perhaps, on balance, gave me 5 m.p.h. The actual course flown was perhaps 35 miles. About 600 feet went on the approach. But the gliding angle works out at only about 1 in 20, which was a lesson to me. On paper, and with the help of the wind, it should have been nearer 1 in 30."

The conclusion to be drawn from this last long glide back to earth was not the same which is inferred by Mr. Nicholson's account. On the other hand, the conditions were not identical. I believe that large bodies of air which are apparently stable are, in fact, often in the course of slight vertical motion—either up or down. As a principle, it is inadvisable to rely on travelling any particular distance from any given height. As examples of masterly airmanship, however, both the flights which have been described are typical performances of really experienced pilots.

* * * * *

The Channel Crossed

Ever since the rebirth of British Gliding in 1930 pilots had discussed the possibility of soaring the English Channel. What Bleriot had done with an engine could, they believed, be accomplished without one. The prospect seemed nearer when Robert Kronfeld was towed to 10,000 feet over the coast of France on June 20, 1931, and from there glided direct to Dover. This at least proved that should a sailplane win such a height on its own account the flight would be within reach.

For a period during the following year Mr. P. Michelson kept his Cloudcraft Phantom at Dover in the hope that he would eventually get sufficient height by slope soaring to make the attempt. At the time it was not appreciated that such an ambition was beyond the realms of possibility. The next moment of interest came in August, 1937, when Mr. Wills soared from Dunstable to Dover, arriving with over 4,000 feet in hand, but with no further lift. He wisely resisted the temptation to turn out over the sea. In the following year Mr. Kit Nicholson got to Lympne with 2,000 feet to spare, as already described. But the lift had ebbed away by the time he reached the coast. In September, 1938, Mr. Wills again found himself on the coast. On his journey down from Dunstable he had soared three times to over 8,000 feet, only to reach the sea low down and under stable conditions.

The crossing was eventually made on April 22, 1939, when Mr. G. H. Stephenson, flying his Gull, took off from Dunstable, and 2 hours 40 minutes later landed in France. He wrote the following account:

"On Saturday, April 22, we arrived at Dunstable late, having made an unsuccessful attempt to get towed off from Heston. At the surface the wind was 28 m.p.h., gusting up to 40 m.p.h. Its direction was north-west by west at 4,000 feet.

I was launched at 2.55 p.m., and immediately after reaching the hill hardly ceased climbing all the way to cloud base at 4,000 feet. This shows what sort of a day it was. The clouds were smooth inside, and appeared lighter when looking upwards than downwards, a factor which helped me to fly blind to Hatfield Aerodrome.

I now made for Abridge, but just before reaching Epping Forest lift became scarce. However, I passed over Abridge and Stapleford and reached the Thames at Stanford-le-Hope. Thinking of a friend who was to come and retrieve me with the trailer, I hesitated a long time before crossing the river. But a thermal over the water decided the issue.

The Medway was crossed at its widest part at 3,000 feet, and I decided that with luck Canterbury Aerodrome was within reach. We proceeded cautiously along the London Road and reached Canterbury with 2,000 feet in hand. This was en-

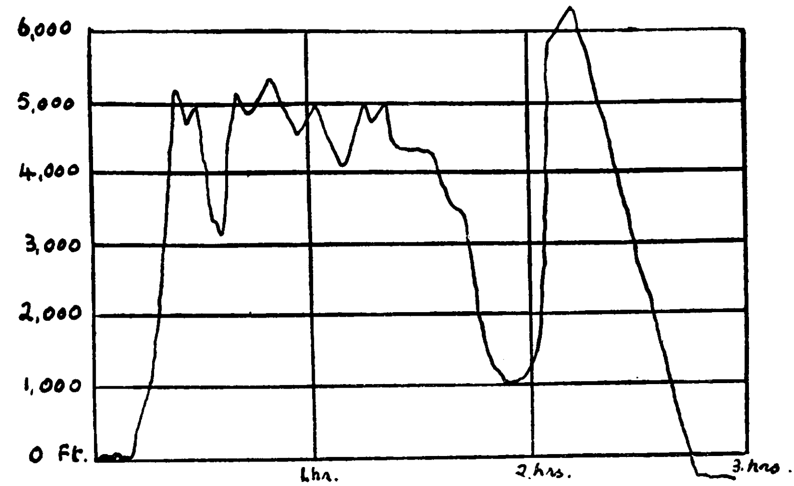


FIG. 39.—*The barograph record of Mr. Stephenson's cross-Channel flight on April* 22, 1939—*a total distance of* 127 *miles.*

couraging, and I decided to have a shot for Hawkinge. It meant turning a little south-east to allow for drift in the weak thermals.

The aerodrome was reached at 1,000 feet, and then the big surprise came. I flew slap into a newly formed thermal at 5 feet per second, worked it up to 10 feet per second, and immediately thought of the Channel. The lift increased to 15 and even 20 feet per second. I checked up the direction of Cape Gris-nez and entered a large cloud at 4,500 feet. A few minutes later, at 6,000 feet, where I was probably still climbing, I let the speed fluctuate and decided that to come out was a bird in the hand. We emerged from the south side of the cloud just off the coast. There were a few ships below, but none ahead.

South-east of the cloud I had just left, and adjoining it, was a rather broken cloud, for which I made. It was little use, and ahead of it was a 10 feet per second sink. Ahead again was blue sky, and I wondered if it was all sink. But at 50 m.p.h. we were very soon clear of it and the sink was normal. I had forgotten to allow for drift, so a slightly curved track was flown.

Five miles off the French coast the sink was reduced slightly, and I set the speed at about 35 m.p.h. The coast was crossed at about a mile east of Cape Gris-nez. The height was 2,600 feet. The sink was now a little below normal, and, forgetting about St. Inglevert Aerodrome, I went downwind looking for a place where an aeroplane could land to tow me back home. There was no field large enough, and as height was running out I chose a small field near the village of Le Wast, 10 miles east of Boulogne. The landing was very gusty, but it worked out all right at 5.35 p.m.

I cannot speak the language, which was a snag, but everybody was very helpful and seemed to display intelligence in handling the Gull. I found that my gliding certificate worked well as a passport."

It will be noticed that Mr. Stephenson claimed no lift over the sea. Nor, save for the land-sea breeze effect, is it often discovered. I have myself flown thousands of miles over the sea in power aircraft, and most of them at heights between 500 feet and cloud base where one would expect to find upcurrents if they were there. Many times I have passed just beneath large cumulus clouds and have expected a shaking. But the air has been only mildly unstable, particularly where the clouds were decaying after their formation over the land as they drifted away seawards. Apart from an occasional meeting with a wide band of lift (one in particular about 40 miles N.E. by E. of the Tay), apparently due to the meeting of water currents of differing temperatures, there seems to be very little prospect of a glider pilot getting help on a sea crossing. I've no doubt that a frontal storm which drifts out from the coast takes with it many of its land characteristics, and I further admit to having noticed clouds far out of sight of land which suggest considerable turbulence. Moreover, I have been well shaken on a stormy day. But I cannot say that I have ever met substantial thermal currents more than 3 miles from the shore. The sort of aircraft we flew in the Fleet Air Arm were slow enough to make ordinary thermal effects quite plain. On the other hand, along the shore-line and sometimes for as far as 3 miles out to sea the air has proved to be very turbulent. The effect has extended on rare occasions to 12 miles out; but after that any roughness has been due more to gusts than anything else.

The theoretical limit for any water crossing by a sailplane is therefore in the region of 50 miles. I have assumed an initial height of 10,000 feet, a rate of sink of 5 feet per second at 60 m.p.h., and a tail wind of 30 m.p.h.

While somebody some day may soar the Gulf Stream, I wouldn't give much for the chances of a sailplane maintaining height for 10 minutes on end anywhere more than 10 miles from the coast over the North Sea or the English Channel. It would be nice to be proved wrong.

* * * * *

The flights recounted in the previous pages were each, in their way, the work of polished pilots. There is an intermediate stage between slope soaring and cloud flying through which everyone has to pass, and before the experts grew cunning they, like the rest of us, were assailed by doubts, and, given a choice to make, occasionally made the wrong one. The account by Mr. H. C. Bergel of his first cross-country in July, 1935, is a nice example of a minor error of judgment and a pleasant sense of humour. Mr. Bergel later joined the ranks of those who don't make mistakes—or at least are very rarely found out making them.

He was launched from Dunstable Down at 11 o'clock on July 6 in a north-west wind of 15 m.p.h. Cumulus clouds were sailing overhead, and here and there were signs of cloud streets forming at about 3,000 feet. After a brief excursion to 1,200 feet in a thermal, he returned to the hill, where he soared for only a short time before the wind failed and he was forced to land.

"Using up my stock of bad language, I waited for the towing car. Very luckily for me, no one else turned up to fly the Grunau, and at 12.45 p.m. I was launched again, with no more hope than doing another 20 minutes' slope soaring. By this time the clouds were thinning and becoming flatter and altogether less promising.

About three minutes after the launch, when I was 150 feet above the hill, I ran into a thermal. I was so angry with apparently losing my opportunity that I threw my customary caution aside and circled. It worked. So I circled again, and it went on working, till after circling interminably I found myself at the base of the clouds at 3,200 feet. Taking a deep breath, I waved goodbye to Dunstable and tried to spot my position. I decided that I was over Hemel Hempstead due south of Dunstable—which was impossible. It then dawned on me that the wind at 1,000 feet was due north (against all the rules), and I got into a panic about being carried over London. So I set off east.

Soon I was down to 800 feet over Radlett, having conspicuously failed to find lift under the clouds, and having been just reduced into setting off into the blue in hope. As a last resort, before landing ignominiously a bare 10 miles from Dunstable, I made for some red-roofed villas grouped together. They worked and I settled down again to interminable circling, at last reaching cloud base at 3,400 feet (the clouds were steadily getting higher).

Once again I set off east. Once again I lost height rapidly, till I reached Southgate at 1,200 feet. Once again, in desperation, I went for houses and in particular a burning rubbish dump. And again it worked. I smelt the rubbish dump halfway up, and I went on round and round till I got to 3,800 feet.

After that it was a nightmare. With a howl of terror I found I was in sight of London Bridge! I raced off east, circled a bit over the Mile End Road, got to Barking, and circled a bit more. I now had my eyes on what looked like a usefully flat and open field running down from the main road to the Barking Power Station. As I was then losing height, I kept my eye on it as a hopeful landing ground. When I was down to about 1,800 feet I looked a bit closer, and found that the whole field was one gigantic spider's web of 133,000-volt cables!

Shivering with fright and cold—but mostly fright—I pushed off east to the Ford Works at Dagenham and got another few hundred feet of lift. I was at last preparing to land on the first reasonable looking space when I spotted Hornchurch R.A.F. Aerodrome about 1½ miles upwind. I got there with about 800 feet to spare, and landed just half an hour before two squadrons were due to land in formation after the Duxford Review. The total distance was 39 miles."

As a matter of history this was a first-class flight, the pilot's principal mistake being to fly cross wind to the east instead of to the west or south-west clear of London.

My own first soaring flight was in a Derbyshire evening thermal which I have already suggested introduced gliding to me at the level of a heavenly vision. Probably not more than a score of British pilots had experienced the phenomenon before, and I doubt whether another score have experienced it since. It was an unusual piece of luck for a newcomer—particularly as all evening thermals are not so docile.

My single brief account of the smooth passage through the pastel-tinted sky is unworthy of the subject. Not only was it a gloriously smooth ride, but it merits an attempt at serious explanation. Others who caught it subsequently received a battering which in itself demands respect, and an account of two flights which were made on June 14, 1938, are an epic in their way.

"June 14 was a warm day with bright sunshine," wrote Mr. G. Swale in the *Sailplane*. "The wind was W.N.W. and blowing from 15 to 20 m.p.h. At 4 p.m. a very long front passed over with the wind backing to the south-west and increasing some 10 m.p.h. After the front the wind returned to the west-north-west at about 5 p.m., maintaining its increased strength. During the next hour and a half thin wispy clouds were forming in lanes across the line of the wind, following the ridges separating the valleys at a height of some 500 feet, rising later to about 1,500 feet. That was the observed sequence of the atmospheric conditions, with the addition that the ground temperature was steadily falling.

At 7 p.m. the taper wing Cadet was launched. The general assumption was that the cloud on the hill would blanket out the hill lift and there would be a very low ceiling with rough conditions. This frequently happens.

It was rough going up the winch rope, and when the machine entered the hill lift it was very rough. But at about 800 feet the lift became stronger and smoothed out, and the Cadet, heading out into the valley, was well away.

I was next off in the Kite. As with the Cadet, the launch was very rough, but at 600 feet the roughness disappeared and the variometer showed 10 feet per second rise. I allowed the machine to drift over the ground headed into wind, and maintaining an indicated air speed of 35 m.p.h. At this the ground below moved neither backwards nor forwards, and I proceeded to climb rapidly in smooth air. So smooth was it that it was possible to relax completely.

At 3,000 feet the reading of the variometer slowly dropped back to 3 feet a second, and remained constant at this up to 5,300 feet. I was still in the same position in relation to the ground.

I decided that the time had come to explore and to try to find out how far the lift extended. I turned partly downwind. Stoney Middleton, 3 miles away, was soon reached. No sink. From there I made across to Miller's Dale, 5 miles, heading west for Chapel-en-le-Frith, 7 miles. Here I encountered slight sink, and this continued all the way across the hills to Castleton, but only at the rate of some 6 inches per second with an air speed of 45 m.p.h. I arrived over Castleton with 4,000 feet.

The problem to be faced now was how to get down. The smoke from the cement works in the valley showed that the wind was increasing, and there appeared to be no downdraughts anywhere within the area. However, by putting up the speed to 50 m.p.h. and gently side-slipping, 1,500 feet was reached. At this height I paid a visit to the landing ground, and turning over the back wall with 50 m.p.h. on the clock I shot up to 2,000 feet. There didn't seem to be much prospect of getting down that way. I went out again to lose height, and over Bradwell village found downdraught for the first time. Descending to 800 feet, I dashed for home, and then the fun began. The wind at ground level had increased to about 50 m.p.h.; the Kite was literally tossed about like a cork on the sea, and before it was all over, with the machine safely on the deck, that 800 feet had taken some 10 minutes to get rid of, with the clock frequently showing over 60 m.p.h."

* * * * *

A second account by another pilot, Mr. S. D. Dixon, throws further light on the conditions. An interesting comment which he makes is that the atmosphere looked "dead."

"I got away in the club Grunau at 8.38," he writes, "and turned north to make the first short beat to the north-west slope some 400 yards away. By the time we arrived there—say 1 minute—I was surprised to see wisps of cloud between me and the hill, and to realise that the altimeter was already at 700 feet.

From then on I became fascinated by two facts—first that the green ball was trying to get out of the top of the tube, and secondly that it didn't matter where one flew. The ball just stayed at the top. I tapped it twice, looked at the altimeter, and realised that in 4 minutes we had climbed 2,100 feet. About now the green ball got 'lazy' and hung about half an inch from the top of the tube. The air was amazingly calm—no stick movement was needed at all.

The ground was now covered by six-tenths thin wispy clouds. In front to the west was a stratum of cloud which was dropping away in exactly the way it does in a power climb. At 3,000 feet on the clock I decided to carry on up to Silver "C" height (3,281 feet) and then scoot down to let the others 'have a go.'

I tried to work out what reading was necessary for this. Camphill is 1,200 feet, plus launch of 300 feet, minus calibration error. The problem was solved by clocking 4,000 feet and allowing an adequate margin.

So now we'll go down . . . don't suppose the barograph is inking, anyway. Speed up to 40 to 45 . . . funny, the green ball has stuck . . . no, it's still going up. Speed up to 50 . . . that's better; the green's only an inch up—ah, yes, fly out farther . . . no use. The clock says 4,500 now. This is awkward. What about flying back behind the edge . . . wherever that may be . . . somewhere below the clouds, I suppose? Keep the speed 50 to 55. Green ball getting very lazy now . . . almost bouncing on the bottom. Must be getting late . . . too late . . . it's getting murky down there. Wish I was back over the wall in a downdraught. Must get rid of this height some way.

Try over to Mam Tor—that's better. The red ball kicked once in 5 minutes. No luck on the return journey—lost only 200 feet. This is serious! Try back over Grindleford, round by Tideswell crossroads. Very occasionally the red ball appears with the speed at 55 to 60 and the altimeter at 3,700.

It's not so smooth going down—can't see much ground anywhere and these clouds below don't look at all thin. Here goes! Sixty on the clock and a very rough passage through the clouds. Come out at 2,500 feet where the moors look dark and forbidding.

About 2 miles to go with nothing nice to land on in between. But should make it easily. The red ball's hitting the top now . . . very, very rough . . . there must be the heck of a lot of wind. Can just get in, I think . . . must get in . . . steeplechase two walls and get into the small sloping field near the hangar . . . touch a wing tip on the ground . . . round we slew . . . was that the skid going? I'm afraid so."

*   *   *   *   *

As a final comment Mr. Dixon says: "Over an area of 7 miles north and south and 6 to 7 miles east and west the lift was of the order of 600 feet a minute, and rarely less at 3,000 to 4,500 feet, and conditions dead smooth. Below 2,500 feet flying was just plain hectic! And below 1,000 feet verging on dangerous. The ground crew could hear the machines whistling at 3,000 feet, and prayed audibly as each came in to land."

*   *   *   *   *

Mr. C. A. Kaye of the Derbyshire and Lancashire Club analysed the phenomena upon the facts as they emerged from the pilots' reports.

"The effect," he says, "occurs with a west or north-west wind, and if there is a west wind there is a swing towards the north-west during the phenomenon.

It only occurs after a warm, sunny day, with clouds usually of a cumulus type and not very high (between 2,000 and 4,500 feet).

It occurs after the sky has cleared, which is usually after 6 p.m. G.M.T., and in conditions of good visibility. Its development is accompanied by haze up to 2,000 feet and by the appearance of a lenticular cum-line-squall type of roll cloud in the distant west. This roll is grey-blue in colour and has no light and shade effect as in a front, but this may be due to the sinking sun behind the cloud. The lenticular breaks up about 4 miles before reaching Camphill, and only wispy fragments cross the valley at between 1,500 and 2,000 feet.

The air is warm and smooth before and during thermal, but when the sink arrives—as it always does—the air is cold and turbulent.

The stronger the wind, the more lasting is the thermal.

The thickness of the thermal effect from the edge of the hill to the limit of the lift is two or three times that of the best normal hill lift. The lift in and below the wispy bits of cloud —when they arrive—is slight, and the clouds as they approach and pass are seen to be dissolving. The barometric pressure falls just as the thermal begins, and rises as it passes.

Theory.—West or north-west winds blowing across Castleton, Hope, Bradwell, and Hathersage valley form a ceiling which imprisons heated air over many square miles. The valley is closed at the west end, and one of the few escape roads for heated air, if any, is via Bradwell Dale. This confining effect is strengthened by the presence of clouds during the day.

When the cumulus clouds disperse and the sky clears, a roll of cold air pours into the valley over the Kinderscout and Chapel-en-le-Frith line of hills, and in the manner of a front pushes the warm air out of the valley.

A confirmation of these ideas has occurred several times, particularly on one occasion when the maximum height obtainable was only 2,000 feet. But the cold air could be seen coming down into the Castleton, Hope, and Bradwell valleys in the form of a light mist. This seemed to have the effect of forcing up the warm air to a height of 1,500 feet above the soaring ridge, where it condensed into a layer of cloud. It was possible to soar just above this, but no farther, although the lift between the hill and cloud level was as much as 10 to 15 feet per second."

* * * * *

From the foregoing, and from researches made in Poland into an identical phenomenon at a soaring centre in the Carpathians, it is deduced that cold air running down the hillsides as night falls is the basic cause. Temperature measurements were made by observers stationed at various points down the hillside, with the results shown in the diagram overleaf. The implication of this is that the effect is one of a cold front advancing upon a body of unstable warm air. The theory at any rate fits.

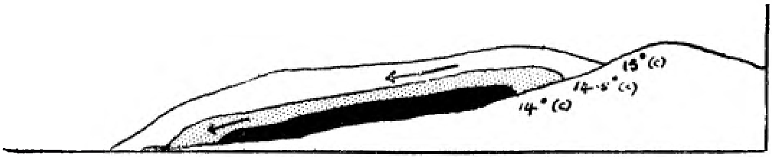


FIG. 40.—*Cold air trickling down a hillside to displace the warm air lying in the valley. A possible explanation of the "evening thermal."*

* * * * *

All distance flights which have as their object the covering of the greatest number of miles in a straight line are the result of opportunism and planning. The record flight of 209 miles from Heston to St. Austell made by Mr. Wills relied more upon planning than the exploitation of chance. But more often than not opportunism plays the greater rôle. While it may be practicable to work out a schedule of the proposed flight on the ground, the actual conditions in the air may at any time cause an alteration to plans, necessitating immediate decisions which will change the character of the flight.

The ways and means of gaining a safe height from which to start have already been discussed and will be the subject of further notes later on. These for the moment are not my concern. It is now rather the problem of remaining in the air and continuing the journey once it has been started. Pilots have found themselves after a promising start leaving cloud-land behind and entering an area of clearing skies in which lift is scarce. If reaching a particular goal is no object, an immediate change of direction may save the day. A wrong decision at this moment will mean an early termination of the flight in a field. A correct decision, on the other hand, may extend the flight indefinitely. The truth of this has been repeatedly demonstrated when a number of pilots have taken off at the same time and from the same place with the object of covering the greatest possible number of miles. The results of a dozen pilots will possibly vary between 15 and 150 miles, although they all started with an equal chance. Averaged over a number of occasions, it will be found that two or three names repeatedly head the list for the longest distances. The goddess of luck, to which much is often ascribed, cannot be held to account.

Unfortunately it is impossible to set down a code of procedure which if followed will lengthen every attempted journey. The combinations of temperature, humidity, wind, and the ground over which the flight may be made are too many and may vary too fast to set up rules. At the best it is only possible to offer suggestions covering a few of the typical situations.

The first does not warrant more than a brief note. It is just that pilots are prone to overlook the change in the force and the direction of the wind with increasing height. If the air is moving at 35 m.p.h. at 4,000 feet on a day when its speed is no more than 12 m.p.h. at ground level, any changes in its direction must have a big influence. As a veer of anything up to 50 degrees is a common occurrence, and sometimes much more, it is useful to study the weather report beforehand so that a course may be shaped accordingly. Moreover there are many good soaring days when the wind is at least 50 m.p.h. at cloud base and upwards, and this in itself must influence the decision of a pilot as to his most economical cruising speed. Whereas it might pay to fly fast downwind in light airs giving a ground speed of say 75 m.p.h. made up of 10 m.p.h. wind and 65 m.p.h. indicated air speed, it might be a mistake in view of the loss of efficiency of the aircraft to fly so fast in a high wind. It is probable that a ground speed of 95 m.p.h. made up of 50 m.p.h. wind and 45 m.p.h. indicated air speed would be a better proposition. In the first instance the pilot might be losing height at 7 feet a second, as against only 2½ feet a second at the lower I.A.S. It is equally plain that any attempt to fly across wind to reach a particular part of the country where better conditions are expected is made more difficult in winds of a high velocity.

The next problem which frequently confronts a pilot is the dissolution of the clouds. When this happens towards the evening, there is usually nothing to be done about it unless the coast is within reach and there is a chance of picking up lift from the land-sea breezes over the shore. But more often than not there is a second choice in clouds lying varying distances from the pilot across the wind. The instinct is to make for the nearest bank, but it often happens that it is in the process of decay, and that the choice of the further clouds in the opposite direction is the better one. It is here that the recognition of the difference between clouds which are growing and others which have passed their prime is so important.

Under the foregoing conditions the pilot will probably have been relying on thermal lift as opposed to frontal conditions, and without labouring the point it may be remarked that the nature of the ground below should be always watched. Much has already been said about the thermal-producing qualities of different types of ground. They are never more important than during those difficult moments on a cross-country when ill-fortune has forced the pilot down to 1,500 feet or less. It is now that a quick decision to make towards the most likely thermal-producing area will save the day. There is another comment to be made under this heading, although it concerns a less critical moment than the one just mentioned. A choice may arise between passing a large industrial town to one side or the other. It will be remembered that the smoke haze on the downwind side of such towns is often an effective screen to the sun's heat, and that thermal activity is reduced accordingly. By flying across wind it may pay handsomely, in spite of loss of time, to skirt the area to windward.

Cross-country soaring in frontal conditions is perhaps less under the control of the pilot than those of which I have been writing. But the example of one flight already quoted in this chapter will have suggested that the great altitudes which the conditions make available to anyone who is not afraid of blind flying in rough air are potential reservoirs of distance. Once again, height will depend upon the state of developnent of any particular frontal formation, and cloud recognition to this end is still essential.

Associated with clouds of both types, and also the lift within them and beneath them, is a final consideration which all really experienced soaring pilots recognise. This is the quality of the lift. There are days when the sky is full of rising columns of air, and it is on such days that long distances will be attempted. It may then be wise to abandon any lift which is less than the average for the day in question. The time factor enters much into distance flying, and to spend half an hour in gaining a few thousand feet in lift of 3 feet a second is a mistake when a brief search may produce lift of say 7 feet a second. Mr. Wills' comments on this point will be noted on page 297.

Such, then, are the salient considerations of distance flying. There are others which sucesss and failure will demonstrate—the use of cloud streets and the saving grace of hill lift. The moments to use them or discard them can only be selected by the pilot himself—the result of his experience.

FLYING KIT

Advanced soaring which involves altitudes of more than a few thousand feet automatically raises a subsidiary problem which cannot be entirely ignored. The decreasing temperatures through which the pilot will have to fly can, through their effect on morale, have an influence on the performance within reach of any particular person. This is specially true of cold-front conditions when cumulo-nimbus clouds are associated with a rapid fall in temperature even at ground level.

In the first 4,000 feet of a thermal flight there is likely to be a temperature drop of 20 degrees Fahrenheit. During the next 4,000 feet—which must almost inevitably be made through cloud in a sailplane—there will be a further drop of 12 degrees. These figures are based on a lapse rate of 5 up to cloud base and a lower rate of 3 within the cloud itself. The conditions in which such heights are attainable are associated with hot summer days in which the ground temperatures are high. Assuming for the sake of example that it is 65 degrees (F.) at launching level, then the air at 8,000 feet is only 1 degree above freezing point—33 degrees (F.)—and, being in cloud, it is also wet.

Now, the average sailplane pilot, whatever his other sterling qualities, shows a lack of foresight in the matter of his flying clothes. I am no wiser than any of my friends, and have found myself circling in a wet cloud only a couple of degrees above freezing point with a thirty-mile-an-hour "fog" whistling through the hairs of my chest. It is possible that modesty is at the root of much stupidity. "I can't possibly reach 8,000 feet on a day like this" is perhaps the mental comment of the pilot who takes off over the hot soaring slope in a cotton shirt. It is on just such a day that he finds himself half an hour later circling into the shadowy base of a great cloud, his variometer recording a lift of 10 feet a second, and his skin a new temperature drop of 5 degrees every 100 seconds. A few minutes later the pilot is beginning to feel the first effects of nausea, brought about by rough air through which he has to circle on instruments in zero visibility. His resolution to carry on is not strengthened by being cold, with the certainty of being colder. His position in an open cockpit is worse than that of the importunate climber who assaults an alp without a windproof jacket and is caught in a blizzard. An alp at least does not heave around. In a sailplane with a fully enclosed cockpit the discomfort is delayed and slightly mitigated, for at least the rampaging blast is kept out. When faced with the vileness of such conditions my blood turns to water, and I abandon a flight which might otherwise have provided much pleasure and most definitely a "line" for the bar that evening.

If you look through the barograms of half a dozen typical cross-country flights made during the summer you obtain a picture of the conditions enjoyed by the pilots. They usually record a period of slope soaring at about 500 feet where the temperature is pleasantly warm—say 60 degrees F. Then it can be seen from the rising line that a thermal drifted over the slope and was successfully picked up, carrying the pilot to 3,000 feet and a temperature of 45 degrees F. At this point—which was probably at cloud base—he set off across country, gradually losing height to 1,000 feet and a temperature of 55 degrees, where he picked up a second thermal. It is evident that this time he didn't stop at cloud base, for the barogram shows a climb to 6,700 feet, and when he resumed his flight across country the temperature was only 37 degrees. But now the record shows that he entered an area of deteriorating soaring conditions. In fact, half an hour later the pilot is obviously only saved from landing by slope soaring over a convenient ridge which is actually 600 feet below his starting point. The temperature is not less than 63 degrees.

It is now an hour since he left the ground, and he has passed through a temperature range of 26 degrees. But the flight is only just beginning, and he picks up a very good thermal off his low hill, reaching 3,500 feet, from where he appears to have flown into an area of heavy cumulus fed by frequent convection currents—perhaps a cloud street. At any rate the barograph shows that for over an hour he never sank below 2,000 feet and climbed on two occasions to over 5,000 feet. During this period the temperature ranged between 50 degrees and 39 degrees. But it was at the end of this part of the flight that he obviously found the best cloud of the day—probably a cumulus which was in the process of becoming cumulonimbus. With only momentary checks, the graph line records a climb to just over 8,000 feet while the temperature fell to 30 degrees. It is probable that the sailplane began to ice-up at this point, and that this circumstance, coupled with the cold, caused the pilot to abandon the cloud. At any rate, the barograph records a steady descent from now on. Half an hour later he is back at 2,000 feet, and except for one more quick climb there is a continuous descent to a landing which was made 800 feet below the point of his original launch 3 hours 40 minutes before.

With this prospective guide the pilot can go shopping. I should like to see what he brings back.

In most sailplanes there is a limit to the amount of clothes you can wear. I doubt whether I could squeeze into a glider cockpit with a Sidcot suit, an inner lining, and flying boots. As far as the boots are concerned, I would in any event prefer to leave them behind, because they rob the pilot of sensitive rudder control. The ideal footwear is socks only, more usually modified by a light pair of rubber shoes. But it is the feet which get insufferably cold, and every pilot must solve this problem the best way he can. I am inclined to believe that a pair of over-size light walking shoes with two pairs of oiled wool stockings pulled up over the bottoms of heavy corduroy trousers would be as good a protection as any for the lower half.

The top half of the body presents a lesser problem. I believe, in fact, that the ideal combination is a sheepskin waistcoat, a polo jumper, and a windproof golf jacket. You certainly sweat less at low altitudes in such gear than you do in the rubberised cloth of a Sidcot suit.

In a closed cockpit the question of headgear does not arise. But in the open variety it is a matter of some moment, and the ordinary flying helmet and goggles and a balaclava which will cover the lower part of the face is worth while. The goggles are necessary, for in the wet, cold air even a thirty-mile-an-hour wind can become very trying. I prefer an open cockpit, possibly due to a fetish born of flying the Navy's Swordfish. The wind in your face is a tonic on a summer day, and the discomfort of cloud flying can, after all, be disposed of at will. Moreover, an open cockpit always gives one a better sense of balance—an amateurish admission which I don't hesitate to make.

Gloves can be any kind which are not bulky. For myself, I use an ordinary leather pair as carried by gentlemen in bowler hats. If you absolutely insist on having warm hands, there is nothing better than a light pair of gauntlets over which have been drawn a pair of woollen gloves. Anybody who tells you that the woollen gloves should be beneath the gauntlets has not tried the sequence the other way round at high altitudes.

It is, of course, almost inevitable that in spite of warning the pilot will sooner or later—and probably sooner—find himself with a golden opportunity to make a cross-country flight at high altitude inadequately clothed. One of the drawbacks as well as the charms of soaring is its uncertainty. For perhaps weeks he will enjoy the zephyrs of the west wind on his home ridge, relieved from monotony by gentle thermals which take him up a few hundred feet without tempting him to something more ambitious. Then the moment will come when the signs all point in one direction—to a cross-country flight which will end at least a hundred miles away if the cards are correctly played. He will either seize his chance and freeze in the process, to say nothing of landing in a strange place without a collar and tie, or return ignominiously to the soaring slope after an initial boost into the sky which led his admirers to expect something better.

I have said nothing about really high-altitude flying, partly because I've no experience of it in sailplanes, and partly because the British Height record in 1944 stood at a modest 14,170 feet. At the same time, there is little doubt that heights much in excess of this will eventually be achieved by British pilots, and special precautions will accordingly have to be taken. The World record of 22,441 feet is not so far above the level of thunderstorms which form over the British Isles that the altitude is not approachable. I certainly hold the view that 20,000 feet will be exceeded within the next five years.

Now, Mr. Wills's official British record represents about the limit which can be attained by the ordinary man without oxygen. Pilots of aeroplanes have from time to time exceeded 20,000 feet without such assistance, but they have taken an unnecessary risk, and I believe that the rough conditions of cloud flying in a sailplane are likely to bring on unconsciousness sooner than smooth clear air in which the pilot is subjected to no strain. For myself, I find that up to 15,000 feet I feel no effects of altitude whatever, but being relaxed in the seat of a power craft is a different thing from combat with the controls in turbulent air. And, moreover, I will admit to a feeling of tiredness brought on quickly by such actions as leaning forward to test the petrol gauges or increasing the hot-air supply to the engine, and even shouting down the intercom. to a crew who seem determined not to hear. Furthermore, any badly executed acrobatic, such as an unduly harsh pull out of a loop, undoubtedly produces more pronounced signs of black-out at great heights. I once succeeded in putting myself completely out by trying to loop a Gladiator after the fashion of a Swordfish. In the upward half of the loop, made at some 10,000 feet, I ceased to take any interest in outside affairs until I woke up on my back performing a most inelegant inverted side-slip. I am perfectly certain that at 5,000 feet I should not have made such an exhibition of myself.

Pilots in a pressure chamber who are invited to remove their oxygen masks at 35,000 feet usually remain conscious for from 90 seconds to 3 minutes. If they are given a writing test, their writing will begin to deteriorate after the first 60 seconds and will quickly degenerate into an indecipherable scrawl. As soon as their oxygen is plugged in again by a safety pilot, they will immediately begin writing again legibly, and when asked if they would like their oxygen to be turned on they will say that they are still feeling fine. They will not know that they have been momentarily unconscious. In this lies the danger of altitude. The effects are so insidious that it is possible for a pilot to lose consciousness without knowing it, and in fact it may be impossible to persuade him during a test such as this that he has been "out." At lower levels the effects are more gradual. Some men will last for half an hour at 25,000 feet, but the least exertion will only be made with the greatest effort, while long before consciousness is lost the brain works so slowly that the simplest problems are beyond its solution. I have even noticed myself that at the modest height of 15,000 feet or so the conning of the aircraft on to a new compass course is fraught with mind strain out of all proportion to the job of turning the compass ring and applying a little rudder.

When these considerations are taken into account with the sub-zero temperatures inevitably encountered, the prospect of breaking height records in a sailplane is not one of merely hanging on sufficiently long inside a cumulo-nimbus cloud. An oxygen mask and very special clothing are essentials. In fact, I would say that future record breakers will face a tough proposition, for even with oxygen and suitable flying clothes the twin problems of icing and rough air will have to be successfully surmounted. Maybe a heavy coating of grease on the wings will dispose of the former, but I doubt it. Moreover the turbulence inside a thundercloud of sufficient proportions to carry a pilot to 25,000 feet will be sufficient, if he is unlucky, to break up his aircraft.

These pleasant reflections are perhaps a sufficient introduction to the pilot's account of the greatest height yet achieved in a sailplane. It will be seen that in spite of oxygen and protective clothing it was not all beer and skittles. His performance foreshadows others, to be made, let us hope, by Englishmen.

Erwin Ziller, who took off in a Kranich sailplane on November 21, 1938, from Grunau in Silesia, entered the well-known standing wave on the lee side of the Giant Mountains, reaching a height of 28,215 feet above sea level, and 22,441 feet above his starting point.

"On November 21 in the forenoon I started from Hartau Aerodrome in the sailplane Kranich," he writes. "I had fitted this up with oxygen equipment in the hope of making an altitude flight.

According to my altimeter, I cast off from the aeroplane at 3,940 feet. Owing to poor upcurrents, I was slow in climbing until I reached 6,500 feet, when the Kranich suddenly rose strongly in powerful updraughts. At 11,800 feet I entered the clouds in which the instruments immediately became iced up, and I had to do my best without them for a long time. I was still in cloud at 21,300 feet, when I made an attempt to get out into clear air. This brought me into an area of downdraught which sent me back to 7,500 feet.

Then, flying on in a southerly direction towards the Schneekope, I reached the frontal area of a 'moazagotl' cloud (standing wave) and climbed smoothly and swiftly to 28,000 feet. From 19,000 feet to about 28,000 it was necessary to fly through ice clouds where the temperature sank to minus 40 degrees Centigrade (72 degrees of frost Fahr.), so that even my fur boots gave little protection from the cold. Owing to this and the oncoming darkness, I was compelled to terminate the flight. I landed after a flying time of 4½ hours, having covered a distance of 43½ miles from Hartau."

THE STANDING WAVE

ON March 21, 1941, I was flying down the east side of the Grampians between the mountains and a line which joins the towns of Edzell and Kerriemuir. It was a rough day, so that even my old Shark, which weighed nearly five tons, was behaving like a steer at a Rodeo.

Then, without previous warning, we flew into smooth air. The relief from being tossed around was enough without seeking the reason why, and it was only when I noticed the strange movements of the altimeter that I took a closer interest. Without having touched the throttle or altered the trim, we had begun a smooth, rapid climb from 2,000 feet at a rate of 1,000 feet a minute. This so fascinated me that I did nothing but sit back and watch the altimeter making its circles round the dial. A glance at the rev. counter proved that a capricious engine was, for once, doing nothing out of the ordinary. Nor had the speed fallen or the attitude of the aircraft altered. We were, in fact, flying straight and level at a constant 90 knots, and yet we were climbing at about the maximum rate of which the Shark was capable on full throttle.

This was my first flying experience of a standing wave, the most interesting type of air current which can be used by a glider pilot—and used, too, so it seemed, by a venerable old war horse of the Fleet Air Arm.

I had done my best in a sailplane to pick up a standing wave in the days of peace, and had taken a small part in organising the launch of a friend who was the first pilot to ride such a wave in this country—and incidentally to break the British height record for gliders. And here I was shooting heavenwards with 5 tons of metal beneath me and wondering what it was all about.

A north-westerly wind was sweeping across the Grampians at 35 knots. At the moment we met the smooth air I was looking under a massive roof of cumulus clouds into the gorges of the North and South Esk rivers, and saw the white gleam of snow on Driesh and Mayar. The black rock of shadowed clefts receded into the hinterland of the mountains, an austere prospect of highland wastes.

But to the east the sky was clear save for a long roll of cloud, which stood out from the hills and lay for 5 miles parallel with their length. Beyond it I could see the sea and the margin of the coastal plain, a bright horizon of gay blue, flecked with the tails of white waves.

I was rising rapidly to the bar of cloud, and soon I was level with it at 4,000 feet, and climbing fast through the gap between it and the mass of cloud over the mountains. As we passed at 200 yards I noticed that it was revolving slowly, like the shaft of some vast piece of machinery.

Within a matter of minutes the altimeter was reading 6,000 feet, from where there was a view across the tumbled cloud-tops stretching to the western horizon and hiding beneath their ultimate turrets the peaks of the Cairngorms. Looking directly down, the thin tongue of Lundie Loch lay in a fold of the hills, while on the other side lay the twisting bar of the lenticular cloud. Beyond this there was the blue sky and the plain and the distant sea.

I made an experiment by throttling back the engine to a tick-over. Immediately the rate of climb ceased, but even now we maintained our height of 6,500 feet. This was a remarkable state of affairs in an aircraft which was celebrated for its brick-like qualities in a glide. There was no longer any doubt that I was soaring the same wind which the farmers below the Hartside ridge in Cumberland know as the "Helm"—the wind which comes tumbling over the mountain edge like a cataract of water, to lift off the roofs of barns and scatter the haystacks. The "Helm" wind of Hartside was supposed to be the only one of its kind reaching fully developed proportions in the British Isles. But here I was soaring its twin brother in Scotland, and wishing that instead of a heavy naval aircraft I had a 400-lb sailplane beneath me.

If you have noticed the effect of a ledge of rock which lies just below the surface of a smoothly flowing stream, you will have seen in miniature the construction of the wave phenomenon. The water flows unbroken across the submerged ridge, dips into a trough, and rises again to a crest. Thereafter a second and third wave may stand downstream of the first, each smaller than the last, until the smooth flow of the water flattens out once more into an even current.

When a current of air sweeps across high ground, and comes suddenly upon a step which takes it to a lower level, there are occasions upon which it, too, will form one or more standing waves. They are dependent upon a fine balance of meteorological conditions coupled with the contours of the ground below (see Fig. 42).

I met the same wind again on December 17—and in the same place. This time I had been taking some air photographs, and the lubricating oil in the camera had frozen at 7,000 feet, putting a stop to our official business. Once again there was a solid carpet of cumulus cloud over the mountains, with a break to the east. The "bar" was as well defined as before, standing out about 2 miles from the foothills, and as I watched it turned slowly in greasy-looking white folds.

This cloud marked the crest of the wave. It was, as it were, encompassed within the curve of its crest, and was revolved by the wind speed over it.

As I expected, when I flew down its 5-mile length on the west side, the aircraft climbed fast. But when I crossed it, and flew down its seaward length, I required nearly full throttle to maintain height. To the east I was on the downward side, where the air was descending with the same smooth rush as it rose on the westward side. This time I was flying a Lysander, but the effect was the same as it had been on the Shark. Once again the remarkable smoothness of the current was surprising. It was possible to fly the aircraft "hands off." Even when I flew close in to the bar cloud only slight turbulence was experienced. An interesting point was that though the cloud was at 5,000 feet the wave had apparently bent the air above it to its shape, for the lift continued to be felt up to 8,000 feet. Had I been flying a sailplane I've little doubt that the ceiling would not have been less than 10,000 feet.

In February, 1943, I had my third and last experience of this particular wind. This time I was on the ground shooting pigeons at Lundie Castle, immediately below the area where I had met it in the air. Once again a strong north-west wind was blowing. Towards the late afternoon it increased to hurricane force. The trees in the woods round about came crashing down, and I sought sanctuary in the open. Clinging to a fence on the edge of a ploughed field, the branches of trees from a belt of wood 300 yards away flew past 10 feet above the ground. A hail of twigs darkened the sky for a period of minutes. A blackbird was rolled over and over across the plough, to pick itself up, apparently unhurt, in a spinney 50 yards downwind.

It would have been difficult to believe such a thing possible when you looked at the wall of mountains which was apparently sheltering us. But the nature of the "Helm" type of wave is to cling closely to the slope down which it flows, and apparently to acquire great acceleration on its way. I've little doubt that half a mile or so beyond where I was standing it commenced its upward trend again, for the crest was marked in the bar standing downwind 4,000 feet up.

That afternoon a thousand trees were blown down. I've good cause for remembering it, for both roads to the house were blocked and we had difficulty in finding a way through the fields back on to the main road.

Twenty miles away, on return to my aerodrome, I learnt that the gale had been severe, but that no gust had exceeded 60 miles an hour. I am sure that for a while the steady speed of the wind at Lundie was in the neighbourhood of 80 m.p.h., and gusted to 100 m.p.h.

The only notable gliding record of this wind in the British Isles goes to the credit of Mr. Noel McClean, who successfully picked up the "Helm" at Hartside after numerous attempts by a party who had specially gone there with the object of attacking the British height record. His performance was the more meritorious by virtue of the scientific approach which was made to it. It was preceded by the collection of valuable data from a meteorological officer who had kept a weather station on the top of Cross Fell nearby. This scientist had observed that the "Helm" favoured an inversion at between 4,000 and 6,000 feet, and that it was invariably accompanied by the cloud bar at between 2,500 and 5,000 feet, which hung, revolving visibly, just in front of the ridge. Immediately above it, at a height of between 8,000 and 16,000 feet, was a second cloud—the "high bar"—which hung as stationary as the first.

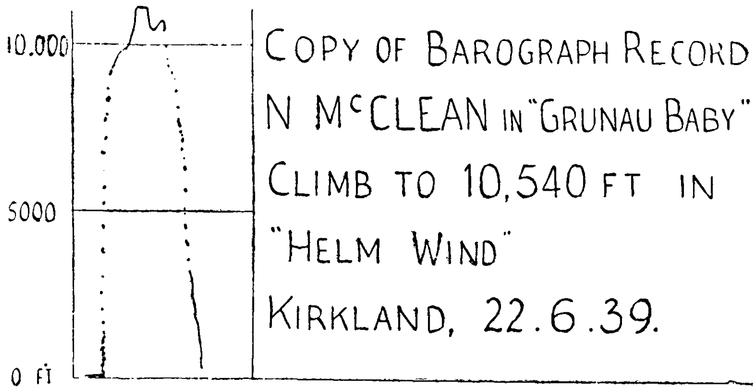


FIG. 41.

At times of high humidity these clouds united to form a solid wall, and often the first cloud formation was repeated three or four times at equal distances to the west over the Eden valley. No cloud formed in the blue spaces between the walls.

When the "Helm" is blowing it creates a distinctive noise in its terrific charge down the rocks and among the trees at the foot of the ridge. Its strength is notorious throughout the district, with the result that the older farmhouses have been built with no windows on their east sides, while long ago there is a record of railway engineers being warned of the danger of laying a line through the valley.

On June 23, 1939, Mr. McClean was winch-launched in a Grunau sailplane from the foot of the ridge at Bank Hall Farm. The strong north-easterly which had maintained the bar for the past 48 hours was blowing at 50 m.p.h. down the slope. McClean turned into the hill, and immediately picked up a rising current of very rough air. Its instability at only 1,000 feet above the launch gave him an anxious time, and for a minute or two he was thrown about violently before the lift suddenly smoothed and increased in strength (see Fig. 41).

The variometer now showed its maximum reading of 25 feet per second, and the needle became jammed at the top of

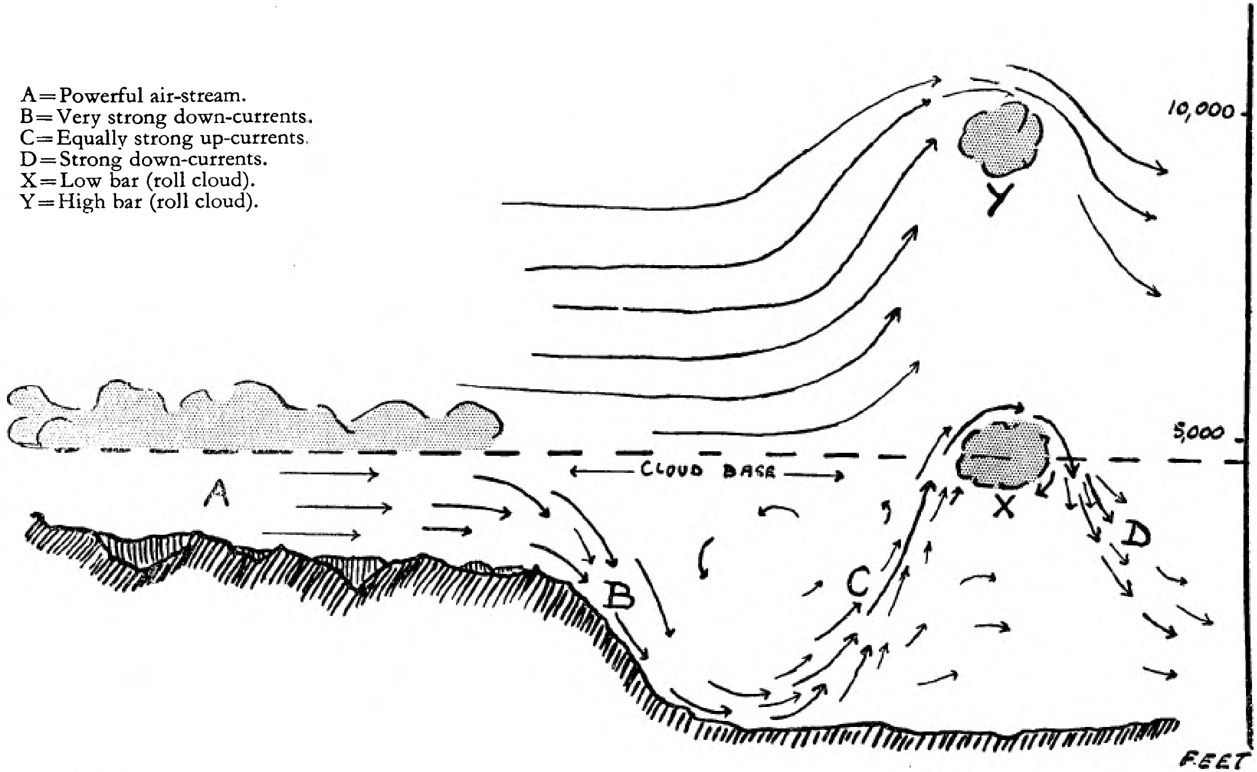


FIG. 42.—*The apparent construction of a standing wave. It has been observed that the air-flow above the low bar is bent to the shape of the wave below.*

the dial. There was reason to believe that the speed of ascent rose to the neighbourhood of 40 feet per second, and continued thus up to 9,000 feet, where there was a temporary lull.

The ceiling was reached 20 minutes after take-off. From this point the pilot could see the coast of North Wales in the south, the mountains of Scotland in the north, and far away to the east, through a gap in the clouds, the gleam of the North Sea.

His ensuing attempt to get back to the earth was not without its comedies. However steeply he dived he was still thrust back to his original height. The normal tactics of side-slipping had no effect, and it was not until he flew eastwards, above the plateau which sweeps back from the crest of the ridge, that he got into air through which he could descend.

The last thousand feet back to earth were sensational, for he was caught by the downward path of the "Helm," and swept in an airy cataract over the crest of the ridge to an unbelievably quick descent and a difficult landing in a field at the foot.

THE GREAT MOTHER

ONE day she will be all smiles, caressing your wings with gentle fingers and tugging playfully at your hair. On another she will become limp like a tired lover or a beauty fallen into a deathless sleep. And then only a few hours later she is a raving harridan shrieking for your blood and having it if you are fool enough to come within her reach.

As I look out of my window in London, I see over the dome of the Albert Hall a massive cumulus—one of her children. The underside is a deep purple and the flanks steeple into the heavens, yellow-stained, rising in successive turrets to a crown of virgin whiteness, a crest noosed in the brilliant afternoon sun. The nursemaids in Kensington Gardens see in it the threat of a shower of rain; the lovers find it peaceful and lovely; the children perhaps look up and see against that dazzling crest the wings of a bird, and maybe they dream a little dream that they can fly and that the cloud is their palace.

None of them recognise it for what it is. None of them recognise from the ground the elfin children of the great mother, even though they may see their outer draperies. But the airman has few illusions. He knows the wild passions which seek to destroy the intruder of such a cloud. For him the noble proportions of this lovely thing are a cloak for all the spite and hatred which the great mother can pass on to her children.

The view which I have of the sky, even from the sixth floor of a block of flats, is by instinct something different from that of others who have never flown. It recognises beauty, but interprets the soul behind it. It is suspicious and calculating. That wisp of cirrus is a fairy world of ice crystals, and I remember how a cloud of them once blew into the cockpit through a panel and transformed the "office" into a little Christmas scene. The smoky bank which lies beyond the cliffs and looks so lovely in the spring sunshine is a monstrous fog which has no pity and no friends. The white balls of cotton-wool growing out of nothing in the blue sky are the happy delights of another day—a period of brisk thermals and good soaring.

The turbulence and the temper of the sky is never fully obvious from the ground. Sometimes the signs are deceptive and one can have a rude awakening. I have been astonished by my own incorrect estimate of air conditions. I remember a sunny morning in October when there was a ground wind of only 15 knots and a lovely sky of high cumulus, when I was seized by some witch of a wind and nearly turned on to my back.

We had been flying at 2,000 feet along the coast, and had just turned out to sea in mildly rough air when, without warning, the port wing received a jolt which might have been delivered by a 10-ton hammer. The opposite wing slammed down to the vertical, and for a second the aircraft was out of control. It was a most unexpected blow, and to this day I cannot account for it. But I have noticed often when crossing the coast on a sunny day how a narrow belt of air along the tide-mark will toss in turbulent distress, especially on the East Coast when the wind is from off the land.

It was on the same day that I was smitten so sorely that I met a fine cloud street. We were on a course which took us across the Sidlaw Hills from Crombie Loch, flying parallel to the marching columns of cumulus which arched their backs across the sky and ran to the horizons parallel with the wind.

Our track took us down one of the lanes between a line of clouds on either hand. The air was no longer so rough as it had been, and I was relaxed, with the stick moving gently under the pressure of two fingers. We were at 3,000 feet—a thousand feet or so under cloud base on the sunny side—when suddenly we began to climb. The indicator rose from its neutral mark to a reading of 2,000 feet per minute without alteration of attitude or of engine revolutions. I had rarely experienced such powerful lift which was maintained for so long. We picked it up over the wooded banks of Crombie Loch, and still felt it at 9,000 feet over the summit of Ark Hill. I had to climb to 10,000 feet before I got out of its influence.

On the way we passed close to the line of cloud on the starboard hand and left its uppermost peaks at 8,000 feet. The average height of the cloud-tops was no more than 7,000 feet,

Opposite: "We could see it coming from afar, a dark shape that smudged the face of the sun" (see page 162).

Three stages in the development of a cumulo-nimbus cloud. (Royal Meteorological Society *photos.*)

Opposite : Night falls and the clouds begin to dissolve. Mr. J. S. Sproule and Flt.-Lt. Murray in the course of breaking the world's endurance record in a Falcon III.

and it was strange to find turbulence extending so high above cloud level.

It was sufficiently remarkable to be worth investigating further, and I turned back and flew down the opposite side of the street. Here at first there was smooth air, but as we came down to the level of the cloud-line a stronger and stronger downdraught required an increasing throttle opening to maintain height. Eventually it was only possible to keep level with the clouds by using full cruising revolutions—and this in an aircraft which had over 1,000 horse-power available. The greatest downcurrent was about halfway down the purple side of the cloud, where we were in deep shade from the thick cumulus above (see Fig. 43).

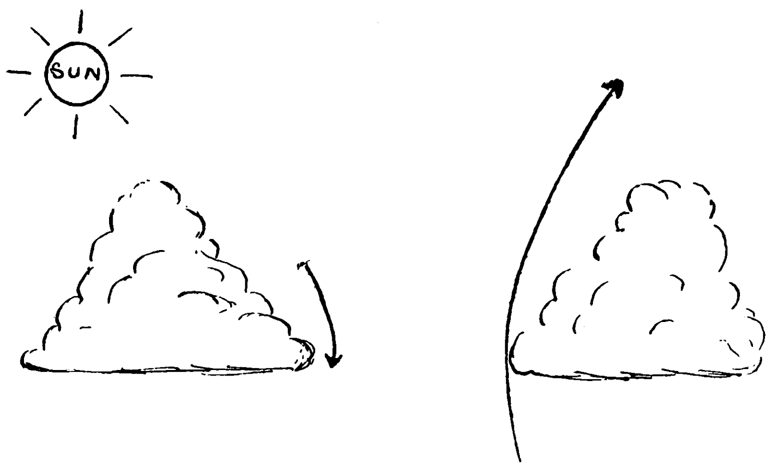


FIG. 43.

On some occasions the expression on the face of the sky is an unmistakable indication of her humour. It can be a challenge which it is a joy to take up, or a threat which it is best to avoid. One's attitude varies with the aircraft which one is flying. A stable juggernaut like a Swordfish will react differently from a featherweight sailplane with sylph-like lines. Yet in a sailplane one will seek out the turbulence which in a power aircraft one would fly round.

A great front swept down on Bradwell Edge on a summer

Opposite : Soaring the slopes of Skiddaw in the Lake District. Photo : Abrahams, Keswick.

afternoon when I was cruising in the company of others above the face of the slope. We could see it coming from afar, a dark grey line that smudged the face of the sun and grew up into a dark wall. As it came nearer it grew darker, and from its forward edge hung a grey apron of driving rain. It stretched from horizon to horizon, a frontal attack from which only retreat was possible.

One by one, in rapid succession, the other sailplanes landed. For a few minutes I couldn't make up my mind whether to follow their example or wait for the monster, climb up its face, and be carried away downwind to be deposited at some unknown destination when the storm blew itself out. My mind was made up for me as the front of the storm advanced. I was picked up like a feather and swirled up a thousand feet in half a minute. It was dark, tempestuous, and savage in its onslaught. The desire to ride with it departed; the thought of being deposited perhaps 50 miles away without money, inadequately garbed, and facing a long wait while some generous soul came to collect me with a trailer, was altogether too depressing. I would land and shelter, and have hot tea in the clubhouse while the rain blasted itself into rivulets against the windows.

It was a matter of seconds to disengage from the toils of the front. I might have dived, but in that tremendous current the insignificant weight of the aircraft would have been as nothing. It was better to run ahead of it, to slip off height in a screaming side-slip, and to dodge back into the landing ground beneath the forward edge of the front. I was only just in time, and as I touched down two stalwarts came running to seize the wing tips and hold them against the gusts.

A cold front, which was only soared in England for the first time in 1931, became a recognised vehicle for cross-country flights in gliders. It was realised that their forward edges were the plough over which unstable air was shovelled. At any point between a mile and a few score of yards from the vanguard of clouds the updraught might be encountered, and from then on it might only be necessary to maintain a relative position ahead of the advancing mass. The nearer to the front, the more violent were the conditions.

There was an Easter meeting in Derbyshire at which a sequence of snowstorms provided the material for many pilots to make their first acquaintance with secondary cold fronts. A strong wind was blowing from the E.N.E., and the sailplanes were taken round to the rugged slopes of Mam Tor to obtain the preliminary hill lift. An elastic launching rope was used, and pilot after pilot was flicked from the brow of the mountain as the storms came over.

One pilot was caught in a snow-cloud and found himself flying blind in furious airs. The cloud rapidly enveloped the crest of the hill, and at one moment a cliff loomed up and flashed past his wing tip. Before long a second extraneous object appeared, this time a sheep. The next moment the pilot was on the ground, himself intact, but not his aircraft.

Mr. Wills made a brave flight on this day. He circled up in intermittent snow to 2,200 feet before switching on his blind-flying instruments and entering the cloud. Circling inside it, he found steady lift of 5 to 7 feet per second. But the snow grew thicker as he went up, and it occurred to him that in such an upcurrent it must be snowing upwards. Somewhere at the level of balance within the cloud there would presumably be a layer into which the snow was falling from both sides.

The snow was so dry that it showed little tendency to stick to the cockpit cover, and inside it seemed warm and comfortable in comparison with the howling blizzard without. The cold, however, was really intense, and the interior of the perspex panels became frosted and the pilot found himself flying blind in the fullest sense of the words.

At 4,000 feet the snow was so heavy that he feared icing up of the wings or the blocking of the pitot head. So he stopped circling and, after difficulty in finding south on the swinging compass, held a steady course so as to get out of the cloud. After two or three minutes of more blind flying a thought struck him, and he scratched a piece of ice off the cover and found that he was already out in clear air at 4,000 feet, with the town of Macclesfield directly below.

Having got his position, he steered back into the cloud and climbed again before setting a westerly course which brought him out over Woodford Aerodrome. Here he had to decide whether to make for his original goal of Blackpool or run downwind for Wales. He decided on the latter, wrongly as it proved. He came down in a practically unbroken downcurrent. At 800 feet the air became extremely wild, and at 400 feet he was caught in another downdraught over a wood, forcing him into a small field surrounded by trees. Slipping in over the tree-tops in a last-second effort to avert disaster, the port wing went firmly into the ground, and that, for the time, was the end of the aircraft's career. It was a fine flight under difficult conditions.

* * * * *

It will be realised that conditions such as these are bound up with the movement of air masses whose origins may be hundreds of miles away. They were referred to briefly on page 88. If the front which swept the cold shoulders of Mam Tor that afternoon was not conceived in the womb of an equatorial disturbance, it was almost certainly related to it. It may now be opportune to follow this out in greater detail.

Around the central belt of the earth the heat of the sun so expands the air by radiation that the ceiling of the Tropopause is lifted by rising air to some 60,000 feet, while for the same reason a band of low pressure lies over the same latitudes (see Fig. 29). Now, it has already been shown that there is a tendency for areas of low pressure to be filled up by an influx of air from areas of high pressure, and on these premises there are reasons for believing that the furnaces of the tropics are the source of the world's air circulation.

In fact as well as in theory a large mass of tropical air flows towards the North Pole, and some of it gets there. A part sinks in the region of latitude 30 degrees north and builds up a well-known high-pressure area, a factor with a large influence on the trade winds. The remainder reaches the world of perpetual ice, where it cools, sinks, grows dense and heavy, and adds its quota to the high-pressure cap already existing over the roof of the world. If this flow from the equator were continued without replacement the eventual result would be a concentration of the world's air supply around the poles and a vacuum round the equator. In fact the descending air over the Arctic builds up such a pressure that from time to time it breaks out in the form of a polar front which drives down from the north to smash through the prevalent westerlies and give rise to the bitter weather which is so well known in this country—even during the summer months.

The middle latitudes are a battleground in which the thrust and counter-thrust of the warm streams from the south strive with the cold air masses trying to break out of the north.

Now streams of air of differing temperatures do not readily mix. They are like oil and water, and apart from the fact that oil and water are not compressible (while air is the reverse), they behave in a similar way. It is thus that air masses will meet and flow past and over each other while keeping a sharp dividing line between their respective boundaries. It is the dividing lines which are of interest to glider pilots, for these

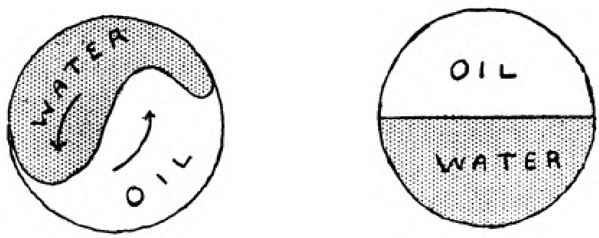


FIG. 44.

are the actual fronts upon which so much depends. The dense air from the north has the characteristic quality of undercutting or sliding beneath the warm air from the south, a point which has already been stressed. To this can be added the known fact that the steeper the slope of the front, the more turbulence will it create along its length. If the advancing cold mass is imagined as the top surface of a wedge, it will be readily understood how a steep face must create a more sudden displacement of the air ahead of it. And it is the cold front that always bears down with the steep edge—an angle represented by a slope of about 1 in 50 as compared with the more gentle slope of up to 1 in 150 associated with a warm front.

Whereas this polar air which bursts out of the Arctic can displace the warm air from the south, the latter cannot in its turn make a successful assault on the cold air in the north. It has not the weight behind it to be successful. On the other hand, it can and does slip round and over it to take the place of the evacuating cold mass.

From the foregoing it will be seen that the boundary layers between great air movements may extend for hundreds and sometimes thousands of miles, affecting the weather over a vast area.

While it is the cold front created by the invasion of polar air into the middle latitudes which is of special interest to glider pilots, there are two other types which have an equal influence upon the prevailing weather. The first is the warm front created by a surge of tropical air which is permitted to enter the middle latitudes by the movement of polar air, the second the occluded front which is the result of a cold front overtaking a warm front—the warm air between the cold masses on either side of it being squeezed upwards. The cloud formations associated with each type differ considerably. The extent to which they differ will in turn be affected by the type of ground over which their respective masses have been travelling, governing not only their temperatures but their humidity. The air mass which has travelled for a long distance over the sea will naturally have a higher moisture content than that which has been passing over a large continent, and the

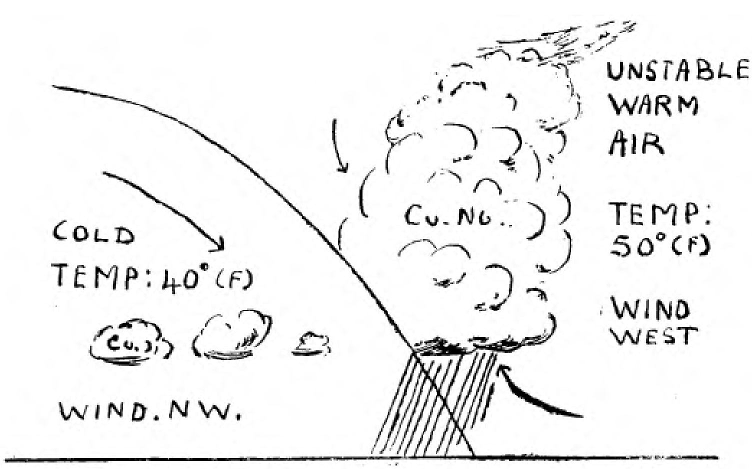


FIG. 45.—*Section through a cold front. Slope 1 in 50, barometer rising, temperature falling, narrow belt of heavy rain.*

result may be a tremendous capacity for the creation of cloud. Similarly, the passage of a continent will tend to keep the air mass dry, and, moreover, give it a second characteristic which is no less significant. Besides being dry, it may initially be unstable, for the sun's heat on the good earth will be radiated, heating up the lower layers by day and maintaining the thermal circulation of which the reader already has some knowledge. Hence, when two air masses finally vie with each other for mastery, the outcome will be affected by whether they are stable or unstable, dry or moist.

From the pilot's point of view, the cold air mass is usually associated with bumpy conditions. It is for ever moving into warmer regions which raise the temperature of its lower layers, and these, rising, carry their moisture with them to condense into cumulus cloud of considerable vertical development. It is for this reason—the reason of the vertical currents so created—that the visibility associated with a cold air mass is usually good. All the factors which tend to reduce visibility near the ground—smoke, haze, and moisture—are carried to great heights and spread through vast areas of space.

On the other hand, the weather of the warm air mass is often less attractive to the pilot. When it is travelling towards the colder regions it may be initially unstable, but its low layers are continually being cooled. Now, cooling air, with warm air above, has no tendency to rise, and the creation of turbulence is eventually hindered. The air current is therefore likely to

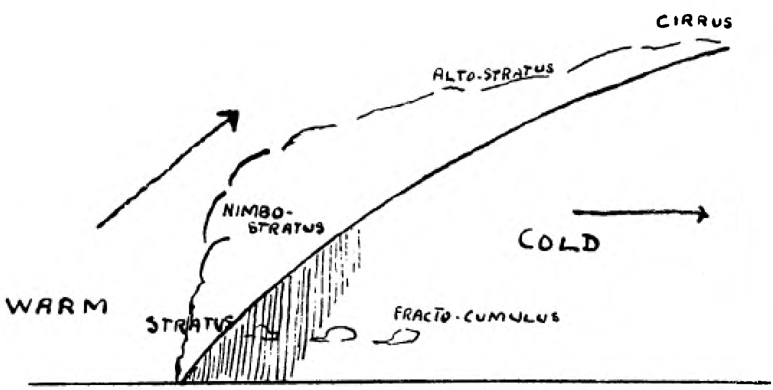


FIG. 46.—*Section through a warm front. Slope* 1 *in* 50, *drizzle, with* 10/10 *overcast.*

become more and more stable, flowing smoothly in a horizontal plane.

Those clouds which form are of the stratus or sheet type—they have no vertical development—while at ground level fog may form, and over the land the soot of factory chimneys will lie close to the earth, held down by the blanket of warm air above.

The weather maps which were once a familiar feature of the newspapers show roughly circular systems denoting areas of high and low pressure. The relationship of these diagrams to the air currents of which we have been speaking may not at first sight be clear. Nor are they usually given in sufficient detail to be of much use to the forecaster. They are, however, the basis of the chart upon which the meteorologist works, and every morning in all weather offices a fully notated map will be drawn afresh.

The circular shape of the systems drawn in over the oceans and continents which they cover is the result of innumerable reports from weather stations in every part of the area, including wireless reports from ships at sea. The barometric pressure, the wind speed and its direction, are the principal bases upon which it is built. Each curving line represents a contour of continuous air pressure, the pressure falling towards the centre of a cyclone and rising towards the centre of an anticyclone. The direction of the wind will be shown in such maps by arrows, and it will be noted that in the northern hemisphere they follow the isobars in an anti-clockwise circuit in a depression and a clockwise direction in a high-pressure area.

But before these maps were ever drawn the system of which they are a picture had to be built up. We are brought back once again to the meeting between two air masses, and it is not difficult to understand how a circular motion is imparted. Leaving aside the characteristic of one mass to climb or slide beneath another mass, there is the adjustment which will take place in the horizontal plane. If you could imagine a pool of water lying on a sheet of glass being propelled into contact with a pool of oil lying adjacent to it, the tendency for one to flow round the other, thus initiating the circular movement, will be understood. It is at this point that the birth of the low- or the high-pressure system takes place, and it is diagrammatically illustrated by Fig. 47.

At "A" the two masses of air are coming into contact. For the purpose of illustration they have been shown moving in opposite directions, although this condition is not at all essential. The growing extent of the boundary between them will mark the line of the future fronts.

At "B" the boundary has been kinked; its apex is lying in a newly forming area of low pressure. The air is developing a circular movement, and already the first signs of a cold and warm front are marked along its edges, while the cloud formations associated with their respective conditions will be building up. In the small diagram on the right a cross-section of the system shows how the warm body of the air is becoming enclosed by the cold masses. This area is called the warm sector.

The system has developed still further at "C." The kink is now sharply defined, and at its apex the barometer is falling rapidly. It will be seen how the cold air is circulating to the left, coming round to stab the warm air in the back. Along this line, marked X in the diagram, cold-front conditions with heavy cumulus cloud will now be evident. If the warm sector itself is unstable, cumulo-nimbus may be expected. It will be noticed how the lines of equal pressure flatten out through the warm sector, the winds following a straight path. At "Y" the warm air meets the back of the cold air, and along their line lies the warm front, with low cloud and possibly rain or drizzle with a sharp veer in the wind. The sectional diagram shows how the two fronts are growing together owing to the faster movement of the cold front.

At "D" the system is fully developed. The sectional diagram shows that the cold front has now caught the warm, and that the two are about to become occluded. The old warm sector, that part belonging to the original warm air mass of "B," is just about to be squeezed into the upper atmosphere. At "E" this process has been completed, and the remains of the original fronts may be expected at X and Y. They will be weak and in the process of dissolution.

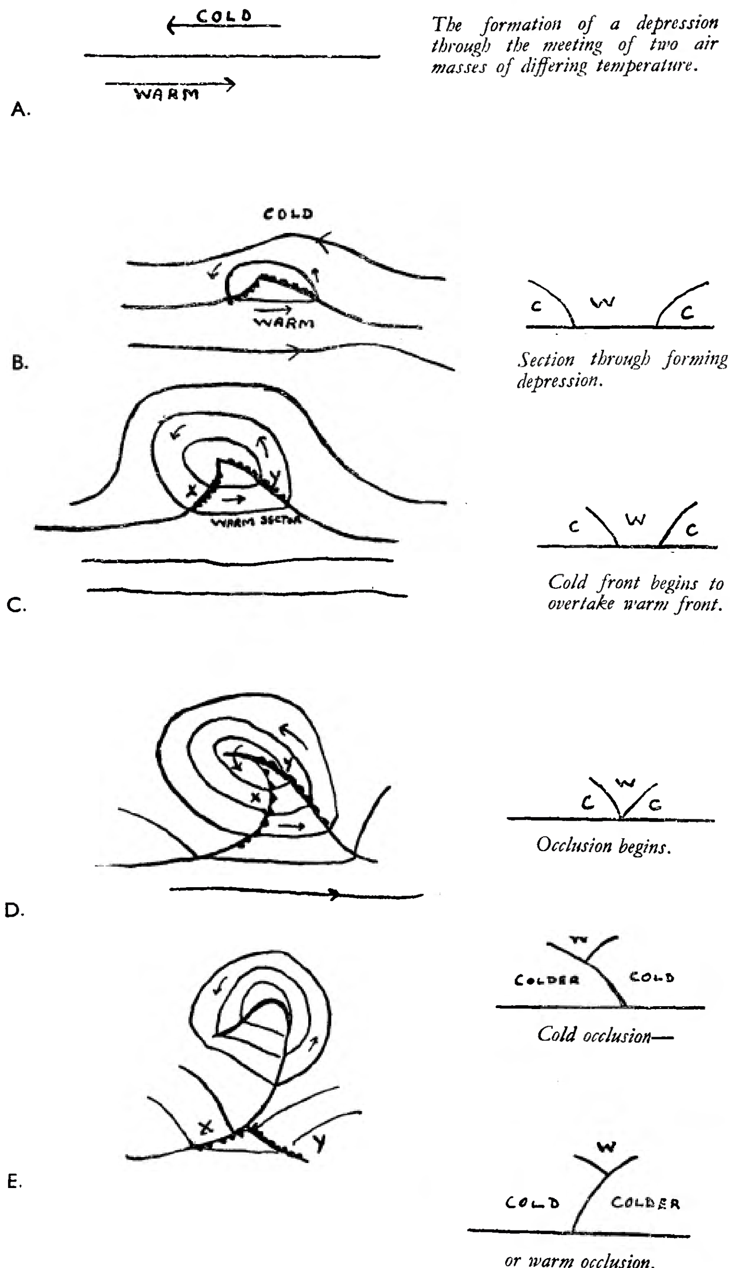
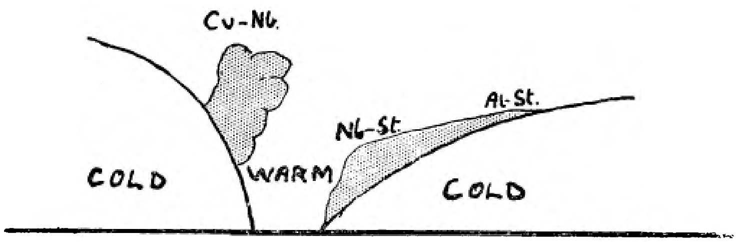
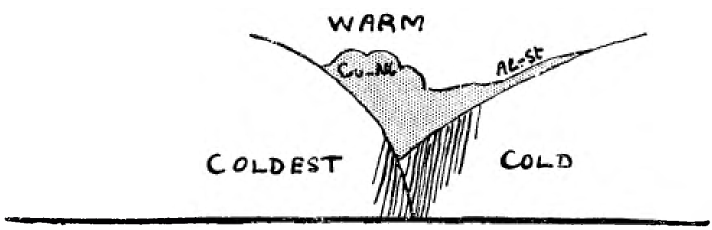

COLD
WARM
A.
The formation of a depression through the meeting of two air masses of differing temperature.
COLD
WARM
B.
C W C
Section through forming depression.
X
Y
WARM SECTOR
C.
C W C
Cold front begins to overtake warm front.
X
Y
D.
W
C C
Occlusion begins.
E.
X
Y
W
COLDER
COLD
Cold occlusion—
W
COLD
COLDER
or warm occlusion.

FIG. 47.

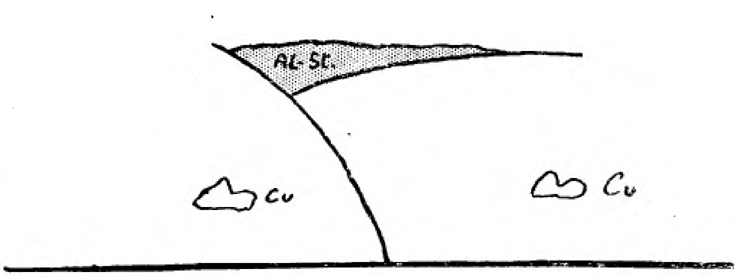
The character of the occlusion will not always follow the same lines, for its occurrence brings into contact the two bodies of cold air which were previously separated by the warm sector. If the cold air which was behind the warm sector is colder than that which was ahead of it, then all the conditions necessary for a second cold front exist, and the result will be what is known as a cold occlusion. In this instance cloud base is likely to lift, although the clouds will not retain the turbulence of the original cold front. Alternatively, if the cold air behind the warm sector is not so cold as the cold air ahead



Cold front overtakes a warm front



and becomes occluded,



finally deteriorating with a clearance of the weather (cold occlusion).

FIG. 48.—*A development of Fig. 47, showing the associated cloud formations.*

of it, the approaching mass will climb up over the mass ahead and form a warm occlusion. Accompanied by a veer in the wind, nimbo-stratus with bad visibility and heavy rain may be expected. The new conditions are no better and possibly much worse than those originally existing at the face of the warm front before the sector was lifted.

A little later the old warm mass may still be in existence at a great height, where it may form a continuous layer of stratus cloud. By this time the decay of the whole system may have set in. The area which it occupies may now be assaulted by a new and more powerful system, one which may take its place, but whose characteristics may be influenced by the remains of the old.

This is one of the reasons why there may be several distinct cloud layers at different heights, presenting a confused picture which it may be difficult to diagnose.

The anticyclone is the child of very different circumstances. It begins by the descent of an air mass through the air below it, piling up the pressure in the centre of the column and gradually forcing out the bottom layers round the edges, just as water round the perimeter of a circular fountain may overflow. The descending air is always dry, and although it is cooling (hence its descent) it does not give birth to much cloud. At some point above the earth a clearly defined inversion may be established below which haze created by smoke and moisture can reduce visibility at ground level to a mile or two. Above the inversion, marked by a dark line for the flier, visibility is extreme and the sun shines in a cloudless sky.

In winter, when the lower layer of cold air next to the ground may be very wet, fogs may form or at best those murky conditions popularly known as anticyclonic gloom may cast a pall over the whole earth.

Anticyclones which cover a big area take a great deal of moving. They resist the onslaught of other systems and smother them at birth. In their centre the winds are light, although round the edges there may be a stiff breeze, and if this has passed over water it may be the parent of considerable cumulus. The anticyclonic conditions often discovered in spring over Great Britain can bring down cold air from

Scandinavia which in its passage across the North Sea can become sufficiently humid to create on the boundaries of the system big banks of cumulus and cumulo-nimbus cloud which will have great turbulence.

The theoretical considerations of the previous pages will have practical manifestations which should be observed by the glider pilot—and at the risk of repetition I shall refer to them again in writing of the manner in which they can best be flown. In the meantime a brief summary of the outward and visible signs of the two principal types of weather will not be out of place.

As has been implied, the approach of a warm front is heralded by the cloud sequence in the sky. Initially cirrus is seen moving towards the observer at a great height from the direction of the front, to be followed by cirro-stratus as the warm air climbs up over the cold below it, cooling, sinking, and thus forming these high clouds of the advancing depression. Then gradually the sky becomes covered by stratus clouds at successively lower levels. At first they are only thin and the bright light of the sky shines through them. But as the centre of the depression approaches they become piled to great depths, and at the point where the front reaches ground level the whole cloud layer, now thousands of feet deep, will hang a few hundred feet above the ground, and may even be down to ground level. Rain, drizzle, and hill fog will possibly complete the picture of misery, and will persist until the front gradually passes (see Fig. 46).

Alternatively, the approach of the cold front is denoted not only by fall in temperature, but by the formation of deep cumulus clouds in the warm air immediately ahead of it, the front itself possibly developing into a great wall from whose ragged base sheets of heavy rain are falling. Once they have been recognised, it remains only for the pilot to make up his mind how they can best be used. To this end he must develop his cloud sense and by experiment discover for himself the most effective and the safest way in which he may harness the upcurrents which some of this weather will bring. Advice to this end is given in the following chapter.

CLOUD SENSE

IF you penetrate deep into the kingdom of clouds when they rise in tumbled ranges to heights of over 15,000 feet, you can feel small and lost and ignorant. You may enter the kingdom by a doorway through which a shaft of sunlight falls, claw your way up the sides of purple ridges, charge through castellated domes into steeper valleys, and, looking up, find the walls meeting at the top of a canyon thousands of feet overhead. The ground is nowhere in sight; you are a timid explorer in realms of whose welcome you have increasing doubts.

I remember a day when range upon range was revealed momentarily through a brief window, putting the nose of a Hurricane through the gap. It had been cold, with a yellow watery light down below. Changing into fine pitch and opening the throttle, I shot upwards at nearly 3,000 feet a minute, to discover myself in a great valley, itself roofed by more clouds through whose clefts a pale light filtered. But along the valley was what looked like a mountain pass, a grey-white shoulder with a brighter light beyond it, and, still climbing, I came into a country of Himalayan proportions from which the sky was hidden by leaning peaks.

With the Merlin engine turning over at 2,600 revolutions, thousands of feet were reeled off on the altimeter. We dodged between dark walls, twisted round great outcrops, and finally plunged nose first into a solid bastion of something whose proportions could not be estimated. In the increasing darkness the air became hard like cobblestones. The wing tips of the Hurricane, just visible on either side, seemed to judder like the mudguards of a car. The hood of the aircraft was still open, and the cold air came in like a blast from a glacier, and simultaneously I began to wish that my exuberance had taken me to more congenial places. Then without warning we burst out into blazing sunshine, with peaks of blinding whiteness rising on all sides, and the whole great range stretching away in 15,000-foot summits to the horizon. Climbing level with a crest, I throttled back, plunged the Hurricane into the recesses of a gorge, hurtled into gloom for many hundreds of feet, and pulled back the aircraft into a loop. The castellated turrets revolved about me, the blinding white crests, the glaring sun, and the vault of the deep blue sky; and then on my back I was looking into the gorges of the lower foothills, closing into gloomy valleys through which I should eventually have to break. So I went over, and down again, and smashed through the flank of a peak at nearly 300 m.p.h.

It was very childish and very exhilarating. It was a momentary realisation of those ambitions to which insignificant man has aspired from his humble place on the ground. It was only when I began to look for a hole through which to descend that I attained a more respectful attitude. There were no holes. The bottoms of the gorges were closed, and I should have to plunge down like a discredited angel out of heaven.

I never like descending through cloud, particularly when the descent may have to continue through many thousands of feet of heavy cumulus. Wild airs can blow inside, ice can sprout on the wings as if by magic. However, there was no other way of returning to the comfortable world of mankind, and after trimming the aircraft so that she was losing height at 1,500 feet a minute at a speed of 160 m.p.h., I flew down a gorge and eventually penetrated its floor. With eyes glued to the artificial horizon, I held her on a course through a sea of wild currents alternating with strangely smooth patches. It began to get warmer, and also darker. The sting of rain lashed the windscreen and froze in clear, transparent rivulets. Slithers of ice gathered on the wings, but long before it reached alarming proportions we were cleaving through a brighter patch, a brightness which increased as the cloud thinned, till we burst into clear air with the ground visible between the twin rumps of another cloud 5,000 feet below. Putting the nose farther down, we screamed earthwards like a hurrying prodigal. The black gloom of a town took shape over the nose, and then, clearing the last rim of the lower clouds, the whole earth was opened up, with the friendly coast studded with bays and the lick of the sea on the shore.

I should not have known how to interpret those masses through which I had passed in terms of gliding country. They were too big, not necessarily in a meteorological sense, but too big for my timid spirit. When I have talked of the spiritual manna of the heavens I have often implied too much. They would have been spiritual poison for me that day, though there are many pilots of greater appetite and courage who would have been prepared to seek for a way through. In a powerful aircraft with a high rate of climb and a full set of instruments there was nothing in such a voyage of exploration—a minor risk of icing, a prospect of a rough ride, but nothing more. In a sailplane it would have been a voyage of adventure.

Maybe the clouds would have been difficult for a sailplane. They were so jumbled together, so confused, one layer piled on top of another, with gloomy spaces in between, that a glider pilot would have found little guidance. I suspect that I had been flying through a big front which was rapidly becoming occluded and degenerating into a thick lifeless blanket from whose lower stratas rain would eventually begin to fall.

In thinking of clouds one must develop one's sense of their meaning from simple beginnings. We go back to the little cumulus which grows in a summer sky—the first evidence of convection—of warm air risen from some field or village. The presence of its little cloud overhead is evidence for the airs upon which the sailplane soars.

I have said elsewhere that the early morning is too soon for their birth, but they will germinate as soon as the sun warms the earth, to die and dissolve again as the first chill of evening steals over the land below.

If thermals could be stained like germs on a microscope slide, they would no longer be difficult to detect. As it is, the pilot who is waiting to take off has to rely on slender evidence of their presence. Probably the sign is so insignificant that it would pass by unnoticed to anyone who was not looking for it.

On a good day a thermal will build up—to form eventually a little cloud—over one particular place at regular intervals. I have already described likely places—but whatever the source, its growth and release may be quite regular over a period of

Opposite.—Top : Perfectly developed lenticular cloud banks in hot, squally weather.

Bottom : Fair weather cumulus forming in light winds as the day advances.

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page 160.)

hours. When such a place is within reach from a hill-soaring site, it may be explored repeatedly until a sense of its timing is acquired. The first pilot to utilise it will discover it by chance, but other pilots who follow, by flying out from the ridge over the active ground, will, by trial and error, learn the time intervals at which the release occurs. Thus a single field may in the course of a day provide the link between the earth and the clouds for a dozen different aircraft at a dozen different times. The frequency of the thermals can vary, but in my experience they recur over any particular place at between five and twenty minute intervals.

Other scraps of evidence can often be found on hot, calm days. Under these conditions the wind sock will be hanging limp until the moment a nearby thermal breaks away. Immediately afterwards a little breeze will spring up, created by the airs which move in to take the place of the rising bubble. These will momentarily stir the sock, and if the launch can be timed to coincide, the chance of picking up the bubble is a good one. An accurate sense of timing is needed because the sailplane will have to be launched from ground level, as the lack of wind will be insufficient to keep it in flight over the soaring ridge. There is perhaps a period of three minutes available from the moment the wind sock stirs to the moment when the pilot must be 300 or 400 feet above it. Unless the aircraft is ready the chance will be missed.

On a cross-country flight the same type of evidence is sometimes forthcoming from factory smoke which rises suddenly in a vertical column. Not only can this be seen from a distance, but it is a certain guide to the whereabouts of the upcurrent.

Two miles north by east of Dunstable there is a 400-foot chimney from which gases at a temperature of over 300 degrees F. are released in a perpetual white cloud. The smoke is not only a guide to thermals which may happen to drift across, but a producer of thermals on its own account. A series of experiments were conducted as a result of two flights made in 1938

Opposite : Typical orographic cumulus taken at 6,000 ft. over the Grampians. The damp air from the sea has been forced up to condensation level by the high ground. (*See also Figs.* 51 *and* 52.)

when a pilot found lift inside the smoke up to 3 feet a second—a result which meant that the gases were rising at a minimum of 6 feet a second after allowance had been made for the natural sinking speed of the aircraft. The possibilities of using the chimney as a sort of moving staircase appealed to members of the Imperial College and the London Gliding Clubs, even at the risk of asphyxiation.

The opening at the top of the chimney was 10 feet across, and through it 120,000 cubic feet of gas was passing every minute. Calculations showed that it was possible for a thermal current to be generated which would be large enough to support a sailplane turning in circles of 250 feet diameter. This area would represent about 300,000 cubic feet—or 150 times as much as was coming out of the chimney. Dilution of the smoke would therefore have to be taking place to this extent. The proof of the pudding was found in calculation of the loss of heat sustained by the smoke between leaving the chimney and reaching a dilution of 150 times. The answer was that the diluted mixture remained approximately 1·8 degrees F. or 1 degree C. above the mass of surrounding air.

Now, it has been shown by other experimenters that a difference of 1 degree C. between two bodies of air is sufficient to set one of them in motion—provided that the warmer body is not held by viscosity to the ground. As the top of the chimney was 400 feet above the surface, there was never any question of this, and the premises for soaring the smoke were established.

On the day on which further trials took place a 25 m.p.h. wind was blowing from the north-east. An observer was posted on the top of the down nearest to the chimney, and gave by signal to the pilot of a waiting sailplane the information that the smoke had changed its drift from a horizontal plane to a steeply slanting ascent. After waiting 4 minutes in order to allow time for the disturbance to drift the 2 miles to the gliding site, the sailplane was launched. The result was an elongation of the normal glide to earth from 3 minutes to 10 minutes. At one moment the pilot was neither gaining nor losing height, suggesting that the upcurrent had a speed of at least 3 feet a second.

It was noticed that as the thermal arrived the wind suddenly dropped and then blew in gusts until it had passed. It would appear to be within the bounds of possibility that more experience might lead to the use of such a chimney as a reasonably certain agent for lift from this site in a north-easterly wind. The conditions prevailing at the time were anticyclonic and the lapse rate was probably low. With a high lapse rate and more natural instability, it is probable that the initial velocity of the diluted gases would be given additional impetus, either creating a thermal entirely of their own or adding to one which had broken away immediately below.

My wartime flying job often took me across the Highlands, and when the heather was being burnt in the new year a similar phenomenon was noticeable. In most instances its characteristics were most marked, disposing at least of my own doubts on the possibility of artificial thermals. When the visibility was good one could see the smoke of a fire 20 miles away, and if it lay more or less in the direction I was steering I would usually investigate it. Not once, but on half a dozen occasions I have watched the smoke which lay flat over the moor suddenly rise up until it connected earth and sky like a waterspout. At the top of the column it would sometimes mushroom out to form a flat-topped smoke cloud, no doubt the result of a temperature inversion. The column itself was always unstable, and although its diameter was never great enough in which to circle a large-power aircraft, there is no doubt that a well-handled sailplane could have remained within its influence. Burning heather has a peculiar acrid smell, not unpleasant when it is diluted, and invariably the strong scent seeped into the cockpit, to oust for a moment the perpetual whiff of hot oil and petrol.

Whether the smoke itself was the sole cause of the thermal is extremely doubtful. This was a case in which the air round about the advancing line of fire—probably behind it—was gathering its heat for a spring off the ground, finally boosted by the fire itself. Colour is lent to the theory by the way the smoke would sweep into a circular column almost immediately it left the earth—although a moment before it lay along a line of burning heather quite 100 yards long. It was as though the air was being drawn inwards to feed the thermal of which the smoke was the core. In theory the little system thus created should have been revolving slowly in an anti-clockwise direction—a point which I could never establish.

After a few minutes the column would break off at its base, leaving what remained to rise slowly to the upper cloud, while the wind lay a new bar of smoke parallel to the ground. It would have been interesting to have timed how often the process was repeated, but the King's business could never wait long enough.

Many pilots have, of course, discovered a thermal above somebody's garden bonfire—often at a desperate moment of a flight to avoid a forced landing. These and the factory chimneys and the moorland burnings are all of the same family. In this connection I put forward the suggestion that a smoke candle kept burning on a soaring site would be worth a mint of some other kinds of hot air—not that the candle would produce a thermal itself, but because it might act as thermal indicator when the genuine article was born in the immediate neighbourhood.

Apart from smoke, however, an appreciation of the contours of the ground is an extremely useful guide. The side of a hill which is shaded from the wind but heated by the sun is a hot-bed of thermals on a day when the lapse rate is high. Such a place would be the south face of a hill at noon when the wind was from the north (see Figs. 27 and 34).

Mr. Dudley Hiscox made a practice at Dunstable of taking a winch launch at the moment when everyone else went in to lunch. It is a curious fact that he frequently picked up a thermal immediately after releasing the cable, and it happened so often that there was a strong suspicion that the passage of the aircraft and the cable to which it was attached was capable of unsticking a globule of warm air which had been collecting on the landing field itself.

From a height of 200 or 300 feet the capture of lift is achieved by smart handling of the aircraft and by good judgment. The area of the thermal low down is small: it has not had time to expand and acquire the acceleration which will be given it as the warm air rises into colder stratas. Hence the rate of circling made by the pilot is additionally important, and associated with this is the deteriorating performance of the aircraft at increasing angles of bank.

It has been calculated that for an intermediate type of sailplane the rate of sink in a turn increases from approximately 3 feet per second for a 20-degree bank to 20 feet per second for a 75-degree bank, and that during the same period the stalling speed has risen from 28 m.p.h. to 55 m.p.h. Before trying to assess what is the best rate of turn for any particular thermal, the following table provides striking evidence of the importance of this consideration.

Angle of Bank. (Degrees).	*Speed of Stall (m.p.h.).*	*Rate of Sink (f.p.s.).*	*Minimum Safe Speed (m.p.h.).*	*Radius of Circle (feet).*
20	28	2·8	31	200
30	30	3·3	33	105
45	35	4·5	37	85
60	39	8·0	43	70
75	55	20·0	60	65
85	90	?	?	60

A curve can be plotted for a typical 45-foot span sailplane such as would produce the figures in the above table, showing the radius of its circle with varying degrees of bank. The results are printed in the right-hand column, and they suggest that an angle in excess of 45 degrees is uneconomical.

Now, it has already been remarked that the diameter of the ordinary thermal may be small during the first few hundred feet of its ascent, and to this may be added the supposition that the strongest part of it lies in its centre. If, therefore, the thermal is contacted close to the ground, it follows that the tighter the circle which can be flown the better the upcurrent. In practice this doctrine is subject only to the limitations of the table of the rates of sink.

The flying man's definition of a tight circle varies, and those who have been accustomed to rate 4 turns in a Swordfish, or turns in a Spitfire which are limited only by the amount of G which the pilot can stand, will need to adjust their ideas. They will, however, appreciate that the tighter the turn the greater the wing loading and the higher the stalling speed. It will be clear to them that aerobatic turns for gliders in weak thermals have their disadvantages.

In practice a 30-degree bank is the ideal for most straightforward thermals. At this angle the stalling speed has only increased by 3 or 4 miles an hour over that for straight flight, while the rate of sink at the best flying speed has gone up by less than 1 foot per second.

When a thermal is strong but very small in diameter there may be a reason for tightening the turn up to a maximum of 45 degrees. The radius of the circle is thereby reduced by another 20 feet, which may be invaluable, whereas the rate of sink is still only about 2 feet per second above the best for a straight course. At all angles above 45 degrees the efficiency curve rapidly falls away, while the radius of turn is not substantially lessened. On the other hand, unless the thermal has broadened out, a bank of only 20 degrees will result in a 200-foot circle, which may well mean that the aircraft is flying round its perimeter and therefore in its weakest area.

As an interesting comparison, the safest angle of bank for a pilot making turns in cloud on a radio beam is 15 degrees, while the maximum angle for an ordinary blind-flying turn should not be more than 30 degrees.

In power aircraft the effect of the steep turn which has been shown in the foregoing figures for sailplanes can be demonstrated dramatically. Flying a small civilian type of aircraft before the war, I found that the wing loading was so increased by an angle of bank of approximately 80 degrees that the maximum speed as shown on the A.S.I. was reduced for full throttle from 160 m.p.h. to 90 m.p.h., and in attempting the same rate of turn a second time the aircraft went into a spin at a fraction below this speed. The stalling speed for level flight was less than 60 m.p.h. The moral is obvious.

From the point of view of the sailplane pilot it is clear that sufficiently tight circles to remain within the diameter of a small thermal close to the ground are impracticable. In fact, unless one is over a landing field of unquestionable merit, such as one would enjoy on picking up a thermal immediately after a winch launch, it is advisable to look for a safe landing-place as soon as height is down to 500 feet—and even this may be too late in rough country.

On the other hand, when a good thermal is encountered its presence and character make themselves abundantly plain. The smooth air gives place to restless eddies, for which the first sign is the surge of the variometer and the clear sensation of pressure beneath the seat. It may almost immediately disappear again, but the air will remain unstable while the variometer alternates rapidly between a rise and fall. The problem then resolves itself into remaining where you are by circling. A guess will have to be made as to whether the main body lies to the right or left, and if a wrong decision is made you will fly out of the rising air, when the chances of finding it again will be small. If, however, you happen to strike the thermal at a tangent you may be able to detect—as some of my friends claim—the effect of the lift on one wing before the other. A better guide is the ground immediately below, for the probable source of the thermal, taken in conjunction with the direction of the wind, should indicate where the centre lies.

I have felt that some soaring artists have developed a sixth sense which short-circuits the necessity for reasoning or guesswork. It is a fact that some pilots never seem to turn away from the magic upcurrents.

When the thermal is met at a thousand feet or so, the immediate decision is less important. By this time the bubble has spread out and gained appreciable acceleration. A turn in the wrong direction can sometimes be rectified before contact is lost, and the pilot can edge back into the centre of the disturbance. At this stage the speed of the rising air may be anything between 5 and 15 feet per second and the diameter of it several hundred feet. In extreme conditions, when cumulo-nimbuses are forming instead of the little cloudlets which are born of individual thermals, the vertical speed may be even greater. Under these conditions hot, damp air from the ground can rise at velocities up to 30 feet a second.

I have digressed from the formation of early cumuli to write of the ways in which they may be used. This has rightly discredited the visual evidence of the useful existence of thermals as shown by small clouds. By the time the cloud forms the bubble is too far away. It has completed most of its journey, and the cloud itself is merely a sign of its past life. Moreover, a thermal which consists of dry air may never reach a height at which its small moisture content will condense, and under such conditions there is no visible evidence to denote what has happened. The drier the air, the higher the cloudlets must form—but very few thermals do not reach their equilibrium before they have risen to 5,000 feet, and to do this—under ideal conditions—a temperature difference of some 7 degrees F. at ground level is required. It is seldom that a thermal will remain undisturbed on the ground while it appreciates such a temperature. It is more likely to rise after an increase over its surroundings of 3 or 4 degrees and perhaps less.

At the lower end of the scale, in moist conditions, I have not personally encountered useful thermals if the convection clouds were forming at less than 1,500 feet above sea level.

The young cloud of the morning is not, when you reach it, of great use to the pilot. Its cotton-wool folds are comparatively stable, while its size is too small for continuous circling. If, therefore, you reach such a cloud on its own thermal, it is best to head across country, losing height as you go, but keeping a watch for new thermals by which you can take a step back to heaven at the earliest opportunity.

In rapidly developing cumuli in which there remains a substantial temperature difference between the thermal and the surrounding air after the dewpoint has been reached, and in the cumuli of the cloud streets formed along the wind-shaded but sunny side of a line of hills, there is a persistence of turbulence and frequently evidence of additional thermal feeding. The clouds continue to grow, and the pilot on the ground may still not be too late to pick up a feeder. But at this stage the day is well advanced, the radiation of heat is at its maximum, and there is evidence in plenty that the conditions are favourable. The clouds which were only 200 feet in depth may have swollen into bulging domes rising for several thousand feet. The latent instability of the atmosphere has been touched off. Finally, great clouds may be scattered down the sky, sailing with the wind across a blue sky. From this moment there will not merely be lift beneath their keels, but strong vertical currents within their folds. A glider pilot may find in one part currents which will take him up at 20 feet per second, and in another currents descending at no less a speed. The bigger the cloud, the more extreme the turbulence, until in cumuli of great vertical development—rising to 10,000 feet or more—the airs may be tempestuous in the extreme. The danger from such clouds is not the vertical wind speed itself, but the rapid changes in its direction. As I have said, airs rising at high speed may lie next to others descending at no less a rate. If an aircraft passes from one to the other in the space of a few yards, the strain can be overwhelming.

Experience, together with the type of sailplane which is being flown, will teach a pilot how far to go and when discretion is the better part of valour. His own skill will, too, contribute in large measure to his safety. If he can succeed in maintaining control while flying blind in circles, however rough the air, he will be justified in going farther than the man whose skill with his instruments is less, and who may unwittingly allow his aircraft to gain a dangerously high speed or a dangerous attitude. When beset by violent airs and in danger of losing control, it is advisable to centralise all controls and to steer a course out of the side of the cloud—and to this end it is well to remember the shortest compass course to steer. I once so hopelessly lost track of the instruments that in desperation I pulled the stick gently back and, putting on full rudder, endured the sensations which followed until I emerged into clear air in a spin. So drastic a remedy has its compensations, in that the aircraft while spinning has the highest possible rate of descent consistent with the lowest practicable speed. The strains thus imposed are comparatively small.

It is from the great cumulus that the greater cumulo-nimbus develops. Generally, the ordinary cumulus which has great vertical development with black patches under its base, sometimes ragged edged, sometimes spewing out long sheets of rain, can be classified as cumulo-nimbus.

These are the clouds which the pilot will only enter after forethought—and not without a parachute. If he is determined to win height, is prepared for a rough ride, and possibly icing, he will carry on. If to the summit of the cloud there is a fibrous cap spreading outwards (commonly supposed to be in the shape of an anvil) he will give it a wide berth. From such formations spring the thunderstorms, and below them—in the lower two-thirds of the cloud—some of the most violent currents to be found in the sky.

The lightning itself owes its birth to powerful gusts of up-draught which break up big fast-moving raindrops and carry them back into the centre of the cloud, where once again they start to fall as small droplets. Each time the process is repeated, each time the drops are split, positive and negative charges of electricity are separated, the negative associating themselves with the air and the positive with the water. Finally, great differences in potential are built up within the system until the dielectric can no longer withstand the pressure and the charges are released in a flash of lightning.

Hailstones may circulate in a similar way and grow larger with each circuit until sheer weight causes them to fall out of the cloud. They will show the rings of their growth if cut in half like a felled tree.

The technique of riding the storm belongs to the expert with a sense of adventure and to whom a parachute also belongs. Figure 49 shows the possible direction of air currents in a fully developed cumulo-nimbus, and they suggest that the pilot should approach it from its forward edge. The roll cloud itself may or may not be present, but it is easy to recognise as it revolves like the bar of a standing wave. (It is usually associated with frontal thunderstorms.) It is an area to be avoided, for its turbulence will be considerable and comprised of up and down draughts lying close together which will form a severe introduction to a flight which, in any event, is likely to be rough.

The broken cumuli ahead of the storm are more considerate trifles with which to flirt, and it is possible that an upcurrent will extend beyond them up the face of the massif. There is a tendency for the whole air mass for a considerable distance ahead of a frontal as opposed to a convection storm to rise,

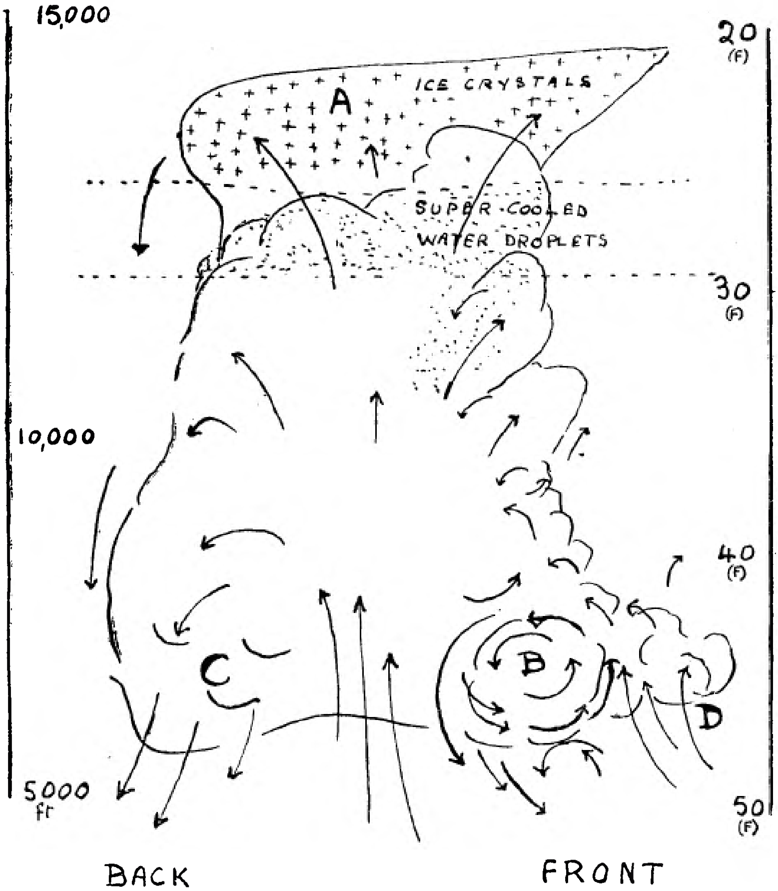


FIG. 49.—A=*Anvil* (*ice crystals*), B=Roll *cloud* (*extreme turbulence*), C=*Mammatus* (*downdraught, rough*), D=*Advance cumulus clouds*.

and incidentally for the direction and force of the wind to alter as the front passes.

In any event, the pilot may be certain that the "cauliflower" heads which grow out of the front wall are the creation of powerful upcurrents, and that within their folds will be areas of substantial lift, even though they may be punctuated with areas of less lift and with downdraughts.

This is not an easy part of the cloud to ride, but it has the charm of being close to safety in the event of a wish to withdraw. It is even possible to circle up the face partially in cloud and partially in clear air, although the differential forces of the currents are not conducive to pleasant flying (see Fig. 50).

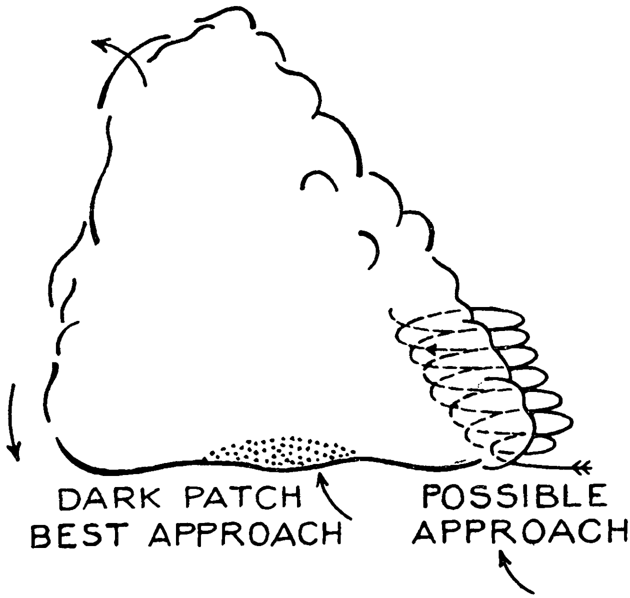


FIG. 50.

Alternatively, there is usually a patch in the base of the cloud darker than the rest, as though someone had spilled a bottle of ink inside it. It is a forbidding-looking place to the glider pilot circling up from a thousand feet or so below, but it is a winner nine times out of ten. I have used the power and stability of a service aeroplane to prove it on several occasions. Downdraughts will give place to a powerful suction in the inkiest part of the roof overhead, suggesting that there is a funnel effect extending a long way into the mass. On most occasions it seems to cover a sufficiently broad area to provide a fairly constant lift without undue turbulence.

Many pilots have noticed how the base at this point is no longer flat, but in the shape of an inverted bowl round whose sides one flies with an ever-decreasing view of the world below. When the bottom of the bowl is reached the lift seems to increase progressively until one is snatched into the womb of the cloud, climbing in broad circles at anything up to 30 feet a second.

There are few British pilots who have carried cumulo-nimbus flights to their logical conclusion, and I am not among them. But there is evidence to suggest that a sailplane which perpetuates its circles through the central darkness will probably remain in the funnel-like current to be shot out of the cloud-top many thousands of feet above the base. Mr. Wills has found it prudent to leave the updraught as it grows increasingly rough towards the crest. My own limited experience prompts the suggestions embodied in the chapter on blind flying as precautionary measures. But to these may be added the problem of icing—one which is inevitable in any cumulo-nimbus which has attained sufficient height to pass the freezing level. (The anvil or cirrus scarf above the crest of the cloud is evidence of this.) Moreover, the variety of icing may be of the virulent type which builds up rapidly along the leading edges of the wings, blocks the pitot head and robs the pilot of the A.S.I., and ultimately freezes the controls. There is nothing to do about it except to set a course out of the cloud as soon as possible. De-icing equipment has not yet been fitted to sailplanes, and is not likely to be fitted on account of its weight—although a coating of anti-freeze grease might be effectual under mild conditions.

The area which is usually not of interest to the sailplane pilot lies towards the back of the cloud. Reference to the diagram illustrates the tendency of the downdraughts to concentrate at the rear of the storm. The presence of Mammatus clouds whose dark lobes often adorn its sides is another indication of downcurrents, and they are usually of very considerable turbulence. While simple enough to suggest diagrammatically, they may be less easy to diagnose at close quarters. Indeed, as I have said elsewhere, the proportions of this class of cloud are so great that positive identification of any part of them is frequently impossible from the air. The "cauliflower" protuberances, which look so small when seen from the ground 10,000 feet below, become domes five times the height of St. Paul's when viewed close at hand. Their overhang hides the noble proportions of the edifice which lies beyond, and beyond that again to the ultimate turrets.

Under conditions of extreme thermal activity, abetted by a lack of wind, a high lapse rate, and great heat, a number of cumulo-nimbuses will grow together, forming ranges of cloud beside which the biggest mountain masses are dwarfed. But as the sky becomes completely overcast the heat of the sun will be cut off from the earth and the fuel for the bonfire will, as it were, be withdrawn. After a brief existence the whole system will then begin to decay. The tops will fall in and the noble mass degenerate into a thick layer of inactive cloud which will gradually clear.

It will have been noticed that the proportions of these cumulo-nimbuses are less pretentious during the winter—and the reasons can be found in the restricted radiation of the earth and the lower freezing level. Moreover, at this time of the year the boundary of the earth's weather belt—the Tropopause—is substantially lower, blanketing the possibilities of extreme vertical development, just as at the Equator the opposite tendency permits cloud development up to 60,000 feet. Similarly, in winter it will be observed that all clouds have a tendency to form lower down, the result of the combination of cold air and the greater moisture content of the atmosphere.

But, summer or winter, there is no moment during the process of either development or decay that a cloud is static. It is either growing or decaying, and a period as brief as 10 minutes may see substantial changes. The birth, growth, and dissolution of a small cumulus may be encompassed in no greater period, while even the fierce mien of a cold front at the point where it reaches the ground will not persist indefinitely as it drives across the country. There will only be a few brief moments when it is in its prime, and thereafter it will fade and wither like an aged man, its final passing marked, perhaps, by no more than a dark line of clouds at which the traveller frowns but is not afraid.

Thus do great clouds which ride the earth like mounted kings fall into decay. They will crumble either from their crests, should they be thrust by their own impetus into stable layers above them, or else from their bases, leaving their crests unsupported, like castles whose foundations have been cut away. In the moments of their growth they will be strong, their heads thrusting higher as writhing wisps of vapour consolidate. In their age their edges become ragged. They may even topple on to their sides as they dissolve. Only the largest cumuli will persist for any length of time after growth is complete. Occasionally such dying monarchs may give the inexperienced pilot the impression of continued activity, leaving him to discover by entering them that they are shadows of their former selves, inactive hulks awaiting inevitable dissolution (see photographs opposite page 193).

The weather forecaster knows all about this, but the pilot who criticises him doesn't always appreciate it. It is no easy task to estimate the life-stage of a system at any particular moment over any specified place.

* * * * *

Cloud sense for the glider pilot need not—for utilitarian purposes—be carried farther than the cumulus varieties of which I have been writing. I should, however, mention other conditions under which they are likely to form and which are in themselves deceptive. The first is the mass of cumuli which forms quickly over a mountain range, leaving the lowland plain comparatively clear. The explanation lies with the wind, which strikes the high ground and is forced upwards into cooler altitudes where condensation may be inevitable. The photograph opposite page 177 is a fine example. It was taken over the summits of the Grampians when the low ground to the east was basking in the sunshine of a clear sky. The clouds themselves were comparatively smooth when I flew through them, and would be of little use to the pilot of a sailplane. The air mass over the mountains had much inherent stability (see also Figs. 51 and 52).

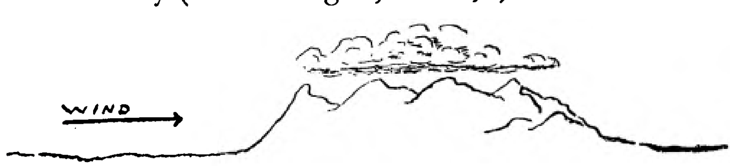


FIG. 51.—*Orographic cloud forming over high ground.*

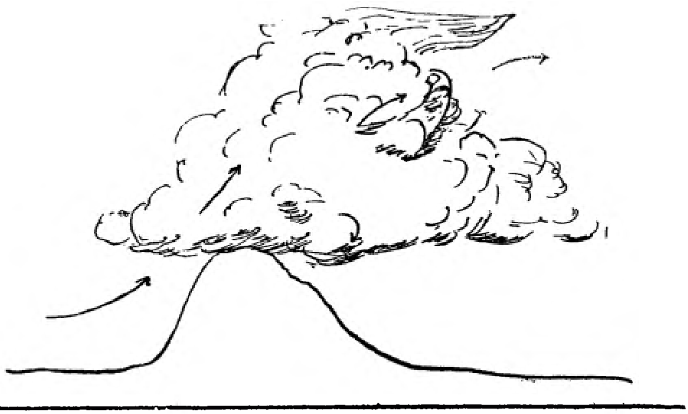


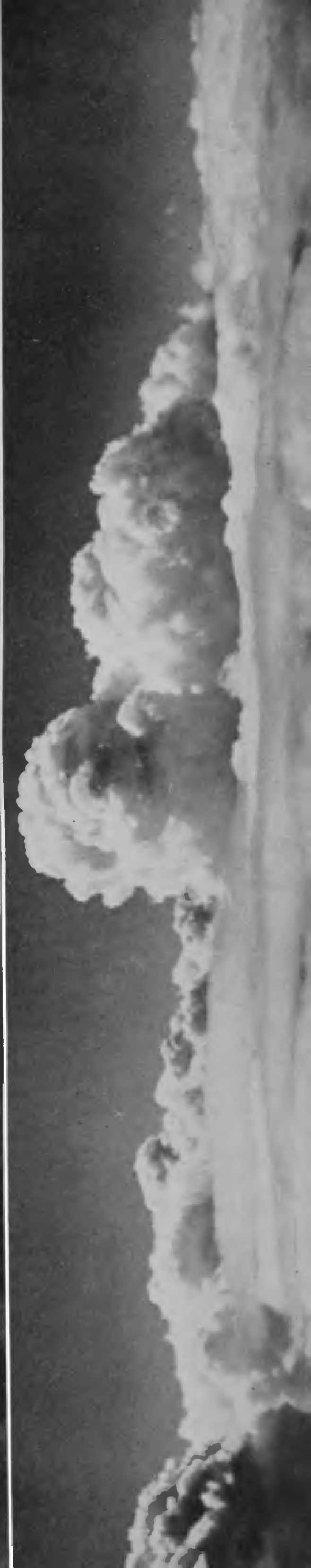
FIG. 52.—*Orographic cumulo-nimbus, the result of unstable conditions.*

The second class of cumulus, usually similarly useless to the glider pilot, is that which forms over the coast in a great wall. It is the result of the difference in temperature between the land and the sea, creating land and sea breezes which, meeting, force upwards the air between them. I have met a similar formation more than 50 miles from land, and think it may be due to differences in temperature created by the Gulf Stream and the colder water beside it. When I have flown into such a wall of cloud the instability has never been marked.

I must now qualify what I have said. Close to the coast, as reported elsewhere, I have flown into currents of considerable violence, but not accompanied by big cloud formations. Nor are the currents so found always useless to sailplane pilots. When Mr. Philip Wills broke the long-distance record, he used the coastal lift along the south-west seaboard at the end of his journey (see page 295). The difficulty of writing of weather is that no statement is ever wholly true. There always seem to be exceptions.

Most of what I have written in the foregoing paragraphs concerns clouds which are created by uneven temperatures and are born of thermal activity on the ground. They are perhaps the most common from the glider pilot's point of view. But there is the greater variety of cloud created by the movement of air masses of differing temperatures and upon

The impetus of a thermal has caused a cumulus head to be thrust through a cloud bank. It is now in the process of decay. (Royal *Meteorological Society.*)

which I touched in the previous chapter. As was pointed out then, some of them are cold and some of them are warmer, depending upon their origins. When they meet they will climb one over the other, set up storms, create fogs, generate winds, and especially build up cloud formations on a great scale. All clouds form for the same reason—that the moisture which is in the air condenses when it reaches its dewpoint. Or, put another way round, a cloud will be formed by a body of air which is cooled beyond saturation. That such conditions can be brought about by the mixture of air streams, themselves created by areas of low or high pressure, has already been abundantly demonstrated.

The particular type of mass air movement to which I want to refer again is the cold front.

As has been stated, when a body of cold, dense air sweeps in to meet a body of warm, moist air, the cold air will cut underneath it. If the warm body of air is itself in a state of instability—and this is most important—the assault upon it will have a trigger action which will set it into great turbulence as it rises. From it will be built up the massive formations which we have come to recognise as cumulo-nimbus.

In the northern hemisphere the wind in the warm sector may be expected to be blowing from the west, but as the front approaches it will veer north-west and blow in squalls, while from the base of the front itself narrow belts of heavy rain may fall. The temperature will drop perhaps 10 degrees, but the barometer will rise and continue rising as the front passes. The pilot will see it as a storm which advances from the horizon. At its forward edge ragged tails of dark cloud may hang, and maybe it will bring with it those sheets of rain or hail which reduce visibility to a mile or less until they have passed.

Opposite.—Top : A cumulus head at 9,000 feet. It has passed the peak of its development and is decaying rapidly. Mild turbulence only might be expected.

Bottom : A similar cumulus head, but this time in the most vigorous stage of its growth. It has thrust its way through a layer of alto-stratus and might be expected to produce severe icing and turbulence. Photograph taken at 12,000 feet.

The photographs opposite pages 160 and 224 and the diagrams shown in Figures 45 and 53 are useful amplifications of the cold-front phenomena propounded in other chapters.

When the front has gone through the cold air behind it may itself give birth to big detached cumulus and cumulo-nimbus formations, each one a miniature storm in itself and of considerable interest to the glider pilot. Visibility between the storms will be extreme, and in the cold biting wind the sun will shine, creating new convection currents and adding to the inherent instability of the atmosphere.

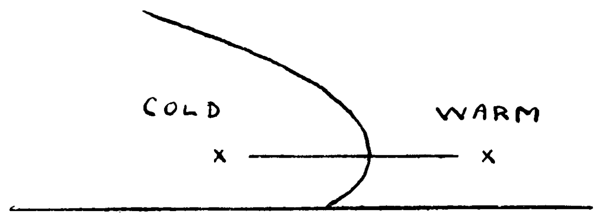


FIG. 53.—*The cross-section of a fast moving cold front in which the cold air has overrun the warm air within the friction layer. The wind speed will greatly increase with height and the frontal slope will be steep. Maximum instability will develop between X-X with line squalls and cumulo-nimbus clouds.*

Compare this once again to the warm front, with its gentle frontal slope of as little as 1 in 150 and its roof of nimbostratus covering the sky with a grey blanket and bringing with it stable air conditions and probably drizzle. One is a wild, untamed thing; the other is a lifeless ghost.

I am only too aware that I have touched on a subject which embraces a big literature and possesses a faculty of its own. The average pilot approaches it with timidity, perhaps guessing that if he once begins to study it closely he will never have any time for flying. I don't, therefore, propose to do more than recapitulate that cumulus clouds with big vertical development are the principal clouds which he should watch carefully—whatever their cause. To this might be added a point which has previously only been mentioned in passing—the visibility prevailing at the time. When the horizon is hard and the outlines of large cumuli well defined, the air is usually unstable. When there is a measure of haze, the instability is often much less marked. Both points are recapitulated as evidence of the characteristics of, respectively, cold and warm air masses—evidence borne out by observation accompanied by much shaking of the liver during journeys here and there over this pleasant land.

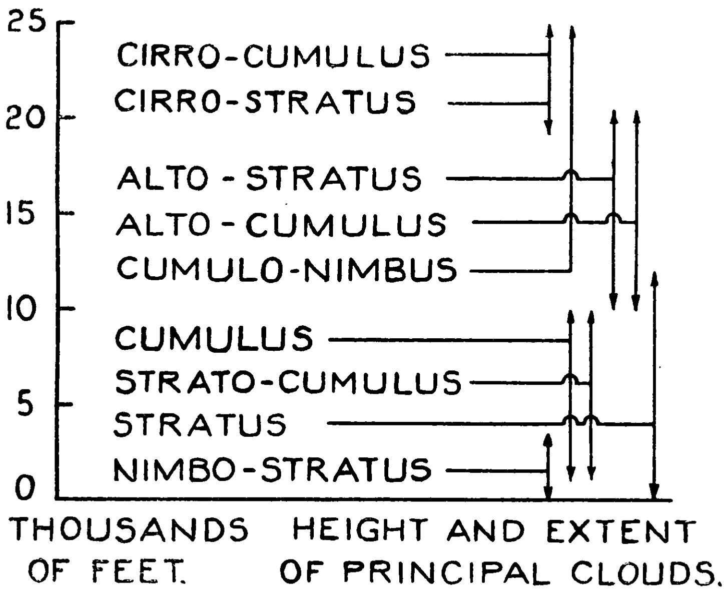


FIG. 53A.

NON-GLIDING WEATHER

A SAILPLANE pilot can unfortunately only learn a part of the story of the air—that part which is associated with vertical currents strong enough to keep him airborne. At all other times he must remain on the ground and, like a prisoner behind his bars, gaze at the sky with hope.

Much weather is non-gliding weather, and it prevents the sailplane pilot from becoming an experienced pilot in the full sense of the word. Unless he has flown through every mood of the overcast his education and the balance of his judgment must be imperfect. Not that I recommend every glider pilot to take out a power licence and go forthwith to mortify his flesh in the non-gliding weather well known and well hated by those whose duties have lain along different paths. But I do think that an understanding of it should be a part of his background of knowledge.

It is easy enough to talk glibly of line squalls, electrical storms, occluded fronts, and industrial haze, and even to understand what brings them about. But it is another thing to appreciate what they mean to the man in the air. For one thing, the knowledge will help him to keep a nicely balanced mind, and for another it will be a deterrent to "line-shooting." The story which the heavens have to tell is a big one, ranging from the saga which the night bomber pilot learns on a trip over Europe through electrical storm and icing to a summer flight through the stability of a cloudless day. Both are out of reach of the sailplane. Hence the introduction of experiences which have nothing to do with gliding but everything to do with flying.

Icing

It is January. The barometer reads 29·1 and is falling rapidly. The reason is a low-pressure system which has moved down from Iceland at high speed, bringing with it wind, sleet, and miserable conditions. No glider pilot would put his nose out of doors on such a day. The low lapse rate alone would discourage him, while the 10/10 sky piled to a depth of perhaps 5,000 feet precludes the possibility of the smallest thermal current.

Below the hull of an amphibian lies the North Sea, white-flecked, grey, and running in the hard lines of a heavy swell. The pilot could do with some sun if only to make the empty waste look more cheerful.

The crew are silent, working out their problems with the studied concentration of their kind and leaving their driver feeling lonely. Then into this little universe a stone is pitched. The engine stutters, the needle of the rev. counter collapses and falls back against its stop. The nose of the aircraft rises, and it needs a big push on the heavy wheel to get the hull level again.

In a sudden access of mental activity our eyes range the sea below, checking the run of the swell and fixing the direction of the wind. Then, while I am still making calculations, the engine picks up again. The needle of the rev. counter climbs back across the scale and comes to rest at its former position.

We fly on, and as the roar of the engine holds steady, I move the throttle lever to reassure myself. It moves one way, but not the other. The carburettor is icing up, the butterflies are jammed.

The ice will perhaps melt if I go very low on to the water. But I don't want to do this, for if the engine falters again we might be in the sea before it picks up. So we maintain height and hope.

During the next half-hour the engine splutters twice more, but at last we are over the home estuary, and with a savage thrust I ram back the throttle lever, break through the crust of ice which is choking it, and put the amphibian into a glide. At that moment the engine stops altogether. We sweep down on to the water, kiss the tops of the little waves, sink quickly, and are clutched as though by a powerful hand. In a smother of foam, which rises and splits into a thousand drops as it hits the windscreen, we pull up and are bobbing in silence half a mile from the shore.

The observer climbs out on to the lower main plane with the starting handle, a motor-launch throws a white feather from its bows as it comes towards us, the wireless operator closes up his book and takes off his earphones. I sit waiting, content to do nothing until the engine starts. The flight is over.

Industrial Haze

This time the barometer is high. An anticyclone sits over the British Isles like some broody old hen who will not move until her chickens are hatched. Its centre is directly overhead, bringing with it those windless conditions often discovered during the late autumn, conditions in which the last brown leaf will hang motionless on its twig and the earth clings wet to the gardener's spade.

High overhead comes the gentle cascade of cold air from great heights, pouring downwards and blanketing the smoke of the cities. No flying man's weather this, with its roof of haze through which the sun is barely visible. A day for digging, maybe, or, better still, for sweeping up the fallen leaves. Yet somewhere it is someone's job to fly, and a voice comes distinctly over the intercom.

"I've got to get some ranges and bearings."

We are just lifting clear of the runway, and the road which marks the boundary of the aerodrome is leaping towards us. Before we reach it, I re-trim the aircraft for a comfortable climb, glance over to starboard to see that the circuit is clear, and pick up the mouthpiece of my own speaking tube.

"Ranges and bearings—you've got a hope."

The observer in the back is puzzled, but as we reach a thousand feet he begins to understand. The aerodrome behind us is less than a mile away, but its outline is already invisible in the haze. To get ranges on his little instrument he will need better visibility than this.

We climb, and I say: "There may be something to see if we go high enough."

We are going up through a strange twilight, while the earth becomes a dark smudge at the bottom of an airy well. I forget about it, and fly on the artificial horizon. A few minutes later we break out through the crust of haze at 10,000 feet, and we are in blazing sunshine. Up here there is only purest air, intensely cold, but with limitless horizons in all directions. I climb another 2,000 feet and level out. The thermometer is reading minus 18 degrees Centigrade, the boost pressure has dropped back in the more rarefied air, and the speed has increased to an indicated 140 m.p.h.

Down below is the flat roof of the earth—a smutty lid created by the city of Glasgow and the Clyde industries 80 miles away. But at this height the vague outline of a stretch of coast is just discernible. Farther south is a headland, a possible object for a range and bearing by a skilled observer. To the west there is nothing—just the dull grey lid over the earth, whose perimeter strikes a curve round the horizon.

I fly north and know that the mountains are below. I can't see them, but by peering vertically down through a side panel in the cockpit I can make out a darker smudge which is the earth. In a few minutes, as I half expected, the observer complains that he can't see anything. He also complains that he is cold. Meanwhile I have been able to appreciate this myself. I have been playing a game by depositing some spit with my finger on the front panel and counting the number of seconds it takes to freeze. The average time is three seconds.

Now that the observer has given up his exercise, I have no further obligations, save to put him safely back on the ground again. So I close the engine gills, pull the weak mixture control back into normal, and close the throttle. As the speed drops I pull up the nose, wait till she stalls, and put on full rudder.

Down she goes, with the starboard wing rearing up like a bucking horse. I take the rudder off and we slip into the true curve of a dive—into the smoky lid, into the dark blur of soot and smells, with a rising scream of foul wind.

The haze seems to have thickened even in the last few minutes. There is a line of dirty grey cloudlets forming over the edge of the sea. Nothing on the landward side is distinguishable—only a blue-black blur which has darker patches about it.

We go down through the murk and level out at a thousand feet where the thin line of roads and the shapes of woods have begun to show. It could be easy to be lost over such a country without an intimate knowledge of it. Then we cross a railway, and I recognise its shape. First to the right and through the valley, over two lakes, and down the railway to the junction. Then right-handed along the road. The aerodrome buildings loom up, and we go into the circuit. I lose the aerodrome again on the way round, but we pass over the cemetery, wait

30 seconds, and then turn in. I don't see the runway until we are over the end of it. But that is of little account, for the aircraft sinks fast with a closed throttle, and before we reach the intersection of the runways the wheels kiss the black tarmac. Back in the dispersal area, I climb out. The field and the dispersal hut look squalid, the rating who is preparing to refuel the aircraft looks squalid. The whole earth looks in need of a spring-clean and a wash, and as I trudge across the grass with my parachute slung over my back I think of the sun and the limitless horizons of only 10 minutes before. And in all those 12,000 feet there wasn't a bump or a ripple.

Haze Again

Today there is a depression which is centred over Ireland. It moves slowly to the west, but very slowly, and there is nothing in its character to recall the fury of the North Atlantic winter. Several hundred miles to the east—over the North Sea between Scotland and Denmark—there is another depression. It also is moving slowly west, and, like its brother, the isobars are well spaced and its character without vice.

Between the two depressions I am waiting to take off on a cross-country journey which should safely deposit the squadron on the other side of the island. We are in an area of calm, midway between the two systems and out of the influence of both of them. Looking at the sky, a few flat clouds are to be seen forming in a butterlike atmosphere of fine haze. Stable conditions, I say to myself—at any rate, stable for a while. The clouds have no vertical development and they are high. There is smoke there, and no doubt it will thicken on the other side by Glasgow—it may thicken a good deal.

A visit to the "Met" office confirms the picture as it can be seen from the ground. Those depressions on either side are eloquent, while the low figure for the lapse rate confirms the probability of smoke haze. Well, it is usually poor flying across Scotland, and this is going to be no exception.

We form up in three flights of three and set a course of 258. Visibility is about five miles over the aerodrome. After 10 minutes' flying the Tay lies ahead, and it gradually narrows and curls west under the cliffs which mark the southern boundary of the Sidlaw Hills. The rounded backs of the Ochills are regimented on the port beam, and we fly into a narrowing valley, full of haze, with a fine promise of something really thick farther on. It pays to adhere strictly to the compass course, watching the landmarks turn up immediately below, and making the necessary corrections until you are flying down the line drawn on the map like a hen following a chalk mark.

I notice two other aircraft flying in loose formation on either hand, but at this stage the London and North Eastern railway is better value. It runs through the valley in a straight line until it dodges round the Ochills into Stirling. Today it does so just at the right moment, and I know that I am not half a mile off track.

The observer is told to keep a look out for a loch on the starboard side. In a few minutes he sings out that it is abeam. I take his word for it, for I can't see it myself. The murk is now really thick. If he isn't imagining things, a lump of ground about 1,000 feet high should follow in 5 minutes, leaving a peak of 1,500 feet a mile to starboard. The peak dutifully develops out of the dark background a trifle more than a mile away and a couple of hundred feet below. This is too easy. There's water down there and a little island covered with trees—Loch Lomond. By rights we should be enjoying the best view in Scotland—Ben Vane and Ben Lomond to the north with a great chain of peaks in between and the silver water in their groins. On the port side I should be looking across the Kilpatrick Hills into the city of Glasgow, and ahead have a vista down the Clyde. Instead, the only thing to be seen is the grey sheet of the loch unrolling below.

More stretches of water turn up, and as we fly over I count them—Gare Loch, Loch Long, Holy Loch, Loch Striven, the two Kyles of Bute—each one a narrow tongue between shadowy masses of rock and heather.

Now the visibility improves. As we reach the shoulder of the Mull of Kintyre the air changes colour and a layer of stratus cloud overhead breaks up. Soon we are flying through the equivalent of melted butter—a golden haze with the sun like a well-polished brass pan in the south. A course is no longer necessary. We fly down the Mull until the Campbeltown Loch takes a bite out of the coastline and we turn in to Machrihanish. I circle the aerodrome and land, closely backed up by eight other aircraft.

It hasn't been a bad trip after all. We were never more than a few hundred yards off track, and once again we had ample proof that an accurate compass course with an occasional glimpse at a landmark is sufficient for safe navigation.

The job in the afternoon is less pleasant—flying over the Firth somewhere south of Bute while a dimly seen cruiser looses off salvo after salvo of 6-inch shells. The observer is supposed to be marking the fall of shot, but I have some doubts about his success. Liquid butter is not particularly transparent, and when a flat calm lies at the bottom of it and there isn't a horizon of any kind, one is apt to be vague about one's bearings. At one moment I am looking at what I believe to be the sky and see a ship steaming in the middle of it. Thereafter it seems to be safer to fly on the instruments. The disadvantage is that the other aircraft in the squadron are turning this particular bit of sky into a kind of wasps' nest, while an R.A.F. pilot appears to be dive-bombing a target too close to be entirely disinterested.

After half an hour the cruiser signals that she can no longer see her own target. We consider this a good thing, for it means that there will be no more shooting and we can go back to Machrihanish. I aim the nose of the aircraft at where the Mull ought to be, and *mirabile dictu* it is.

After refuelling—100 octane for the aircraft and a brew not much less potent and miscalled tea for the crew—we take off and fly across Scotland again. The foul breath of Glasgow hasn't improved, but as we slip into the Stirling valley the sun comes out, and on the east coast we find a superb evening with clear skies.

Once again there hasn't been a single bump in 5 hours' flying—air dead smooth, lifeless, and thick.

Fog

The sailplane pilot never needs to worry his head about flying in fog. The condensation of moisture at ground level is a proof that the vertical currents by which he flies are not present. But as the biggest individual bogy of the air it earns its place in any book which deals in terms of the atmosphere.

Fog forms in many weather conditions, but only for one reason. Unless the temperature of the dewpoint and the air coincide it cannot exist. To investigate this it is only necessary to recall what has already been said about the formation of clouds. For a given degree of air saturation condensation will take place at a given temperature. If it was possible to enclose in a vessel the clear air of a summer's day and cool it in a refrigerator, there would come a moment when its moisture content would condense. Alternatively, a given body of air can contain an increased quantity of moisture if its temperature is raised, just as it is possible to melt more sugar in hot water than it is in cold.

Assuming the air outside at this moment is 55 degrees, and that its moisture content is such that if the temperature fell to 50 degrees its dewpoint would be reached and a cloud would form, then from the airman's point of view the outlook is not unfavourable. There is a gap of 5 degrees. But supposing that the weather office was reporting the approach of colder conditions, and that during the next hour the temperature fell to 52 degrees, then the probability of fog in the near future is strong. So it will be appreciated that fog forms because the dewpoint and the temperature on the ground come together.

It is obvious from the foregoing that the chances of fog materialising out of dry air are remote. The dewpoint of such air must necessarily occur at a very low temperature—one which is probably only to be found thousands of feet above the ground and provides its evidence in the formation of high cloud. But air which has made a long journey over the sea and is wet is a more fruitful medium. It is such air which gives birth to the sea fogs.

There are several recognised classes of this type, some a greater menace than others. Equally there are recognised areas where they have a habit of forming. The Newfoundland banks are notorious and the Aleutian Islands run them a close second. In both cases prevailing currents of warm air from the south flow towards the icy water currents from the north. The air cools rapidly, its high moisture content condensing into vast banks of fog which may persist for days. Fog on a similar scale is formed by tropical air masses flowing northwards towards the colder water currents of more northern latitudes, creating fogs which may stretch over many thousands of square miles and which, incidentally, will survive strong winds.

Contrast this with the "smoke" fogs which gather little more than waist deep in the late evening over the rivers and lochs of Great Britain. They are almost friendly by comparison. For their formation the light airs of dusk are required to waft their breath over the surface of the warm water, an action which can cause such a rapid evaporation of the surface that some of its moisture is immediately condensed. Many times when I have been fishing for sea-trout I have watched a silver coverlet drawn over the water like a sheet. Sometimes it is so shallow that I can still see the head and shoulders of another angler 50 yards away, although his legs are hidden. In the gathering dusk, which is being replaced by the radiance of a rising moon, the effect is lovely—although disastrous to sport!

When an aerodrome lies close to the side of a big river or lake the formation may be sufficiently vigorous for the fog to spill over the bank and hide the landing ground. When there are factory chimneys or a large town in the vicinity its spread is encouraged. On the other hand, it needs only a breeze to spring up for its clearance.

I once made a dramatic landing on a spring day when the airfield was bound in a hard frost and a light warm wind from the sea had carried its wet breath just sufficiently inland to lay a cover over part of the runway. There was a wall of pearly-white fog rising to 500 feet right across the landing path. Overhead the sky was full of aircraft which one by one made the attempt to glide down through the fog. The "T" signal in the square outside the control buildings prescribed that the approach should be made from this side, an error of judgment which was shortly afterwards rectified. Being impatient, I waited until an unsuccessful attempt to land in the right direction had been completed, and then darted in from the opposite end to touch down in brilliant sunshine, stopping a few yards short of the fog wall which blotted out everything beyond. So sharp a line of demarcation is common to such conditions.

If at moments like these the warm wind from the sea is sufficient to keep the fog rolling inland, it may cover a frost-bound coast to a depth of several miles. It may not be stopped until it reaches the barrier of a range of hills. An increase in the strength of the wind, or more generally the warming of the ground as the day advances, will dissipate it.

I have seen fog roll up the Firth of Forth to fill it fathoms deep for as far as Stirling. Then it has overflowed its banks and spread north over Fifeshire, finally covering the Lowlands in one continuous sheet, leaving only Bishop's Hill standing out like a tide-washed rock. In the north and west it has met the special fogs of the Tay, and County Angus has succumbed to the rising tide, lying buried up to the slopes of the Sidlaw Hills, with only Dundee Law standing clear.

Flying an aircraft above it was like flying over a brilliant ocean of sun-kissed snow in which the peaks stood out in atoll-like isolation. Stirling Castle, away down in the south, would fling its black battlements clear of the surface. Flying north, one would follow a fjord-like tongue running up the Stirling valley and burying Auchterarder and Perth fathoms deep. One would know where they lay by the shape of the Ochill peaks above them. And then at Perth I have seen the tide rise into the Isla valley, perhaps penetrating the mountains where the Tay breaks in amongst them on the way to its source. It was deep, motionless, and as wicked as a witch.

This is the kind of fog which will steal in from the sea silent-footed and cover the airways before you know it. One night I was waiting for geese down among the dunes of the Budden Ness. The sun had gone an hour before, and there was a great quiet while the stars came out and the sea sucked at the sand half a mile away. I had just heard the distant honk of pink feet when it happened—happened like a puff of wind that springs up on a summer day. Within almost a minute it had rolled down and over the dunes, hiding the reeds of the brackish pool where I crouched, blotting out the low crests of the sandhills, imprisoning me in a tiny world which measured barely a dozen yards either way. As I looked up I saw the stars go out almost like a candle.

As I groped my way out I heard an aircraft engine. It was perhaps half an hour later, for the groping was slow and full of pitfalls, and now the fog was lying heavy in a canopy for miles. As I stopped and listened I saw a pencil of light come streaking across the dunes, a roar of engine, and then for a fraction of a second a passing shadow. Caught out in the fog, unable, apparently, to find an aerodrome where it was still clear, the pilot was taking the biggest risk of his life. He was making a blind landing on unknown ground in zero visibility. A minute later I heard a scrunch, and then silence. And it was only a modest scrunch—a crumpled undercarriage—a wing. The pilot had got away with it!

Another cause of the same coastal fog is a belt of cold water lying close inshore. Like frost over the land, this has the effect of cooling the wet air stream from the warmer sea beyond it. In this instance, however, the coast itself may be too warm to permit it to penetrate inshore, and thus it lies along the map in a broad white band.

Occasionally the whole procedure may be reversed, and it is a warm wet wind which blows out to sea. But offshore breezes are generally more dry, and unless the sea is by comparison very much colder the dewpoint will not be reached. If it is, the fog will form over the water, leaving the land clear.

Each of these fog types is what is known as advection fog —the process of wet air coming in contact with a relatively cold surface.

There are several other types of equal portent. One of the least expected belongs to the cold starlit night in which for a time every star is a brilliant pin-point. Yet in a few hours, discovered first in some hollow as a luminous pool, the insidious blanket is drawn over the earth. The motorist curses, the airman prays.

This is a fog by radiation. The heated ground has been giving up its warmth, sending it back through the corridors of space, unhampered by a quilt of cloud, until it is dissipated among the stars. Now the light wind of the quiet night stirs into gentle turbulence the air closest to the ground, circulating the chill which it is acquiring from the newly cooled earth, reducing it to its dewpoint and spreading a fog like icing on a cake. It requires great stability and an inversion of temperature as its helpmates—an inversion which holds down the layer next the earth in a cold prison of its own.

Too much wind would drive it higher to mix and warm again with the air above. Too little would not spread it at all, and such fog as formed would be only a foot or two deep. Until the morning the fog will remain, and then the sun will come and burn it off, leaving a brilliant day with cold, clear air and perfect visibility.

It is a little strange that a perfect night can give birth to such a monstrosity—just because it is a perfect night. But it only needs a cover of cloud to prevent the earth radiating its heat away and making the conditions unfavourable. Nor do you find such fogs in the tropics, for the ground remains too warm throughout the night. It is in the cool of an English autumn and when the evening has been humid and warm that the stage is set. There is a connection here with the evening thermal of which I have already written, for on such an evening it will be noticed how the hollows fill first—how, in fact, the cold air of the higher ground will begin to trickle down the slopes and condense, just as the greater mass tumbles into Bradwell Dale from Kindersnout to lift the valley airs.

As I am writing this I am forcibly reminded of one particular fog—and most pilots have a special fog to which their minds go back whenever the subject is mentioned. It is a fog from the pilot's point of view, and as such it is of more concern than all the theories in the world.

A south wind was blowing on the day of which I am thinking—a wet wind from the warm south which was moving into the cooler climate of Scotland and the North Sea. At the same time a depression was pushing ahead of it an occluded front from the west, contributing to the southerly wind and certainly presaging rain over the coast. The outlook was not reassuring, although when I took off the weather was fine, with patches of cloud at 600 feet over the sea—clouds looking like big white powder puffs. Two hours later the situation had changed.

* * * * *

"Our ETA is in 1½ minutes," said the observer.

His news, tardily given in answer to a question of my own, produced an apprehensive sweat within a few seconds. For the past 20 minutes we had been flying through fog at less than 10 feet over the water and we were in no position to cross a coast-line whose sandstone cliffs reared their battlements 120 feet out of the sea. A five-bar gate was about the highest object we would have cleared at that moment. One and a half minutes!

The fog condensed on the windscreen and split into a score of rivulets, through which I could see, dimly, the sea unrolling beneath the wheels like a steel sheet. At 100 knots its passage seemed incredibly quick. There was no line of demarcation between the water and the pearly mist. They merged into unity about fifty yards ahead, so that one's eyes lost their focus. Only by keeping the artificial horizon steady, and by taking quick glimpses at the streaming water through a side panel, was it possible to maintain an equilibrium.

It had been, of course, my own fault. The weather had been deteriorating on the outward journey, patches of fog forming on the water until they lay in ghostly pools for as far as the eye could see. Then on the homeward leg, which was designed to bring us back over the east coast, the pools on the water grew larger, and finally merged like the closing of an ice-pack. They rose up in ever-thickening banks to form sticky white walls. There had come a moment when a decision had to be made—either to climb over the top of the mounting weather or to go down on to the surface of the sea and fly underneath it. As a matter of principle I had chosen the latter course, for I had heard too often of pilots who had sought sanctuary over the top of the weather and then found themselves faced with a descent through continuous cloud to the ground.

It might be well enough with beam radio, but with nothing but a transmitter worked by a half-trained crew the decision was plain. And it was as well, for down below it had grown darker, the fog no longer a thin sheet beyond which the sun was shining, but a massive accumulation of grey stratus—the harbinger of the front moving westwards off the land. Maybe it was many thousands of feet thick at the moment my observer announced that there was 1½ minutes to go.

In such a situation a pilot whose aircraft is not fitted with the necessary wireless aids has only one course. He must turn away from the shore and think things out. This in itself needed care. As the directional gyro swung through 180 degrees, I hoped that a cliff wouldn't rise up and hit us. When we were on a straight and level course again, heading out the way we had come, it was a relief.

We wirelessed our new course to base and asked for bearings. We didn't get them, for our station had not at that early stage been fitted with D.F. So I tried another tack, and told the air gunner to demand the height of cloud base over the coast. If we received a reply that there was a ceiling over the cliffs I could turn in again and make a landfall in the knowledge that we should break cloud before reaching high ground. Unfortunately this request was also refused. It was against the rules to send information of this nature over the air. German aircraft had the habit of haunting this stretch of coast, and the information might have proved valuable. As for ourselves, we had petrol left for at least 2 hours' flying, and there ought not to have been cause for worry.

The fog was still condensing into glissading rivers down the front panel when a dark shape grew out of the blur ahead. It loomed suddenly, leapt towards is, and flashed beneath the starboard wing tip. It was a buoy. The meaning of it was still resolving itself in my mind when another shape, much larger and darker, sprang at me, crystallising in the picture of a dripping hull, a deck-rail lined with startled faces, a funnel, a mast, and a gun platform with barrels pointing aimlessly into the fog. Then it was past, and there was only the pearly-grey sea unrolling.

But the vision was enough. It located us almost as well as any wireless bearings, for it belonged to a minesweeper, and I had in my head a memory of these little ships ploughing their way out of the Tay estuary. What was more, I could remember to within a few degrees the course they followed, and a check by my own compass, backed by the sight of the buoy, placed us beyond reasonable doubt about 10 miles south of the cliffs and of our estimated position.

If the guess was right it was a reasonable risk to turn parallel to the coast, which ran for about 90 miles in a straight line to Peterhead. The chances that a break in the weather would occur somewhere on the way were good.

So I told the observer to signal the new course to base. From the rear cockpit came his brisk "Aye, aye." It was curious how cheerful he was. Like most unqualified air crews, he had a supernatural faith in the ability of his pilot to bring him home—even in fog after being out of sight of land for a couple of hours.

As I was hoping, the mist thinned a little as we flew on. It became possible to fly at 30 feet, which was a relief from the strain of "surf riding." It also had the advantage of being high enough to clear the funnel of the next minesweeper.

Then a strange thing happened. An avenue in the fog opened up on the port side. It was an avenue reminiscent of the nave of a great cathedral, save that its sides bulged with the breasts of half-formed clouds. The roof was nearly 200 feet high, and for some miles it ran straight to the north on a bearing which would intersect the shore.

"You've changed course," remarked the observer. I was now sufficiently jubilant to tell him to mind his own business, and we flew on.

At last the avenue bent to the left, its sides closed in, and forward visibility shrank to a bare 100 yards. I had already decided that we must immediately turn out to sea again, when we burst without warning into clear air. It was dramatic, like walking through the wall of a prison straight into a lovely garden. And how lovely it looked! There, half a mile ahead, were the dark cliffs, and a little to the north the blurred glimmer of yellow sands. It was really a foul day—gloomy and lowering, with clouds only just over the tops of the cliffs and visibility barely 2 miles. But it was a very lovely day compared to the world from which we had come, and which I could see behind me barred by an ugly wall of grey vapour.

I pulled up over the cliffs, flung the aircraft into a steep turn round the Montrose light, and revelled in the nearness of hedges, trees, and open fields which raced beneath the wheels. I had been right. We had come from the Tay estuary, and I had finally crossed the coast within a mile or two of where I expected. I considered myself a clever fellow.

I was still feeling smug when a Spitfire flicked past my tail, did a sensational turn over the tree-tops on the beam, and came screaming across my bows. "There's another man late for lunch," I thought, and only learnt afterwards that I had been the cause of an air-raid warning, and it had been his business to shoot me down. Fortunately, an Albacore is not to be confused with the sort of thing which the Germans used to send over, even in those days. We squeezed into our aerodrome between the folds in the ground and cloud base.

* * * * *

An R.A.F. officer, speaking on the wireless, apologised to any of his squadron who might be listening for the "line shoot." There would be a better case for me to do the same, for the R.A.F. speaker had had the enemy as well as the weather to deal with. I can only offer as my excuse the moral of the story.

Never, under any circumstances, carry on with a flight—unless it is of an urgent operational nature—if you are worried about fog. Every pilot should know his own limitations, and if he thinks there is a chance of running into something he can't take in his stride, it is braver to turn back.

I was once taken up the Black Crag Buttress in Borrowdale by two expert rock climbers. I had never done any of this sort of climbing, and the leader had said, "If you feel worried, let me know immediately; it's a difficult thing to swallow your pride, but it's safer." I learnt on that climb that I had no head for heights, and I was subsequently lowered to safety on the rope from a place where it was still possible to cope with me. It is the same with flying—and soaring is included in this. Don't delay your return until it is too late. You may not be able to do it then.

The quality of pilots, like climbers, varies. Where it would be safe for one it would be dangerous for another. It is a matter of experience and temperament. Not long ago, while standing on the tarmac at Macrihanish, I watched a D.H. 89 slip in between the gap in the fogbound hills at Campbelltown. He had come from the east coast of Scotland on wireless bearings, and had accomplished as masterly a piece of navigation as any I have seen. I was waiting to fly back on the same journey which he had just successfully made. But I knew perfectly well that it was beyond my own capabilities, and I remained on the ground waiting for an improvement. That is what I mean when I say know your limitations. While such conditions can hardly apply to gliding, they do apply to all men who fly. The most valuable thing that a pilot can know—after he has learnt about the weather, the rules of the air, and the theory of his trade—is his own limitations. If he knows those, he has gone a long way to becoming a sound pilot.

BLIND FLYING

THE average pilot will lose his sense of equilibrium (even during straight and level flight) after 1 or 2 minutes of total blindness. Unless he has a glimpse of the ground, or of the sun, or of some object which will renew his sense of relativity, he is likely to lose control of his aircraft.

The experienced pilot, on the other hand, may be able to carry on without instruments for much longer than the inexperienced—not because his sense of balance is more highly developed, but because the individual's definition of an "object" varies. The experienced flier only needs the faintest clue of the whereabouts of some stable quantity. A beginner will need a well-defined horizon.

When inside a cloud layer, a brighter light at a constant angle in relation to the aircraft is sufficient to dispense with mechanical assistance. An artificial horizon is created by light penetrating into the roof of a level cloud layer. In very hazy weather, when the ground is no more than a blot immediately below, and invisible ahead, it is enough to discover a line marking the top of the haze. Alternately, the faintest glow of the sun, a smudge of brighter light, will give a sufficiently constant bearing by which to fly. When over the sea on a smooth day of low visibility, when the water looks the same as the sky, a single cloudlet anywhere round the horizon is a good enough fix to dispense with instruments.

It is really only in thick cloud or on a dark night when instruments are essential. In a Service aircraft such instruments are provided in profusion. There is the artificial horizon, the gyro direction indicator, the turn-and-bank indicator, the rate-of-climb indicator, and, of course, the ordinary magnetic compass and the air-speed indicator. The sailplane pilot manages nearly as well on the A.S.I., the rate-of-climb indicator (variometer), and an altimeter. If he can afford a turn-and-bank indicator or an artificial horizon, he can fly with less strain, but not necessarily with better results. When you have to fly for several hours through rough weather without visibility of any kind, the more complicated instruments are a help. Otherwise the sum of £250 which used to be the approximate cost of a full blind-flying panel is an unnecessary luxury.

The greatest blind-flying instrument which has yet been invented is, of course, the artificial horizon. It gives the pilot a visual picture of his aircraft in relation to the horizon which he cannot see. Floating in the "clock face" is a line which always remains parallel with the horizon outside, and set up against it is a tiny model aeroplane whose relationship to the line is constantly changing. When the aeroplane is below the line, the aircraft is diving, and when above, climbing. When the wings are in any attitude other than parallel to the line it means that there is bank. The degree of offset is regular and progressive, so that the pilot can see exactly what degree of bank, dive, or climb he requires to correct. With this instrument and a magnetic compass a high degree of accuracy can be maintained. When a directional gyro is used as well, absolute accuracy as far as it can be applied to course steering is within reach.

Why one should lose one's sense of direction without these instruments has struck me as being of sufficient interest to take the pitcher to the well of knowledge. The results are gratifying, and the following explanation, which was most kindly written by a medical flying friend, serves as a sound reason for a chapter on blind flying and why it should be taken seriously. I am giving his explanation as he wrote it.

* * * * *

In everyday life we use three senses to tell us our position in space. First and foremost we rely on our eyes—although we do not fall down in the dark as we have two other senses to guide us: our muscle sense, which tells us by feel whether we are standing on our feet or on our heads, and our organ of balance, which informs us whether we are swaying or turning.

It is the combined messages from all three sources, interpreted by the brain, which gives the true picture. The most reliable guide is the eyes—although a blind man going round a sharp corner in a car can still tell which way he is turning, as he will be swung outwards and will feel an increased pressure on that side. His sense of balance will confirm the turn.

But an aeroplane pilot in a perfect turn puts on exactly the correct amount of bank to prevent any such swing, and a blind passenger will merely feel that he is pressing more firmly, but quite evenly, into his seat. This same impression, however, is conveyed during the climbing part of a loop or straightening out of a dive, and so one cannot get a true idea from the sense of feel alone, which leaves only the balance mechanism to tell us our position.

Flying blind through cloud, or on a dark night, we should be in a tight corner if we had only our unreliable "muscle sense" and our organ of balance to guide us—for this last sense has very serious limitations, and only tells us part of the truth. So that the moment our eyes are of no further use we are left with two easily deceived senses which will lead us to disaster if we put our trust in them.

If we examine the mechanism of balance more closely and see how it works, we shall understand why it tells the brain in all innocence many dangerous lies, and is, in fact, a menace in blind flying.

Situated alongside the inner organ of hearing in the skull it is made up of three semicircular canals, one lying in the horizontal plane, the second standing in the fore and aft plane, and the third standing in the transverse plane (see Fig. 54).

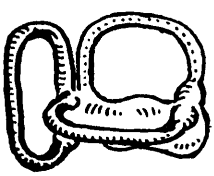


DIAGRAM OF SEMICIRCULAR CANALS

FIG. 54.

Each canal is filled with fluid, and nerve endings resembling hairs grow from the lining of the walls, floating out like reeds on the bottom of a stream. On the wall opposite these nerve hairs are two small lumps of chalk (Fig. 55, 1). When we turn our heads sharply the bony canals and nerve endings turn as

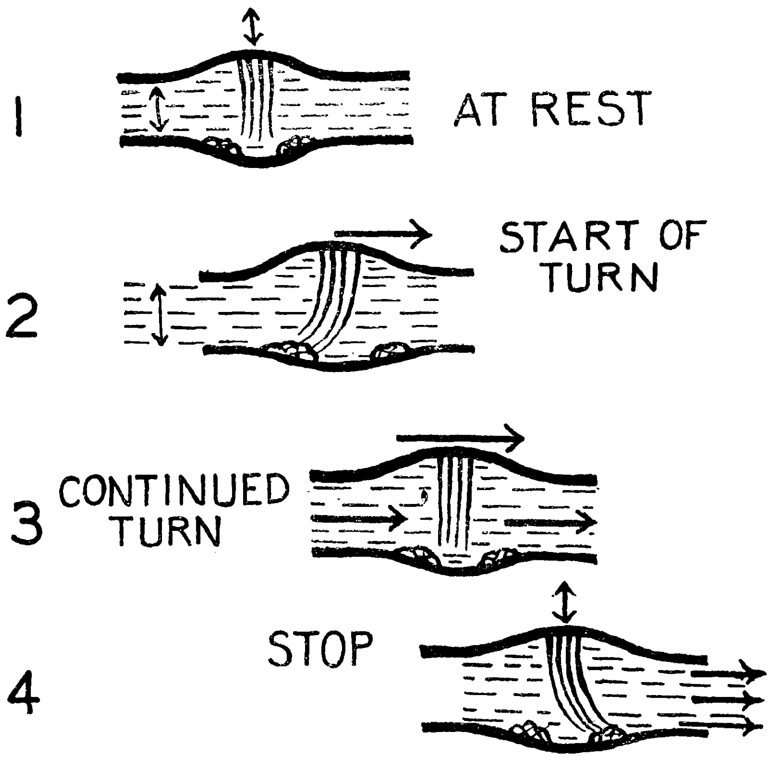


FIG. 55.

one, but owing to lack of friction the fluid has a distinct time lag and does not pick up the rotation for some seconds.

The hair-like nerves are therefore dragged through the fluid and swung against the chalk lump opposite and tickled, sending a message to the brain that "the head is turning." (True.) (Fig. 55, 2.)

If we continue to turn the head the fluid will catch up to the same speed after 5-25 seconds. The nerves are no longer bent and they report that "all movement has ceased." (False.) (Fig. 55, 3.)

Slow down the turn and the fluid will now be revolving faster than the bony canal. The nerves are bent in the opposite direction by the fluid and send a message, "You are turning in the opposite direction." (Still false.)

Now stop turning, and the fluid will continue to revolve for a while. The nerves are bent even more strongly and report, "You are turning still faster in the opposite direction." (A dangerous lie in blind flying.) (Fig. 55, 4.)

Exactly similar false impressions in the fore and aft plane are given when diving and climbing. You may feel that you are climbing and yet be diving towards the ground.

You can test the unreliability of your own semicircular canals by sitting on a music stool with your eyes shut and getting a pal to revolve it steadily but fast, then slowly and finally stopping. Report what you feel and open your eyes. The same can be done in a Link Trainer. If you stall a Link and straighten out with your eyes shut, the need for instruments is at once apparent.

Here is a typical written report by a passenger in an aircraft while flying blindfolded on a test-flight in daylight.

Pilot's Report. (*Actual movement of aircraft.*)	*Blindfolded passenger's impressions.* (*Muscle and balance senses.*)
Turning	*Turning*
1. Steeply banked (rate 3) turn to left	Turning to left, slight bank.
Continuing in tight level turn	Climbing in gentle turn to left.
360° turn complete. Ran into own slipstream and aircraft thrown about	Slight turn to right—straight—left—climbing—dive—straight.
Stalling	*Stalling*
2. Stall, without turning	Flying straight and level (but conscious by fullness in ears that plane must be sinking).
Diving	*Diving*
3. 4,000 feet. Sharp left-hand diving turn until banked slightly over vertical	Turning left (about rate 1).
Straightened into nearly vertical (80°) dive with engine throttled back	Climbing.
Still diving at 190 knots	Reported after 8 seconds "flying straight and level"!
1,000-500 feet. Pulling out	Turning slightly to left, then to right, in a hard banking turn.

Why the last impression of a tight turn when the aircraft was really being pulled out of a dive? The answer is that the air was bumpy. The plane yawed slightly (left turn). This was instantly straightened (impression of right turn) and the pressure of the seat in pulling-out gave the feeling of a hard banking turn to right. What surprised the pilot was the report "flying straight and level" while diving at 190 knots.

* * * * *

If I was trying to teach a non-flying motorist how to blind fly an aircraft, I don't think that either the pupil or myself would experience real difficulty. The idea is sufficiently entertaining to follow it out, for there are probably motorists who would be glad to risk the experiment on paper.

"Look here," I would say in a tutorial voice as we climbed into the cockpit, "you can forget about all those dozens of pretty instruments lying around. They're showmanship—put there to make the learner sweat. Keep your eye on three instruments and I'll teach you to blind fly in 20 minutes."

(The pupil will then make suitable noises denoting surprise and delight.)

"This big one," I would continue, "is the artificial horizon," and in a few sentences I should repeat what I have already explained about its working. "And this little one," I shout (for the engines are now running), "is the direction indicator. When you set the instrument by pulling out this knob, the figure opposite the pointer will stay put for as long as the aircraft remains on the same course. When you start to turn the numbered ring moves round, and there are 360 divisions corresponding to the degrees of a compass. Tell me," I might demand, "what would happen if the aircraft swung through 90 degrees." And the motorist, who shows that he is remarkably intelligent for a member of the lower orders, says: "The thing is reading 270 at the moment, so I guess that it would either read 360 or 180, depending whether the swing was made to the right or left," for which diagnosis he receives full marks.

"And now," I say, "we will observe the revolution counter—any revolution counter. Just keep the thing in the corner of your eye."

So we take off, and as soon as we've climbed to 1,000 feet we fly straight and level. Now we take two observations—first the engine revolutions and second the position of the little aeroplane in relation to the artificial horizon. (It ought to be on the horizon line and parallel with it.) "Keep them there," I say—"lesson one is over."

Next I say we will learn to climb. To do this we open the throttles to suitable climbing revolutions and pull up the nose of the aircraft until the speed falls to the best climbing speed.

"Observe two more things. First the new position of the little aeroplane and second the reading of the revolution counter. Memorise them, and for ever after we may know when they are in this position that we are in the right climbing attitude for this particular aircraft. You can forget every other instrument in the panel—even the air-speed indicator."

"But what about the direction indicator?" says the motorist, and in reply I feel myself at liberty to call him names and remind him that it is but a check on his course. And with that lesson number two is concluded.

The third and last lesson is opened by easing back the throttles until the air-speed indicator shows a reading suitable for descent—say 120 m.p.h.—while at the same time the rate-of-climb indicator is reading a loss of, say, 400 feet a minute. Slight adjustments will have to be made to the throttles before these desirable ends are achieved. As soon as the aircraft is steady I demand that the motorist should observe the new position of the little aeroplane in relation to the artificial horizon and the engine revolutions.

"And likewise you shall know," I say, "that whenever you throttle back to these revs. and put the nose down until the little aeroplane is just in the position that you see it now, you are descending in a proper and decorous manner."

By this time the truth will have dawned that blind flying is not such a black art as many suppose, and, indeed, that if the positions of the little aeroplane are memorised, together with the engine revolutions associated with them, the back of the subject is well and truly broken. Of course, if a constant speed propeller is fitted, the boost pressure gauge will be substituted for the rev. counter.

It is not quite so simple in a sailplane which is not fitted with the master instrument—the artificial horizon. But it is not really difficult if the air-speed indicator is firmly fixed in the pilot's mind as his best bet. This, together with a level bubble (in the absence of a turn-and-bank indicator), can achieve wonders. The secret is to hold the controls lightly and to forget that you possess a rudder. If the use of the rudder is studiously avoided it is difficult for the pilot to get into serious trouble. The really vital thing is to maintain a constant speed, and next to use only just sufficient bank to keep the aircraft turning. He is not then likely to develop a progressive spiral, which can be a bewildering evolution when there are insufficient instruments to indicate what is happening.

The turn-and-bank indicator, not a very costly instrument, is a good insurance, because it tells you something of which a level bubble is incapable. It will denote the rate of turn and will show whether the correct amount of bank has been applied for the occasion. While the level bubble, by remaining central, will inform you on the latter point, it will not show the speed of the turn, and as the tendency when flying blind is to over-bank, this is valuable information. While a 30-degree bank is the advisable maximum when using a full blind-flying panel, 20 degrees is sufficient on the limited instruments of the average sailplane.

Considering the limitations, sailplane pilots can justly claim that circling in heavy cumulus is a difficult and tough proposition. The very nature of their ambition to win height demands that they shall be relentless in seeking out the most turbulent areas, and, having found them, circle continuously. No instrument flying demands more of the mind and the body. Physical nausea which is comparable to the worst that the sea can beget is the natural lot of the pilot, and under it the strongest will may weaken. There can be few occasions when the captain of a power craft would elect to fly such stormy ways. If his charge is an air liner, his instructions, apart from his instincts, are to avoid these areas. Even should he be compelled to navigate them, he would under no circumstances remain circling in the roughest place he could find. Moreover, the full blind-flying panel has been seen to have a decided advantage, and the strain of flying is relieved—a point which would be much appreciated by the air-sick explorer in the purple darkness of a cumulo-nimbus who is trying to correlate the readings of three or four separate dials. Mr. Wills has expressed his sentiments graphically on losing control inside a heavy cloud:

"Suddenly the instruments went completely haywire. I worked out afterwards that I must have stalled: the nose dropped, speed went up; I corrected, but there was a lag in the air-speed indicator, so I stalled again, more violently: the nose dropped a second time, speed went up higher; a third stall was followed by bedlam. The turn indicator jammed hard left; the bank indicator hard right. The variometer showed its maximum of 25 feet a second descent, but as we were certainly losing height at over 150 feet a second, maybe it had gone round six times. The A.S.I., however, exercised in me the greatest and most baleful fascination. It was registering a seemingly innocuous 40 m.p.h., but I had watched it with popping eyes achieve this by going twice round the dial. Hjordis, feeling as tight as a drum, was bellowing like a bull in considerable pain, and perhaps the most dominant of my kaleidoscopic emotions was a desire to move nothing more than half an inch at a time."

If one were to summarise advice to the sailplane pilot one would, I think, put the points in the following order:

1. Wear a parachute.
2. Before entering the cloud note the shortest compass course which will bring you out of it.
3. Concentrate on maintaining a constant flying speed.
4. Limit the rate of turn to a minimum consistent with remaining in the updraught.
5. In the event of getting into trouble, centralise all controls and wait. The aircraft which is naturally stable will probably return to an even keel.
6. In dire straights ease the stick fully back and kick on full rudder until you spin out of the cloud.

Blind flying, of course, needs practice, and its ultimate possibilities can only be realised in the power aircraft fitted not only with the full set of instruments, but with radio beam equipment as well. Such equipment is the logical development of the ordinary instruments, and at least for power craft its installation will one day be universal. If for this reason alone, the sailplane pilot whose career is going to be so much bound up with blind flying can, with advantage, learn something about it. No branch of his art should be ignored.

I met the miracle myself for the first time at an instrument flying school. Apart from any interest in gliding, it convinced me that a pilot whose chief object is to get safely from A to B should not be without it. It obviously not only made bad weather journeys safe, but could make them safe for pilots of little experience—and for most of us this is a quality which counts.

An instructor elected to give me a demonstration before I took over the controls.

We were sitting side by side in a twin-engined aircraft on the edge of a big flying field. Ahead was a sea of green grass, rough, but good enough for the "Oxford" which we were flying. Behind us was the control office with its radio equipment and crew.

As soon as the engines had been started up, the instructor pulled down a shield over his eyes which hid the view of the outside world and gave him no more than a glimpse of the instruments in front of him.

"We will," he said, "taxi out blind, take off, fly anywhere you like, and land again. I will try to bring you back to this point without raising the shield."

This seemed ambitious, but with a final request to keep a look out for other aircraft, we moved off.

It was a strange sensation even to be taxied by a man who couldn't see. First the aircraft was swung sharply in order to test the directional gyro and the artificial horizon. They would both be vital for the blind take-off. Next we turned so as to face the full length of the field, and when I had assured the pilot that it was clear he slowly opened the throttles. It was a normal take-off. The tail came up, the aircraft ran in a straight line, the wheels lifted and a safe speed was gained before we started to climb.

During the next half-hour there was nothing to report about the flight, except that we cruised over half a dozen English counties, and that I, being new to that country, lost all sense of our whereabouts. Moreover, most of the flight was through cloud which yielded only momentary glimpses of a patchwork quilt below.

When I thought we had flown for long enough I asked to be taken home. The problem didn't seem to worry the pilot—although at that moment it would have been too much for me. Several straight courses were flown while we gradually lost height to 2,000 feet. Then, as we broke out of the cloud, I saw the aerodrome below—immediately below. We were like a hound on a strong scent. As we crossed the boundary the pilot made a 30-degree turn to starboard, flew for one minute, and turned 210 degrees to port, bringing us back once more to the aerodrome. Now we were down to 1,000 feet.

The field was recrossed and left a few miles behind. We again turned 30 degrees to starboard and back through 210 degrees to port, bringing us once more on to the original course. All this time we had been losing height, and in another minute we were down to 600 feet. The speed now remained constant at 100 miles an hour, while the rate-of-climb indicator showed a steady descent of 350 feet per minute. We were approaching the aerodrome at the exact spot to within 50 yards of where we had taken off. Over some tall trees I almost lost my nerve and grabbed the second stick. There was not more than 50 feet to spare, and it looked like 5 feet. However, the moment passed, and we skimmed in over the boundary. The wheels touched. We bounced. The pilot held her steady, and as she touched again he eased back the throttles. This time she stayed on the ground, and we ran the whole length of the field to come to rest at the far end.

The demonstration was nearly complete. The pilot, who knew his field as well as the back of his hand, turned the aircraft round, and taxied back to within 60 or 70 yards of the control office. Then he raised his eye shield.

In the hands of an expert this is what can be done on the radio beam. It means that the weather which can keep a pilot out of his aerodrome virtually doesn't exist. In practice it makes landings when forward visibility is nil and downward visibility a bare 100 feet quite safe.

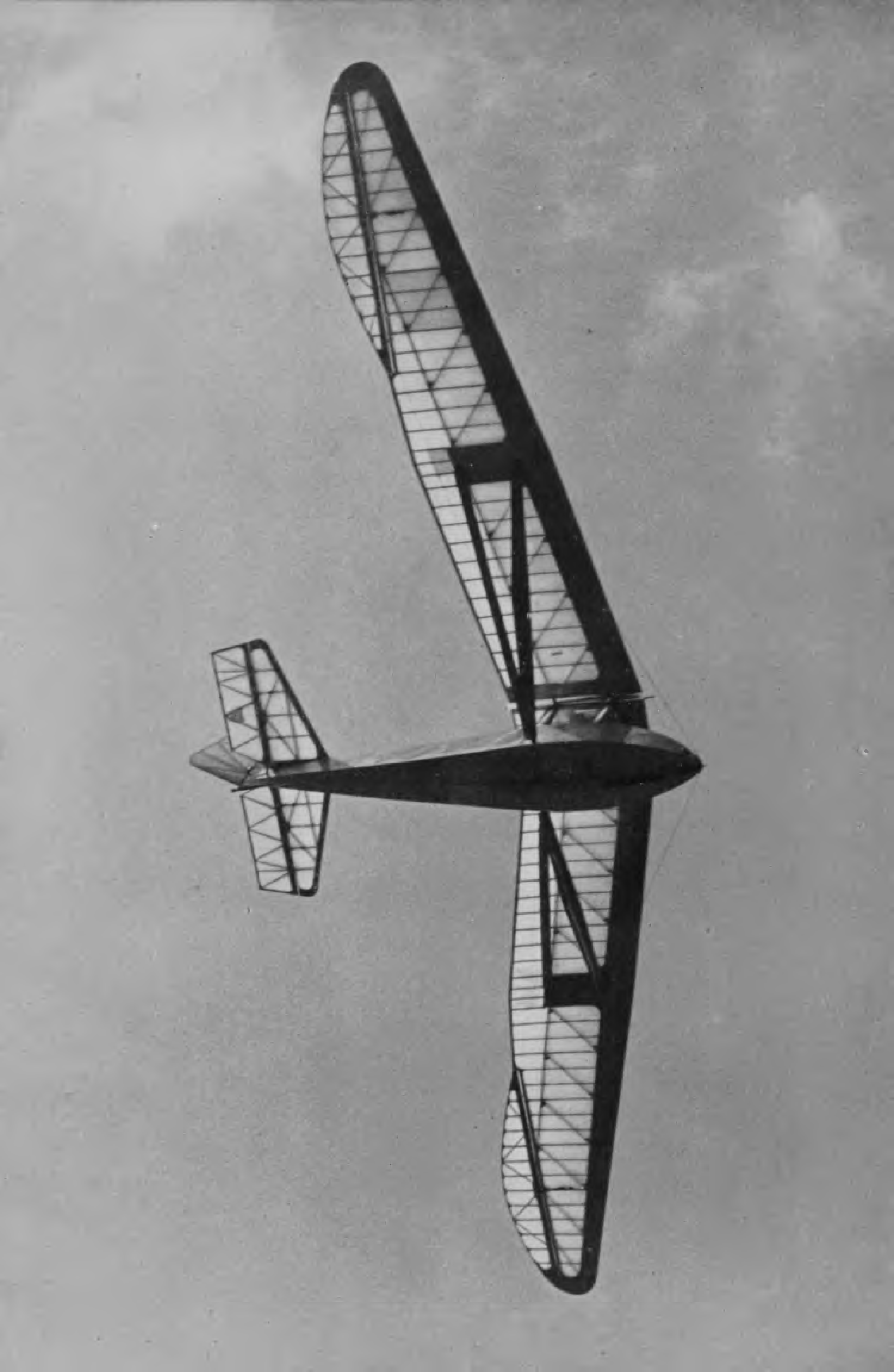
The same morning I took over the controls myself. I had at that time done little instrument flying, but I had had half a dozen beam practices on the Link trainer, so I knew how to interpret the radio signals I should receive on the telephones. The results were interesting. At the first attempt I had to raise the eye shield 50 feet from the ground and 200 yards short of the aerodrome. At the second attempt I managed to come in to the right position for a touch down and only 10 feet up. I was satisfied that it was a proposition for the amateur.

The principle of the beam is quite simple. It consists of a radio path extending in a straight line on either side of the aerodrome, and audible in the aircraft's receiver at anything up to 100 miles. The path is only a few yards wide at either base, but it extends in the shape of a V at an angle of up to 30 degrees.

If you are flying down the centre of the path you hear a continuous note in the receiver. If you are to one side you hear a continuous series of dots, or, on the other, a series of dashes. It is accordingly a matter of adjustment to centralise yourself on the beam, and if you continue on this course you will fly directly over the aerodrome.

On the approach side of the beam there is an outer and an inner marker, the first placed at about 3,000 yards from the boundary of the aerodrome, and the second at the boundary itself. These markers are small transmitters which send a "ray" directly upwards, and which give a distinct signal as you pass over them. The outer marker is a series of quick dashes and the inner a series of dots, rather like the ringing of a handbell. The pilot places himself at 600 feet over the outer signal, and if he is losing height at the correct speed he will be down to 100 feet at the inner. In almost any conditions the ground should then be visible below him and he can make a normal landing (see Fig. 56).

Opposite: A frontal squall drives out over the sea. Conditions of extreme turbulence might be expected under the dark cloud to the right side of the picture. (*See page* 162, *etc.*)



The equipment is expensive, but a wide use will bring it within reach of everybody, just as popularity, abetted by Mr. Ford, did for the motor-car. I have many friends who are occupying plots in the cemetery which the radio beam would have saved. The future must insist upon it.

In America the beam has been used for years between airport and airport on the transcontinental routes. Between each airport it forms an invisible connection, so that the pilot has only to fly down it to arrive at his destination. As a further help a radio compass is fitted, and this has a visual indicator which not only shows him whether he is on the beam, but the number of degrees which he has strayed from it. There is a nice story told of two bored air-line pilots who, after taking off, coupled the automatic pilot to the radio compass and incontinently fell asleep. The first one to awake two hours later was glad to observe that the automatic pilot had kept his aircraft flying down the beam, although they were already 100 miles beyond the home port and flying down the back beam. It suggests the need for an alarm clock set off by a marker beacon.

* * * * *

The only important side of instrument flying upon which I have not touched is night flying. It is instrument flying carried to one of its two practical ends, and if the sailplane endurance record is to be broken again it will have to be undertaken. Some pilots do not like flying at night—most of them because they have never tried it, and a few remarks on the subject may at least remove their fear of it.

In this country the continuance of thermal currents is unusual after dark, although they must obviously persist in thunderstorms. But cloud flying at night in sailplanes has never been attempted, and for the purpose of an endurance flight the pilot's tactics will inevitably be limited to ridge soaring. The problems which arise are bound up with one question—how far will I have to rely upon the instruments?

Opposite : A Falcon III two-seater, whose transparent wings clearly show the method of their construction.

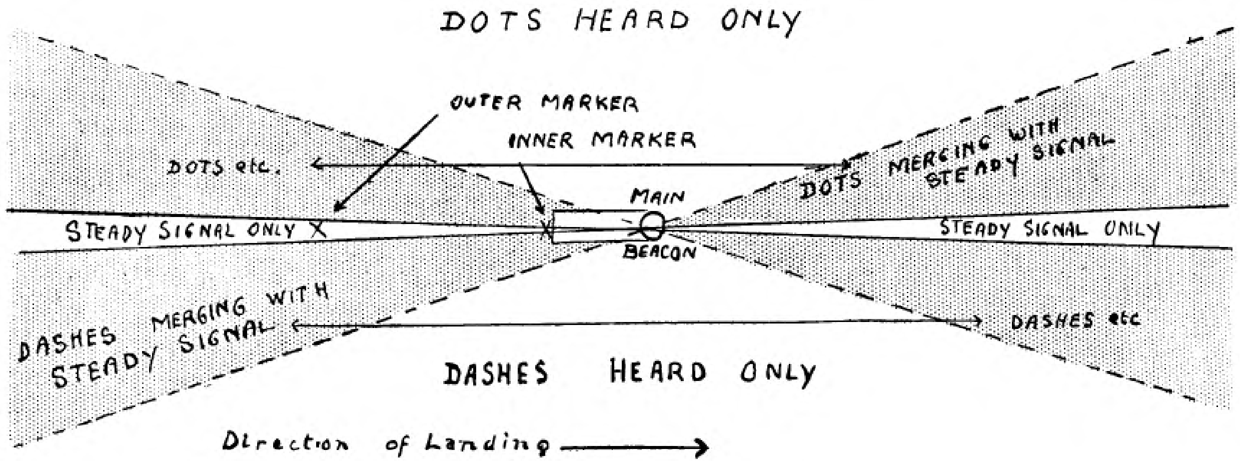


FIG. 56.—*Plan view of radio beam for blind approach.* (*See page* 224.)

The answer is probably not at all, but before arriving at definite conclusions let us consider the salient facts.

On a clear night—that is, a starlit night, but one without a moon—there is sufficient horizon for the average pilot whose eyes have grown accustomed to the darkness to fly without instruments. That is to say, he will have no difficulty in recognising the line round the horizon where the earth ends and the sky begins. The hills will be well defined, and so will the margin of the coast or the outline of a lake or river. Beyond this he may see very little. The differences between the character of the fields below him—of woods, grassland, or plough—will be indistinguishable, although he may see the general run of railway tracks and be fairly sure of the whitewashed walls of houses. While this is more than adequate for straight and level flying, it may need amplification above a soaring ridge whose outlines are obscure against a dark background and over which a turn within the narrow limits of the hill lift will have to be made every few minutes.

Therefore the crest of the hill will need to be outlined by small lamps. On previous occasions helpful motorists have turned on their sidelights, but hurricane lamps placed every hundred yards along the ridge would be a more practical solution.

When there is bright moonlight any form of artificial lighting is probably unnecessary. While glim lights or flares are used on aerodromes whatever the conditions, the runways can actually be seen from several thousand feet, while villages, railway lines, woods, hedges, and different types of field, all show up to a greater or less extent. Under such conditions the outline of the soaring ridge is sufficiently distinct to require little extra lighting. It would only be when shadows cast by the moon were deceptive, such as might be created by a line of trees close to the slope, that special marking would be desirable.

On the other hand, there is a world of difference between this and a moonless night with an overcast sky—and it is under the latter conditions that a strong enough soaring wind is most likely to persist after nightfall. The power pilot taking off from a well-lit aerodrome will check his instruments before opening the throttle. Immediately after becoming airborne, while the runway lights are still flashing by on either side, it is as well to go straight over on to the instruments, settling down with their help to a steady rate of climb, so that the disappearance of the ground which may occur as soon as the illuminated airfield is left behind does not take him unawares. The sudden plunge into complete darkness can be very disturbing and has been the cause of accidents.

In practice it has to be a very dark night on which a pilot fails to find some sort of a horizon. But it is another thing to be compelled to rely on it for a sense of equilibrium before the aircraft is trimmed and the pilot has settled down.

Translated into terms of sailplanes, the continuous outline of the soaring ridge by lights, however small, is essential. No more than a "candle" is needed—for the object of the light is to establish a contour and not to reveal anything of the nature of the ground. With these, and with no more instruments than an A.S.I. and a turn-and-bank indicator, the blackest night should present no terrors.

At the same time, the landing field will require some special illumination to bring the aircraft in, particularly if it has the undulating surface of the average soaring site. A line of hurricane lamps set in the direction of the wind are good enough for putting down any aircraft on a level surface, and more than adequate for a sailplane, which has only to be flown at a steady speed just above its stall right on to the deck. But with the rolling contours of most soaring sites floodlighting of some kind is needed, either in addition to or in place of hurricane lamps. I have flown a glider only on one occasion after dark, and a pair of motor-car head-lamps seemed to be perfectly adequate. (For further reference to this subject, see the account of Mr. Laver's endurance record on page 272.)

Two other points are worth raising in that they affect pilots in different ways. Tests have shown that the night vision of individuals varies, and that where one person can identify objects with a complicated outline in apparently complete darkness, another will fail to see them at all. As a means of improving night sight it has been suggested that the consumption of raw carrots is a good thing—and before we go any farther it will be as well to set the carrot-eaters' minds and stomachs at rest. A whole cartload of carrots, or of anything else, will not enable anyone whose diet is not already deficient in vitamins to see one yard farther. You are either blessed with good night vision or you are not. It all depends on the quality of the special parts of the eye concerned with seeing in the "dark"—and for the comfort of those who wear spectacles let it be said that short-sighted people often have extremely good night vision.

The eye is composed of two distinct sets of lenses—those called cones, which occupy the centre of the eye and work by day; and those called rods, which only function in the weakest light, and even then not until the eye is night adapted. The cones are capable of detecting all the brighter stars, but the rods will detect light which is 100 times dimmer than the dimmest object seen by the cones. Thus stars become visible in their thousands which would not otherwise be seen at all.

At the same time, the rods are incapable of either distinguishing colour or of focusing sharply. Hence the expression "all cats are grey at night." They are at their best in detecting a dark mass, preferably a moving mass, and because they lie towards the sides of the inner eye they are most sensitive when the object is not looked at directly. The best angle is to look 5 degrees away from the object you wish to see. This is the approximate distance of two fingers held out at arm's length. From the foregoing it will be understood how sometimes you may appear to see something out of the corner of your eyes, and then when you look at it directly it disappears.

Full night adaptation requires about 45 minutes in complete darkness. In a bright light the visual purple of the rods is bleached, and acts as a protective screen. But after the first 15 minutes of darkness the chemical process which brings them into action is well advanced—as the simplest test will prove. Incidentally, the rods are insensitive to red light, so that if red goggles are worn it is possible to become night adapted while reading a book in a brightly lit room.

The importance of being adapted before taking off needs no underlining. But while all pilots realise this, some of them insist on switching on a bright light over their instrument panel. The pointers of modern instruments are painted with luminous paint, and if any light is needed at all, it should be kept down to the dimmest glow. Should a bright light, such as the head-lamp of a car, be turned in your direction, the only thing to do is to close your eyes, or close one eye if you happen to be driving.

There are many good night pilots who would make a poor showing at the standard night-vision test. This will no doubt be another comfort to the prospective night flier—and the reason is twofold. First, the day cones and not the night rods look after the landing. The ordinary lights of the aerodrome or landing field are sufficiently bright in every case to call for the cones rather than the ultra-sensitive rods. Even a dim hurricane lamp at 200 yards will be seen by the former. Second, it is not so much what the pilot sees that matters, but how he interprets what he sees. I happen to have poor night vision myself, but experience of night driving has taught me to interpret those objects which I do see quickly and reasonably correctly.

To return to flying by instruments for a moment, there are two final considerations to which every pilot should give some thought whatever his vision. I have heard people who ought to know better say that the senses should be used in conjunction with the dials on the instrument panel. It was and is a dangerous doctrine. At night or in thick cloud there should in my opinion come a moment when a decision is essential either to fly on instruments or to continue to fly on the senses—and never upon a combination of the two. If one is used as a check upon the other, there will come a time when the instruments say one thing and the senses say something else. A typical illusion in blind flying is that the aircraft is straight and level, whereas the instruments record a turn with 20 or 30 degrees of bank. Confusion, panic, and possibly a spin are the heirs of such a situation.

The second point is closely bound up with the foregoing sentiments. Faith in the instruments is more important than faith in oneself. Such faith is not easy to acquire, for the strongest impressions, sometimes amounting to absolute conviction, have to be overcome. I have seen the artificial horizon tip gradually to one side while the gyro indicator has begun to move slowly round, and all the while I would have been prepared to swear on oath that both bank and turn were being made in the opposite direction. It may be good enough to take a swift glance at this instrument or that while passing through a patch of cloud. But the sort of circling demanded by cloud flying in sailplanes—or in any aircraft on a really dark night—calls for confidence and reliance upon the dials in front of you, and upon nothing else.

AIRMANSHIP

I LEARNT more about airmanship in my first twelve months of Service flying than I had in the previous twelve years—and so did every other amateur pilot who in 1939 exchanged a uniform for his grey slacks. It was soon obvious that there were sufficient hazards to be met in the air from outside sources without gratuitously adding to them yourself. I think I was regarded as an old woman by both my ground and air crews.

Before I took off for an exercise over the sea with pupil observers and air gunners I always asked some stock questions. The first was: "How do you launch the dinghy?" The next one concerned the fire extinguisher and how it worked. The third demanded information about the colours of the day, a fourth the tracks they were to make good. Then the rigger would climb up alongside my own cockpit and lay over my shoulders the two top straps of the Sutton harness. If the rigger was a stranger he would generally jump back to the ground and stand by the starter battery. But if he was my own rigger he always waited, and without being told adjusted the straps so as to pull me hard back against the seat. He knew that I shouldn't carry on starting the motor until this was done.

Then the fitter would climb up after the engine had been warmed and the magnetos tested, bringing with him Form 700 for signature. Instead of handing this over folded up, he always gave it to me spread out, so that I could see along the whole length of the line on which I was signing. He knew that I should decline to sign it unless this was done.

This insistence on carrying out the letter of the law was not born out of any special respect for the flying regulations, but out of a continuous stream of incidents, some of them grim, some merely funny, which all led to the conclusion that there is a limit to the thing called luck. This is a conclusion to which every self-respecting airman comes sooner or later. The subject is so important that a selection of incidents due to bad airmanship may at least be a warning to glider pilots.

One day I had just recrossed the coast after 2 hours over the

North Sea when the oil pressure of the Tiger VI engine behind which I was flying collapsed. The first momentary shock of seeing the needle of the gauge flicker and subside to the bottom of the dial was followed by a profound relief that I was over the land. Not merely that, but an aerodrome was directly below, and I was able to shut off the engine to avoid seizing up and make a simple forced landing.

An R.A.F. Flight Sergeant with a bedside manner cheerfully took the engine in hand, and to my surprise returned in 10 minutes saying that it was now ready to be flown home. He had a meaning smile on his face, and when I asked for the explanation he replied that he had done no more than fill up the oil tank, which was dry. Not unnaturally, I returned to my home aerodrome much aggrieved and complained bitterly to my rigger about the lack of oil. There was, of course, an official enquiry, and I was still more exasperated to discover that I myself was to blame. I had signed Form 700 without reading it. In other words, I had put my signature to a document which should have stated in the appropriate columns the quantity of oil, petrol, etc., in the aircraft. The oil tank had not been refilled, as a casual glance at the form would have shown. The rigger who had been detailed for the job had been called away before he completed it, and the fault was mine in accepting the aircraft.

Good airmanship implies a discipline of the mind which declines to take off on a flight until every routine check has been made. It makes no difference whether the pilot has to fly a 4-engined bomber or a single-seat glider.

As an incident of the grimmer variety, the acquaintance who didn't bother to strap himself into the rear seat of an aircraft on a practice formation flight is a fair example. When 3,000 feet up the wing tip of the left-hand machine in the formation came into contact with the tail unit of the leader, with the result that the leader's aircraft was thrown on to its nose. No serious damage was done and the pilot was able to straighten out of the dive and make a safe landing. The man in the back was shot out of the rear cockpit and made an unpremeditated descent without a parachute.

And another one—taking off from a gliding site on a winch launch, a friend reached a height of about 200 feet when the towing cable appeared to become detached from his aircraft. He therefore turned round to make a quick circuit and land again. The winch had, however, merely been stopped. The visibility at the time was poor, and in view of the great length of cable which was being used it was impossible to be certain whether the glider pilot had pulled his quick release. The safety man with the axe standing beside the winch saw the cable lying on the ground and did not accordingly chop it. The result was that the glider, whose pilot had not released the cable, was finally brought up standing as he flew back, and his aircraft did the first half of a bunt into the ground.

Another acquaintance who was blessed with handsome features ruined them through neglecting to tighten the straps of his Sutton harness—a common habit with many pilots. One day he made a bad landing and the undercarriage of his aircraft collapsed. Normally the pilot would have received no injury of any kind, but owing to the loose harness straps he was jerked forward and his beauty ruined on the edge of the gun sight.

In gliding, where the pilots do their own rigging, a popular way of courting disaster is to cross the controls. This is fatal, and lends colour to the importance of making a check before take-off.

I will quote just one more illustration on ground drill which for me has always remained impressive.

I was invited to a Naval Air Station in the Midlands by a man who had several thousand hours' air-line experience and was reckoned to be one of the finest living pilots. We climbed into the "office" of an Oxford at an aerodrome near London, I taking the second pilot's seat. My host's cockpit drill was a revelation. He behaved like a pilot who had never before seen the type he was flying. Switches, trim, rudder bias, brakes, and instruments were tested one after the other, and before we took off he swung the aircraft to make sure of the directional gyro and the artificial horizon—and this in perfect flying weather.

If an experienced pilot methodically goes through the prescribed drill every time he flies, how much more important it is that less experienced people should at least do the same thing. One of the reasons why my friend had lived so long, and was considered so good, was because he obeyed the rules.

Airmanship is not, of course, confined to the ground. If you spend a day at any big air station you can see what is meant by this. You will see, perhaps, a pilot cut into a crowded circuit, dodge across the bows of another aircraft, and land out of turn. You may see a second pilot "shoot up" the hangars and then sneak into the runway from only a few feet above the ground, where his camouflage makes him almost invisible to another aircraft making a correct circuit and coming in above him. Disciplinary action is instigated to deal with these sort of delinquencies in both the F.A.A. and the R.A.F., but in civilian flying there is often little but good manners to promote good airmanship.

Into such considerations as these enter the rules of the road.

Some years ago there was a gliding accident at Sutton Bank which illustrates the importance of the rules. A two-seater and a single-seater aircraft came into collision while ridge soaring, with the result that the two-seater was left without a tail, while the single-seater had the front part of its fuselage removed, destroying the rudder controls. The two-seater came to earth in a tangle of bushes 400 feet below. It had turned over, and alighted gently in on its back without hurt to the occupants. The single-seater, with aileron and elevator control unimpaired but without rudder, succeeded in making a straight glide into the tops of the fir trees above the lake at the northern end of the slope. The pilot was not even scratched.

It must be obvious that if the simple rules of the road are obeyed such an accident in clear weather could never be possible. In gliding this means that one aircraft overtaking another on the soaring ridge shall pass on the inside, while two aircraft meeting head on shall keep to the right.

Sailplanes circling up into cloud in the same thermal are a menace difficult to deal with. I have personally seen as many as four within 300 feet, one of which was circling in the opposite direction to the remainder, and all climbing at slightly different speeds. As far as I know, there are no specific rules laid down to cover this type of thing, and it may need a serious accident to produce the necessary legislation. At the moment the problem is left to the ordinary rules of the road plus any precautionary logic on the part of individual pilots. For myself, I should refuse to enter the same cloud within half a mile of any other enthusiast, nor should I be prepared to face another sailplane on an opposite circuit below the cloud if he came within 100 feet of my own altitude.

For glider pilots in particular the following might be summarised as the more important points of airmanship before take-off.

1. Unless the aircraft has been flown by another pilot that day he should check the rigging for the following:
    (*a*) Wing alignment and wing root anchorages, securing pins and safety pins, ditto wing struts and all control junctions.
    (*b*) Aileron droop.
    (*c*) Tail assembly for alignment, pins, safety pins, hinges, and control junctions.
    (*d*) All controls for free movement and for tension of control wires.
2. Examine the skid. This is the part of a sailplane which may have easily been damaged by a previous heavy landing.
3. Test the quick release gear by getting somebody else to put a strain on the cable while the pilot pulls the release ring. Adjust the harness of both parachute and safety harness until they are comfortably tight.
4. Set the altimeter to zero or to the height of the launching point above sea level.
5. Wind up and otherwise check the barograph, if one is carried.
6. Check the electric turn-and-bank indicator.
7. Have the flight planned beforehand if the pilot intends doing a "cross-country," with intended track ruled on the map and 10-mile circles marked in.
8. Have all the available information about the weather prospects before take-off.

In the air airmanship will depend on two principal factors—

a knowledge of the pilot's own limitations and the rules of the road.

On a crowded ridge it is sometimes the better part of valour to give up an unequal struggle for air space and land. On the days when this is advisable the lapse rate is often so poor that the ceiling is low, crowding all the aircraft into a narrow belt immediately above the crest of the hill. One loses nothing but ridge soaring on such a day, for the chances of thermals to cloud-base are practically non-existent.

Good airmanship in cross-country flying is largely an expression of the pilot's individual skill, and has been dealt with at length. In the negative sense it should prevent him from entering a cloud without a parachute, without noting the shortest course out of it, and without taking some previous note of what sort of a cloud it is. Nor do I think it is fair on either the pilot or his aircraft to enter a big cumulus without adequate instruments, including a turn-and-bank indicator. Once inside cloud, it is not good airmanship to carry on under icing conditions or turbulence which is obviously putting a serious strain on the sailplane. The safety factor of the aircraft itself, which should be known to the pilot, will be a guide to this, but unless the aircraft is his personal property and he is willing to make the return journey by parachute, if necessary, caution is commendable.

While landing at the end of a cross-country flight scarcely comes under the heading of airmanship so much as it does under common sense, I have known pilots choose the strangest and most inconvenient spots for their landings. If it must be a field instead of an aerodrome, then the logical choice is one next to a road with a gate. As a member of a retrieving crew who has helped to transport aircraft over a succession of stone walls, I write with feeling.

After landing it is important not to leave the aircraft unattended until some responsible person has kindly promised to stand by or it has been put in a safe place. Cows and small boys are fascinated by sailplanes, although for different reasons (cows eat them). Furthermore, a strong gust of wind will do £50 worth of damage in a couple of seconds. As a precaution against the latter, and if it is necessary to leave the aircraft in the open, it should be turned at right angles to the wind, and the wing on the windward side laid on the ground and weighted. If the wind is dangerously strong, the cockpit can conveniently be the recipient of about 100 lb. of large stones.

Additionally, it is the duty of the pilot to telephone his friends at the earliest possible moment. A search party has before now scoured the moors for a pilot who was peacefully sleeping in a farmhouse.

Lastly, good airmanship is associated with good judgment in doubtful weather conditions. I was once leading a flight on a cross-country journey when we ran into a front of low cloud, rain, and bad visibility. There was high ground on all sides and more high ground ahead, which was in cloud. As the completion of the journey was not urgent, I decided that it would be wise to land at the nearest aerodrome, have lunch, and complete the trip after the front had gone through. This I did, but the pilot of one of the aircraft decided that he would go on alone. He climbed into the cloud and came out at the top at 9,000 feet, flying on a compass course and relying on finding a clear patch through which he could descend at the other end of the journey. He was not lucky in this and was compelled to fly beyond his estimated time of arrival in order that he should descend somewhere over the sea. Fortunately for him, his guess as to the winds which were blowing brought him out well over the coast, and he finally broke cloud over the water. He arrived 3 hours before the rest of the flight, and had the stupidity to boast that he was a superior pilot to the rest of us.

The truth is that a good pilot will never fly above continuous cloud unless he knows with certainty that there is clear weather at the other end or he has the necessary wireless aids. He will not enter a valley in thick weather without leaving himself an avenue of escape. He will not lay himself open to icing in cumulo-nimbus unnecessarily. He will not make any long cross-country journey without first obtaining a weather report, nor will he embark upon such a journey without maps upon which the route is laid out in pencil, the courses corrected for wind speed, and the estimated time of arrival written clearly over picked landmarks.

FORCED LANDINGS

EVERY landing is a forced landing for a sailplane. But a low stalling speed, usually less than 35 m.p.h., removes most of the difficulties. In a high-efficiency type the lift spoilers which are applied at the last moment—when it is certain that the chosen field will be reached—make a low-speed touch-down at the selected spot more than a probability. In any spot-landing contest which reveals these qualities five aircraft out of six in the hands of capable pilots will pull up within 20 yards of the target, or easily within the boundaries of a tennis court. But just because most crack-ups occur when landing, a perusal of dos and don'ts will be repaid. The most important things to remember might be listed as follows:

1. Pick your field at the end of a cross-country flight while you still have at least 400 feet of height in hand.

2. Whatever other qualities the field may possess, let it be clear of trees on the approach side.

3. Different types of field in order of merit are (for sailplanes) stubble, newly harrowed and newly sown ground, young corn up to 12 inches high, grassland which has no "rollers" in it, and when emergency dictates, standing grain, and if the furrows lie with the wind, plough. A landing on any one of them can be made without damage, though in the cases of standing grain and plough a high wind will make it easier.

Moorland nearly always provides a nice landing ground for sailplanes, although it is invariably fatal to power aircraft. On the other hand, grass fields with ridges running along them are dangerous, the more so because the unevenness of the ground is difficult to detect when the sun is high and casts no shadows.

4. Other points of importance about fields are the nature of the obstacles at the far side of them. The best sort of field is one which has another one like it next door, separated only by a wire fence. The worst is one bounded by a sunken road, a wood, a stone wall, or farm buildings.

5. Given a choice between landing upwind on poor ground or downwind on good rising ground, it may be worth choosing the latter if the wind is light. Downwind uphill landings are fast, but safe and easy in a well-handled sailplane.

6. Remember that on a rough day it will be rougher still near the ground. An extra 5 miles an hour in a sailplane and 10 miles an hour in a power aircraft are advisable.

7. If the worst comes to the worst, a sailplane can be put down on the top of a fir wood. No other sort of wood is recommended.

8. The secret of a successful forced landing—in fact, the secret of any landing—is a good approach. You should never turn your back on the field once it has been selected. The flight of a sailplane is so slow that the pilot can beat up and down almost directly over the boundary of his choice. He will thus be in a position to turn into the field at any moment. The higher speed of a power aircraft demands broad S turns, but still made without losing sight of the field. A side-slip, possible on all gliders and most power craft, is the safest and quickest method of losing unwanted height during the final stages.

9. It is worth remembering that groups of buildings and trees create downdraughts in their lee on rough days. They should never be crossed at a height of less than 50 feet. I have seen a pilot who overlooked this precaution do a creditable reproduction of a Father Christmas descent down a chimney.

10. If a dangerously solid obstacle lies in your path after touching down, the nose of a glider can be dug into the ground without damage by pushing the control column hard forward. If this fails to check the speed sufficiently, it may be necessary to wipe off a skid and perhaps a wing tip by thrusting a wing into the ground on the ailerons.

Drastic tactics are very often thrust upon the pilot because in the middle of making a forced landing he changes his mind. Second thoughts may be well enough on the ground, but in the air the critical stage is too swift in its passage to make them worth consideration. Even if you suddenly realise that your choice is a poor one, make the best of it.

11. Lastly, never undershoot. It is better to make certain of

landing at the far side of a field than in the wall at the near side. A point one-third of the way across the field is the safest mark.

If these considerations are adopted as the pilot's creed, there is no reason why he should not fly for years without even chipping the varnish.

INSTRUCTING

"DO you mind doing a bit of instructing this afternoon?" I looked at the speaker and was forced to consider my own competence. I had never instructed before, and the methods of others were flashing through my mind like strings of express trains. "Keep the nose down—push the stick forward. . . ."

"Ground slides," said the speaker.

The expresses stopped. Ground slides were almost an insult—yes, I could instruct on slides. So I found myself walking up the slope to the far end of the field and meeting a bunch of people whose open shirts, brown faces, and terrific eagerness were astonishing. They might have been a set of new arrivals in heaven about to be issued with their wings. As for myself, I felt like an archangel. Instructing affects people like that—at the beginning. For just once in life the high opinion which you hold of yourself is endorsed by all those around you. Later—not much later either—you wake up to discover that the instructional cluster of which you are the centre is less of a mutual admiration society than a chain gang. All the responsibility for the prisoners is yours, a burden which emerges as you discover that every now and again one of them tries to commit suicide. It is only at this stage that one begins to learn a little about instructing.

There has never been a civilian instructor's training manual, and I hope there never will be. It would destroy yet another informality in a pattern which is made of informalities. Nor are there any qualifications or examinations or ritual attached to the office. One first becomes an instructor because someone else says: "Do you mind giving a hand . . . ?" But the fellow who issues the invitation, casual as it may sound, has summed you up. He's probably discussed it with others of experience, and they have come to the conclusion—not in committee, but over a pint in the bar—that you are to be trusted. If they analysed their reasons they would discover that they had assessed you to be:

(*a*) A sound pilot.
(*b*) Popular, and therefore likely to be obeyed.
(*c*) Unselfish.

In fact, it's a nice tribute to be requested to instruct.

* * * * *

I've shown the pupil's end of learning to fly, but it is surprising how different it looks from the instructor's side. If the thoughts of pupil and instructor were written down faithfully, they would represent such a widely different flow of ideas that they might not even be recognised as belonging to the same subject.

Out of every hundred pupils taught before the war, ninety-nine worked from the ground upwards. That is to say, dual control for *ab initio* training was very rare. Either winch, towing car, or the elastic rope was relied upon to pass the pupil through all the stages from the first slide to the soaring ridge, after which the pupil could break his neck in his own way. First, therefore, I shall confine myself to the kind of instruction in which the instructor remains on the ground and only the pupil flies. The system is likely to go on turning out more pilots than any other for a long time.

It divides itself into three stages:

Stage 1. Ground slides.
Stage 2. Ground slides to "A" certificate.
Stage 3. "A" certificate to the first soaring flight.

Stage 1 can be fulfilled with either an elastic rope, a towing car, or a winch, Stage 2 with a towing car or winch, and Stage 3 with a winch only. That does not mean that a winch is essential before a "C" certificate can be obtained. The whole thing can be done comfortably with an elastic rope if a slope is used. But the normal sequence of rapid instruction envisages a winch for at least the third stage, and preferably for number two as well.

Preliminary Points for the Instructor

1. If you are instructor for the day, contact your winch driver, agree with him on the best position for the car having

regard to the wind, help him to start the engine, and see him safely off into position.

2. Make out your list of pupils in order of flying. Tell two of them to be responsible for the retrieving car, and send them out to grapple with it (it will loosen up their muscles).

3. Send the remainder of the pupils up to the hangar to get out the primary and have it waiting for the retrieving car. Go with them yourself and carry out the daily inspection on the aircraft. Remember where the pad of D.I. forms are kept (this defeats most instructors).

The preliminaries can cause infuriating delay unless they are organised. If the "bunje" only is being used, the winch, of course, is dispensed with, and so is the retrieving car if the pupils are young and numerous.

Once on the site, and you have a new pupil ready in the seat, I suggest the following sequence of instruction:

(*a*) Tell him he's not going to fly. (He may think he is, and be in such a state of mental effervescence that he will take in nothing you say to him.)

(*b*) After satisfying yourself that he knows what the controls are for (and I've never met a boy over the age of 12 who didn't), show him the central position of the stick and tell him to memorise it. Turn the aircraft into the wind and give him 3 minutes' balancing practice on the ailerons. If there is insufficient wind for this, take the wing tip yourself and rock it slowly up and down to simulate gusts, watching at the same time whether the pupil is making the proper corrections. When you are satisfied that he has got the idea, explain that the glider is now to be pulled across the field at just sufficient speed to enable him to repeat the exercise under flying conditions, but without actually flying.

Before the slide commences (if you are using either a winch or a towing car) satisfy yourself on the absolutely vital point that the driver understands his instructions. The driver will be an experienced operator (more on this later), and if he is told that a slide only is required he will provide exactly the necessary speed. The driver who gives speed for a full launch and then is able to make the excuse that he "didn't realise what was required" is not to be blamed to the same extent as the instructor who is finally responsible. Having assured himself on this, he should impress the pupil with the only two points that matter at this stage:

(*a*) He is to hold the wings parallel to the ground by lateral movements of the stick.

(*b*) He is to keep the stick forward of the central position while making the lateral corrections. (This is to establish an awareness of its fore-and-aft importance for the next stage and incidentally to make sure that he doesn't leave the ground.)

The use of the rudder should be mentioned only in a negative sense, although the pupil may be encouraged to ascertain its effect during the slide. As a general principle, however, instructors should proceed on the basis that the rudder does not exist, and during the early lessons the pilot should be told the effects of its misuse. I generally make two statements on this subject, both of which are substantially true and are sufficiently impressive for them to be remembered. The first is: "I will fly a Spitfire from Croydon to Paris, making a tight turn around the Eiffel Tower, and will land again without touching the rudder." And secondly: "It is impossible to get into a spin unless the rudder is used." It may seem that undue emphasis is being laid upon the dangers of this control, and that the pupil will realise later that it is a most useful thing—in fact, that he has been misled. No harm is done, except, perhaps, to the instructor's reputation for infallibility. And the point that really matters is that the pupil will be guarded against the chief cause of most serious accidents.

The towing cable may then be tightened up ready for the launch. The signals for this process are by mutual arrangement with the driver. Those which answer well are:

Take up the slack: Flag or arm moved slowly round the head.

Stop: Both arms held straight up.

Proceed with the launch: Both arms outstretched and raised and lowered continuously.

Three long pulls across the field on a 2,000-foot cable by winch, or six shorter pulls by towing car, should see the average pilot ready for his first real flight. If during the pulls across a wing goes down so that it touches the ground, the driver may decide to stop the "launch" for a fresh start from the new position.

When the "bunje" only is being used, the whole procedure will be slower and less effective, because the time which the pupil has for learning the effects of the controls will be limited to about 3 seconds for each launch. A slide can, however, be given with safety if the crew are properly briefed. The pupils waiting their turn should man the rope and hold back on the tail. If the wind is more than 10 m.p.h., not more than two a side should be required, while three a side should be sufficient in a calm. Considerable judgment, only acquired by experience of "bunje" launches, will be needed by the instructor. It is easy to give too powerful a launch, with the almost certain result that the aircraft will leave the ground. A common reaction of the pupil after this is to clutch the stick into his stomach, with an inevitable zoom. What happens subsequently is in the lap of the gods. The worst may be a stall at 20 feet and a dislocated vertebra, the least a broken flying wire. To ensure against it two precautions may be taken: First get the pupil to start with the stick hard forward and instruct him to keep it there whatever lateral movements he may make; and second, give the man you have posted to hold back on the tail the order to release early. This may result in practically no forward movement at the first attempt, but it will enable you to judge the amount of stretch required for the next launch.

During the extension of the rope the crew will walk throughout, and will not be given the order to run as required for a full launch. If these tactics are adopted the method is safe. The result will be a slide of 30 or 40 yards, depending on the strength of the wind. A total of six such slides should be sufficient for each pupil at one lesson, as compared with one or two long slides with a winch or towing car.

The total number of launches necessary before a pupil is ready to leave the ground will probably vary more in the case of the "bunje" than with the other methods. It will depend largely on the continuity of instruction. A pupil who is given six slides morning and afternoon for two consecutive days will be further advanced than one whose instruction is widely spread. The week-end pupil is handicapped and may take a long time to grasp the essentials. Gliding camps have shown the truth of this in the large number of "A" certificates obtained as the result of consecutive days of instruction. At the London club on one occasion a pupil who had never flown before took his first lesson on a Saturday and his "A" certificate on the following Monday.

Stage 2

The pupil is now ready to fly. He has shown that he can keep the wings parallel to the ground during his slides, and is making his correction rapidly and smoothly. He has perhaps occupied the aircraft while it has been in motion for a total of 5 minutes.

The points which should now be made are of the utmost importance. The instructor's patter should be on the following lines:

For Winch Launch or Auto Tow.

1. We are now going to pull you over the ground at a slightly increased speed, so that if you ease back the stick during the course of your slide the aircraft will leave the ground.

2. You will carry out exactly the same procedure as before, except that the stick is to be held only slightly forward of the central position. In this position the launch can be completed as a slide without leaving the ground at all.

3. When you have settled down, get a good sense of the position of the horizon by looking towards the winch car. Then ease the stick gently back until the aircraft rises. Immediately, but without a jerk, move it forward again until it is almost in its original position. The aircraft should then continue to fly parallel to the earth a few feet up. If, on the other hand, it returns to earth, wait a second or two, and then, when you feel ready, ease her off again, and again ease the stick forward.

4. If the aircraft continues to climb and gains more height, move the stick firmly forward until its path is again towards the earth.

5. It should not be necessary to use the rudder. The pull of the wire will keep the aircraft straight.

The pupil should then be examined to make sure that he understands his instructions, particularly Number 4. The launch may then be carried out.

The safety of this flight and those which follow it chiefly depends upon the skill of the driver of the winch or towing car. (Notes on this subject follow at the end of the chapter.)

It will be found that most pupils show certain faults, which should be pointed out between the launches. The most usual is over-correction of the elevator. The aircraft will probably be eased off the ground very nicely, only to be slammed down hard through too violent a forward movement of the stick. It will then bounce, and possibly start a grasshopper form of progress which the winch driver may decide to terminate by slowing down the tow to below flying speed, completing the launch as a simple slide. Alternatively, the pilot may climb too high in spite of his instructions, and a situation arises with which only the winch driver can deal (see notes). It is more probable that in spite of orders the pupil will be seen to be making big movements of the rudder. The instinct is very difficult to resist, for the surge of the towing cable is apt to swing the aircraft from side to side, and it is only the experienced pilot who can endure this with peace of mind. The pupil should be told again about this.

At the end of the launch it is possible that the pupil is thinking how very difficult it is and how badly he has flown. He knows that his path through the air has been a long wavy line punctuated by bumps. If you think he is feeling discouraged, it is worth telling him that the most difficult evolution which any glider pilot can carry out is a smooth flight in a primary trainer a few feet above the ground. (In my opinion perfection is as near impossible as matters.)

This point is almost as far as can be reached if only the elastic rope is available—unless instruction can be continued on a hillside. The procedure in this case is the same, three a side being required for stretching, and finally—if the weather is calm—four a side. The launches should become progressively stronger until the pupil is safe to be given a full launch. Progress will appear good, for the aircraft in free flight is much easier to control. If there is no dangerous tendency, instruction can very soon be transferred to a slope where longer glides are possible and a rapid approach is made towards the "A" test, for which the crest of a hill at least 400 feet high will be required.

On the winch the time has come to get the most important rule of all into the pupil's head. Two or three pulls across at a height of between 2 and 8 feet should have prepared him for his first high flight, his first glide, and his first free landing. Tell him that he is to pull up to 30 or 40 feet on his next launch, and is to fly parallel with the ground at this height across the field. Explain how much easier he will find it than flying close to the ground with the surge and swing of the cable making it difficult to keep a straight course. Lastly—and this is the point which must be stressed above all else—instruct him to put the nose of the aircraft down as soon as he feels the pull of the cable relaxing. The winch or towing car (the latter with a longer cable) will shut off power or stop so as to allow plenty of room for the glide, and it is this moment for which the pilot must be ready.

Express the instruction in the form of a permanent notation: "The first job of the pilot of a glider in free flight is to get the nose of the aircraft below the horizon."

The instructor should take the opportunity of having a chat with the pupil before he is strapped into the machine. He should introduce the following subjects:

(*a*) The steep natural rate of a glider's climb on the winch and the necessity for checking it until he has more experience.

(*b*) The way to recognise that the climb has become too steep by the snatch of the cable followed by a slack moment before a fresh snatch intervenes. Explain that this snatch is due to the aircraft stalling—although it continues to climb.

(*c*) The importance of levelling off and getting the nose down as soon as the pull of the cable lessens. (There can be no doubt when this occurs, for it is very clearly felt.)

(*d*) The value of looking ahead and fixing a point by which to assist the maintenance of a constant glide path.

(*e*) The way the sound of the wind can help to estimate flying speed.

(*f*) The necessity for delaying the hold-off for the landing until the ground is not more than 6 feet below. In this connection tell him that you want to see the glider flown through the top of the long grass over the last 20 yards.

(*g*) And finally, once again, tell him to put the nose down and keep it down at the top of the launch, and that you want the glide to be fast.

It is seldom that the instructor is given any anxiety by this flight if the foregoing points have been made. The most common fault is "landing too high up," and this must be cured by further practice. Each subsequent launch may be made higher with an increasingly long glide. Gentle S turns executed with bank and limited rudder may be permitted if the pupil is shaping well. After three or four high launches it is quite likely that he will be ready for his "A" test. He should take this in his stride, for it is only an extension of what he has done already.

Stage 3

The step between the "A" test and the soaring ridge is usually a short one. Progress is always rapid once free flight has been experienced. The step includes, of course, the "B" test, which requires a glide of 60 seconds with a right and left hand turn in addition to two other glides of 45 seconds each. Approach to the soaring ridge (if it is within reach) should be discouraged until the test is passed.

Sooner or later, and preferably sooner, a change to a more advanced aircraft will have to be made. While the "B" test can be taken on the primary trainer from a winch launch to 700 feet, it may be difficult to get sufficient height for the full 60 seconds for a pupil who is inclined to fly fast—and therefore safely. A nacelled Dagling or a secondary glider such as the square-winged Kirby Cadet is a more suitable type. From 600 feet a glide of 2 minutes is within the range of the Cadet.

The move from the original primary need not be accompanied by any preliminary ground hops on the new machine. The pupil will find the more efficient type easier to fly, and he will appreciate the "horizon" which the nose of the aircraft will be giving him for the first time (unless the primary has been fitted with a horizon bar).

Points for the instructor to make are:

1. The quick-release mechanism should be demonstrated, and the pupil made to operate it with the cable tight before he takes off.

2. He should stress the importance of getting used to the sound of the new aircraft for the estimation of speed. (This remains important even if an A.S.I. is fitted—a well-trained glider pilot's ears are a better instrument.)

3. The old story of the less rudder the better should be repeated. The turns should be made by putting on bank first and adding the necessary amount of rudder afterwards. They should be preceded by depressing the nose and increasing flying speed. (Later, rudder will be kicked on first.)

4. Warn the pupil against making a turn close to the ground. The last turn should be completed with 50 feet in hand.

5. Be sure that the pupil understands that he must land directly into wind.

It often happens that the instructor finds a good pupil ready for his "C" test immediately after taking the "B." There is no reason why the tests should not follow quickly if conditions are suitable, although I would first prefer to give every pupil at least three complete circuits of the field from a high launch, and if a stretch of the ridge can be taken in as a part of the circuit, so much the better. The introduction to unstable air is thereby not so sudden.

The pupil should now be sent down to inspect the emergency landing field at the bottom of the ridge where the normal landing ground is on top.

Patter for First Soaring Flight.

(*a*) Pull up on the winch to the maximum height, and, maintaining a straight course, establish the best gliding speed. The passage from the stable air to the unstable air will be sudden and will probably occur immediately over the crest.

(*b*) Don't be upset by the instability. Hold the stick lightly and make the corrections smoothly and firmly.

(*c*) Turn to fly parallel to the ridge in the direction which will provide the longest initial beat. This will give plenty of time to settle down and give you the "feel" of soaring.

(*d*) Make the turn at the end of the beat outwards from the ridge, first putting the nose down to increase the speed, and then applying the proper amount of bank. Don't skid the turn on the rudder.

(*e*) If for any reason you get into an attitude which you haven't been in before, put the nose down. It is possible that if you have been flying too slowly a wing will stall as a result of a gust. Putting the nose down will immediately restore full control.

(*f*) Come in to land after 20 minutes by making a wide circuit of the field. Aim at putting the aircraft down at least one-third of the way inside.

A towing car and cable can be used with equal success at many soaring sites. The procedure is the same, although it is unlikely that the pilot can be given the same initial altitude. This will mean that he enters the soaring area with a smaller margin, and he should be warned that if he comes within 100 feet of the crest and *is still sinking* he should immediately turn in and land. This equally applies to a winch launch, but it is a less likely event to occur.

If the landing ground is at the bottom of the slope, the pilot should give up the attempt to soar *as soon as he is level with the top of the ridge*, and should concentrate on making a good landing below.

When the elastic rope alone is available, the "B" test can best be given on a calm day from the crest of the soaring ridge. The "C" test will follow with a normal full launch into a soaring wind. This will place the pupil only about 40 feet above the hill-top, and will entail a prompt turn along the ridge to remain in the upcurrent. Local conditions will govern the instructor's decisions and advice, and no hard-and-fast rules can be laid down for the most propitious moment to authorise the flight. But scores of pilots have taken their "C" from a "bunje" launch, and there is nothing dangerous about it. The instructor will, however, make two special points:

(*a*) He will tell the pupil to level off and settle down immediately the launch is completed, but *before* making the turn along the ridge.

(*b*) If the pupil fails to soar, he should be told to turn out over the valley *without delay* and land in the emergency field at the bottom. (He will already have prospected this.)

In no case should an instructor send off a pupil for his "C" before the conditions over the ridge have been tested by an experienced pilot. The quality of the lift should place his ability to soar beyond reasonable doubt. The wind should be smooth and not gusty.

As soon as the final certificate has been won, the pupil usually passes out of the hands of his instructor. But the latter will, if he is conscientious, continue to keep an eye on him. The pilot's rapidly increasing confidence may now lead to dangerous faults, the chief of which is to fly too slowly in the hope of climbing higher than others soaring the ridge. The quicker the tendency is firmly suppressed, the better for everyone.

Side-slips may be explained and practised, but a warning given to complete each slip 50 feet above the ground. Tail-swishing and cross-wind landings should be discouraged, although an explanation of how they are executed is useful. Any form of aerobatics should be threatened with reprisals only limited by the instructor's imagination.

The best and quickest method of learning to fly is, of course, in a two-seater fitted with dual control. There were three types of aircraft available for the purpose in 1939, two of which had a high performance and were suitable for teaching the most advanced forms of cloud flying. They were the Falcon III, the Viking II, and the Gull II. The most important dimensions of the latter are given in Figs. 64 and 65.

It is not proposed to do more than indicate the lines on which instruction should be given. There is, in the first place, very little precedent for it. Those two-seaters which were flying before 1939 were used principally for other purposes—usually joy riding. That the possibilities were largely wasted is obvious, and there is very little doubt that the future will envisage dual control from the earliest stages, probably with aero-tow launches as suggested on page 49.

While teaching pupils in power aircraft I have been able after 20 minutes' dual to remove hands and feet from the controls and leave all the flying to the other man. The course has been erratic and the turns verging on the sensational, with a pronounced tendency to slip inwards; but, left to sort out the tangle for himself, the pupil has generally managed to get the aircraft back on to an even keel without help. In fact, I have refused to come to his rescue, believing that he is learning much more through being compelled to make his own corrections. I see no reason why, within limits, the glider pupil should not benefit by the same treatment.

The next stage will be the approach for the landing, and after doing one or two together with the instructor the pupil should acquire an appreciation of the technique. If the landing is not completed, but made only just behind the ridge, the aircraft can, as it were, go round again, using the hill lift to climb back into position for a second demonstration.

The landing itself is so simple in a glider that it will present fewer difficulties and take up much less time than does the same stage in power flying. It ought to be possible to make a pupil "safe" after less than a dozen landings, compared with a minimum of 50 landings in a power craft.

A mixture of dual control and ground instruction should assist in the process of learning. As soon as straightforward flying and the elementary technique of landing has been assimilated, a hop may be given in a primary by winch or bunje. It will act as a test which will show how far the pupil has progressed. It should be possible at a very early date to get him over the soaring ridge for his "C" flight. Although I am unable to provide statistics, such experience as is available suggests that the normal time of 10 hours after which a pupil is considered fit for "solo" on a power aircraft should be cut to 2 hours on gliders. The amount of instruction which can be given in a two-seater at each lesson is so much greater that the necessary experience can obviously be put into a much shorter period.

The only big disadvantage to the idea with the present available types is that they are not typical of the average single-seater. Their reaction to the controls is considerably slower, reminiscent of the difference between flying a Spitfire and a Wellington.

The whole procedure of instruction will inevitably be reversed. The pupil will get his first taste of the air ridge soaring or possibly thermal flying after an aero tow. He will be acclimatised to rough air right from the start, which should not only dispose of his fear of such conditions immediately, but teach him more about the effects of the control surfaces than is possible in calm conditions.

The sequence of instruction will be similar to that for power flying. As far as ridge conditions permit, he must learn first to fly straight and level, and to follow this with gentle right and left hand turns. After two periods of a quarter of an hour each these should have been mastered with a moderate degree of efficiency.

There is only one further note which I want to add. From time to time every gliding club will find among its new members men with power-flying experience. In the future it is likely that many of them will have had a great deal of experience, having flown bombers by night to the Continent or fighters in mortal combat by day. Beware of them! No one is more dangerous than an over-confident power pilot who thinks there is nothing in gliding. His idea of proving it may be to demonstrate a climbing turn from which he will make an undignified and damaging descent. I have seen it happen.

However experienced the new recruit, it is advisable to give him a preliminary hop in which his height is limited to a few feet. This may be followed, if he is safe, by a full launch and a simple circuit and landing. As soon as he gets the "feel" of the aircraft he may be sent anywhere—ridge soaring, thermal flying, cloud flying. He knows his "stuff" probably as well as his gliding instructor, if not very much better. But he must be certain of the *feel* before he becomes a fair risk for the club's property.

Notes for Winch Drivers

I have already suggested the influence which the winch or towing-car driver has on instruction. His importance cannot be put too high, for as soon as the aircraft moves it is out of the instructor's hands and the safety of the pupil is transferred to his charge.

One cannot become a driver without serving an apprenticeship, preferably as the stand-by man with the axe at a winch. From this position, and with duties which only arise in an emergency, he can learn from the man who is doing the driving. I am not going to do more than list his routine duties, each of which ***must*** be carried out:

1. For training purposes place the winch as closely into wind as the site permits.
2. See that there is sufficient petrol for the job on hand.
3. Warn the retrieving car which will take out the cable to lay it in the straightest possible line in order to avoid "surging."
4. See that the stand-by man has his axe and knows how to use it.
5. Obtain clearly from the instructor in charge the type of launches required—viz., ground slides, hops, or full launches. (A field telephone may be installed or special signals arranged.)

As soon as these points are settled flying can commence. From this point the skill of the driver counts above all else. The following progressive notes may be found useful.

Slides.—Endeavour to keep the speed constant at a fraction below the speed necessary to fly. If the pupil lets a wing trail along the ground, he may succeed in picking it up, and the driver may assist, by a little more speed over a very brief period. If it does not come up rapidly, stop the launch.

Opposite: The Nacelled Primary trainer, which is the open Dagling with a fuselage built around the skid and the wing tips rounded off. This aircraft can be slope soared in a good wind. (*See page* 251.)

If the cable has not been laid out in a straight line, it is easy for the aircraft to describe a curving track which rapidly develops into a swing. This can be true either of a slide or a pull across in the air at a low height. In each case it may be checked by slowing down as the swing starts and picking up again as soon as the nose gets past the centre of the reverse swing.

The correct speed for the slide can be estimated by the attitude of the glider as it comes towards you. If the tail plane is seen to be above the wing, the speed is too high. If one wing remains down and is slow in coming up, it is too slow.

Hops.—The safety of the pupil depends upon the winch driver interpreting the attitude of the aircraft correctly. It is most important, for instance, that a new pupil should not be allowed to climb on his first flight; but this is just what the pupil sometimes endeavours to do, either through cussedness or more often sheer panic. The winch driver can save the situation ninety-nine times out of a hundred by slightly slowing down the launch so that although the aircraft remains in the climbing attitude, it slowly sinks back to earth. A pupil can be brought safely down in this way from as much as 100 feet.

As soon as the driver decides that the moment has come for the pupil to make his straight glide back to earth, he should shut off his power suddenly. It is important that there should be no doubt in the pilot's mind that the launch is over, and that he must get the nose of the aircraft into the gliding position.

If the power should be shut off and the wire fails to come away from the nose of the aircraft, the driver may safely continue to take up the slack cable following the aircraft. This may happen when the primary is fitted with a quick release which the pilot has failed to pull.

Full Launches.—Full launches will only be given to advanced pupils or qualified pilots. Apart from the driver's duty of estimating the speed of launch required for each particular type

Opposite : Part of a factory producing sailplanes. The process relies on jigs, a point clearly illustrated in the lower photograph, which shows a two-seater Gull under construction.

of machine, taking into account the wind, his principal concern will be to see that the cable is released at the top of the launch. The moment when he must no longer delay in giving the order to cut the cable is one difficult to judge. But better cut too early than too late. In a fair wind the pilot of a sailplane may continue to cling to the cable with advantage until he is almost directly above the winch. But as the vertical position is approached the driver will slow down, until at the moment of casting off his engine is little more than ticking over. If the cable is not now dropped, the stand-by must cut.

THE EVOLUTION OF BRITISH SOARING

ONE afternoon I sat on a spur of rock on a cliff-top by the sea. Two hundred feet below white tongues licked the feet of Mother England, gurgled in the hollows between her toes and sucked at small patches of shingle. At this point the cliff turned eastwards and a zephyr from the south fanned its vertical face.

Among the narrow ledges of the cliff a colony of fulmars had their home. They had migrated from the north to establish this breeding ground on the iron-bound coast of Northumberland, and they found it good. There was one particular bird which I was watching. She came towards me on motionless wings from the eastern end of the face, rising from sea level and climbing without effort to the crest. She flew a few feet out from the rock, where she rode the gentle updraught of the south wind. A hundred yards away she momentarily lost height. The airs failed her. But with a barely perceptible flexion of her wings she swung outwards over a spur, and with uncanny instinct picked up an eddy which took her up again at an increased speed. For a moment she was climbing at perhaps 5 feet per second.

Now it was near here that an ancestor of mine swung from the gallows at Bamburgh Castle, the reward of a too successful enterprise upon this very sea. He no doubt had observed in his lifetime the flight of the Long Houghton gulls, even if the fulmars were after his time. And without doubt other men of imagination were witnesses to the same soaring flight, for all along this rocky coast the sea birds had nested for centuries. Among them were the men who invented the steam-engine, the electric light, and the turbine.

A little closer observation, a little more logic, and my ancestor, instead of being hanged for piracy, might have employed his surplus energy in building the first sailplane and soaring the Chillingham ridge behind him. For untold centuries the raw materials for soaring flight had been within his reach—timber, fine fabric, and toughened metals. Nothing vital to the design of a modern sailplane was not available 500 or 5,000 years ago.

Da Vinci deserves less credit than he has been given. His designs were a poor compliment to the greatest intellect of his times. Had he taken a common gull and studied it in the careful way scientists study things today, he might have advanced the conquest of flight by nearly 500 years. He would certainly have short-circuited those abortive experiments which persisted into the twentieth century and were characterised by a wing of unrecognisable airfoil and a fuselage which could have only done credit to a builder of bedsteads. He would have laid his dead gull on a flat surface and noted the shape of the leading edge of its wing—a rounded section with a curving upper surface and a marked under camber, the tips swept back for stability. Then he would have observed the clean entry of the fuselage, from the pointed beak to the curving breast, and thence to the flexible tail. He might well have guessed that a flying machine would need to be based upon such a shape.

But he and his successors made a wing with a sharp entry and a plain section, and then they added a tail unit which was carried on poles like a builder's scaffolding. They were fascinated to the exclusion of all else by the flapping action of the birds, and with the aid of cord and hinges attempted to copy it. They struggled with the problem of raising themselves in smooth air instead of considering the more simple problem of using the lift of a cliff-top. They tried to produce a power craft before they had the power, and all this with the example of the gulls before their eyes.

It is staggering to contemplate the ease with which soaring flight might have been achieved. Suppose that Da Vinci had looked a second time and observed that a gull's wing was not, after all, a plain section warped like a piece of board left out in the rain, but that it had an upper and lower surface with definite characteristics. Supposing he had appreciated that the shape of its body was more than a divine fluke, and that he had envisaged similar shapes for his aircraft—with the contemporary skill in woodworking, what might he not have accomplished?

His attempts at flight failed because he declined to study the airflow over all surfaces of a body. He assumed that lift was the result of air pressing on the under surface, and the flatter the surface the greater the lift. Experiments with kites encouraged the theory.

So anti-gravitational properties were attributed to the feathers of living birds. Moreover, it was considered that these properties were more pronounced in the feathers of soaring birds than in those of, say, the domestic hen. One brave pioneer covered the surface of his apparatus with feathers. When being nursed back to health he explained his failure by the choice of hen feathers, and disclosed that the feathers of an eagle should have been used. How green was his valley!

The fact that the forces acting on the lee or low-pressure side of a surface are much greater than those on the weather or high-pressure side was disregarded, and this in spite of the evidence that strong winds dislodged the thatch from the sheltered side of a roof and not from the windward side. There are many even today who are unaware of this law—the basic law governing flight.

Man being what he is, the world had to wait for the present century before witnessing an intelligent approach to aerodynamics. The first advance came between 1908 and 1916, as a wing evolved which was more than a warped board. In those years we saw the first signs of a genuine airfoil with an upper and lower surface. Then the war of 1914 came, and with its incentive for research a tardy realisation that drag was as important as weight, and at increasing speeds much more important. The earliest Briton who dropped a stone and then the branch of a tree over my Northumberland cliff might have reasonably come to the same conclusion. By counting how long it took each to reach the sea, he could scarcely have failed to appreciate that two objects of the same weight could offer a different resistance to the air—that the frontal area of objects had a profound influence on their drag. He had the proof of it any day he liked in the arrow which he fitted to his bow.

But, as I say, we had to wait, and in 1915 we began to clothe the scaffolding poles and give them the elementary streamline of a modern fuselage. Even then progress was slow. Although the designers had worked out the formulas governing the vital factors of drag, nearly twenty years passed before they were carried to their practical conclusions.

The initial mistake was to make the approach to flight through the agency of power. The petrol engine was at once the best and the worst thing which entered the world of aeronautics. Initially, it compelled the clumsy bird-cages to fly—against most natural laws. And then it kept men's minds thinking in terms of brute force instead of grace of line. In itself, the petrol engine introduced mechanical difficulties—problems of stress through increasing weights. And it was not until the development of cantilever construction for wings that a monoplane of really high speed, strength, and efficiency was evolved. The petrol engine was the mesmeric influence which kept the biplane alive long after it was theoretically dead, and with its extended life persisted most of the evils which had long been recognised. Imagine one of the fulmars on that Northumberland cliff fitted with two pairs of wings braced by cross wires and an ugly blunt snout. Then imagine bits and pieces stuck on here and there, such as a pair of wheels, and a general absence of fairing on all sharp angles! I wonder whether she would have soared that day?

It was not until the late twenties that the world saw a flying machine that did its intelligence credit. It was not until long after that—not until 1938—that a British-built sailplane gave full acknowledgment to the enemy called drag and dealt it a really mortal blow. With the living example of the fulmars we took an unconscionable time in learning the lesson.

British gliding owed its "coming out" to the *Daily Mail*, which in 1922 offered £1,000 for a soaring flight lasting longer than 30 minutes. Thirty-five competitors were attracted, and they assembled during October on Itford Hill—a steep Down some 500 feet high near Lewes, in Sussex. The most significant thing about this—the first British Soaring meeting—was the character of its competitors. Those who were to be taken seriously were aeroplane pilots of note and enterprise, men who had already seen their visions in terms of power. They had come for the advancement of a sport to which petrol is anathema. After the meeting they faded away or went back to their engines, where some of them added further lustre to their names. There followed a period of inactivity lasting for nearly 8 years, until new soaring enthusiasts emerged, men who had little previous flying experience, and who had no prejudices in the matter of design and no beliefs beyond their conviction in the greater possibilities of soaring flight. But until 1922 there was virtually no data upon which the possibilities could be assessed. There were, of course, those tantalising birds which had been giving demonstrations since the dawn of history, and in 1911 there was Mr. Orville Wright, who had remained airborne in a glider for 11 minutes. But the first world war had come and gone and the flight was only a hazy memory. Some new evidence of the real potentialities was filtering through from Germany, where a pilot was reported to have stayed up for 21 minutes in 1921; and then only two months before the British meeting came a second report of another pilot who had soared for 1 hour 6 minutes. It is a pity that this feat was not investigated more closely, for the aircraft in which it was performed was ahead of its time. It was a cantilever monoplane of 43-foot span with an enclosed fuselage, remarkably like the sailplanes which we were not to produce for another 10 years.

But Itford was needed to demonstrate to the British the possibility of soaring at all. It demonstrated it in the strangest collection of aircraft which was ever assembled at one point. Although thousands of men had already fought and died in the air, and flying machines were no longer a subject for cartoonists but a proved and powerful weapon, aviation went back to the "ark" for its gliders. The winning aircraft, which was soared for 3 hours 21 minutes in the hands of a French pilot, looked like something which Mr. Wright might have discarded in 1910. It was a tandem monoplane—that is, a monoplane which had two sets of wings of equal span, one at the front and another at the back. Even amongst other strange designs it so completely hoodwinked the technical press that it was ignored until it took off on the last day of the meeting for its record flight. It was the first proof that the skill of the pilot meant as much as the quality of the aircraft (see Fig. 57).

Another success was the Brokker, which was constructed out of a Bristol Fighter fuselage bought by its owner

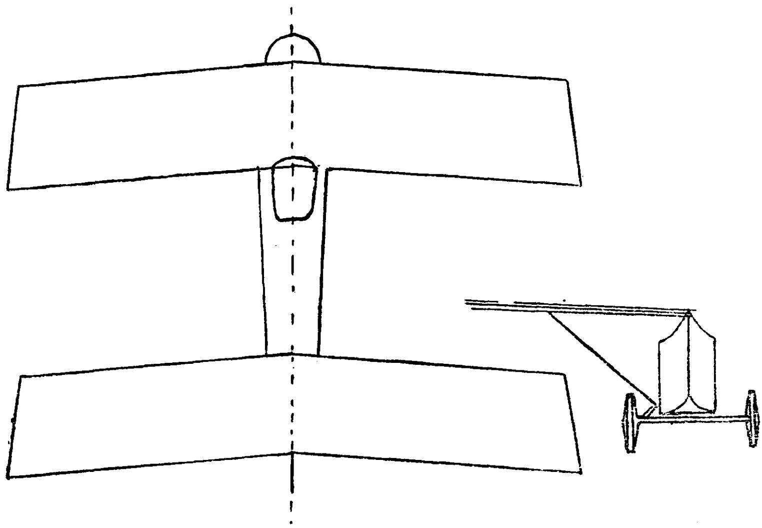


FIG. 57.—*The Peyret, soared for 3 hours 21 minutes at Itford in* 1921.

for 5s. and a Fokker top-plane acquired for a similar sum. The only other capital outlay was the sum of 8s. 6d. alleged to have been spent on dope and piano wire. Yet it soared. This aircraft and the Peyret (the winner) looked little better than the wing flappers, the direct-lift helicopters, the man-propelled aeroplane, and the ornithopters which were among their co-entrants.

Mr. Fokker, of course, was there, and, as might be expected, he provided the first sensation of the meeting. Mr. Fokker had obviously given some thought to the problem of soaring, and he was the subject of the following report:

"Instead of flying out from the hill, as had all the other pilots with the exception of one, Mr. Fokker hugged the edge of the slope and proceeded crab fashion towards Bostal Hill in the south-east. The machine rose and fell as it got into and out of the ascending currents. For quite a long period the biplane appeared to be standing still in the neighbourhood of Bostal. It was then seen to turn and commence its return journey, still at a greater altitude than that at which it had taken off. . . ."

Was this soaring flight lasting 7 minutes the first in Great

Britain? It was certainly one of the first, and it demonstrated the elementary technique of ridge flying (note the frontispiece); and when Mr. Fokker took up his aircraft that same evening and stayed up for 37 minutes he made authentic history. The "crab" method of progress which had yielded such a dividend was the talisman (it kept the aircraft within the area of lift immediately above the hill), and it had been duly noticed by Mr. F. P. Raynham and Mr. Gordon England. Both these keen observers were greatly impressed, and copied the style immediately. The results were flights of 11 minutes and nearly 5 minutes. Thus was the art of soaring born in the land.

Not one of the machines at the meeting showed much regard for anything which was eventually to become the measure of sailplane efficiency. Mr. Gordon England's aircraft with its cantilever wing of 28-foot span and a mere 100 lb. weight was the possible exception. The Fokker, in both the two-seater and the single-seater versions, was a 40-foot biplane with a nacelled fuselage, the tail unit being carried on extension spars of primitive design. Mr. Raynham's 36-foot span monoplane weighing 160 lb., in which he finally soared for 1 hour 53 minutes, showed promise save for the extraordinary arrangement of a second control for working the ailerons. The winner was a tandem affair, as already mentioned. It weighed 147 lb., and its two sets of wings were each of 21 feet 8 inches span, giving it a wing loading of 2 lb. to the square foot. The control surfaces operated on both the forward and the rear wings, and were ingenious and effective. At the same time, the outline sketch of the aircraft given opposite inclines one to the question "was this really as recent as 1922?"

The meeting had two results, both of them unexpected. First it revealed a largely unsuspected interest in light aircraft, although not necessarily motorless aircraft. It inspired the light aeroplane trials which followed, and while these in turn were a failure from the point of view of discovering the poor man's flying machine, they encouraged the de Haviland Aircraft Company to produce the first of the famous Moth series —the first flying machine to be taken up and widely used by the general public. The second result was the immediate formation of several gliding clubs in an abortive effort to establish the new science on a permanent basis. Some of them held meetings and published annual reports, but their members did very little flying. For the next eight years the only serious work was accomplished by individuals working alone without encouragement, money, or very much skill.

In Germany much more was taking place. Balked by the Versailles Treaty of access to the normal channels of aircraft development, the strongest encouragement was given to experiments with motorless flight. In a few years the Germans discovered more about aerodynamics than the rest of the world had learnt in the previous decade. Military aircraft designers became glider designers, and although the sport was not openly militarised until 1933, it taught such firms as Junkers lessons which they never forgot, and of which England saw the results in 1940-41.

The first of the German Glider meetings had been held in the Rhön mountains in 1920. Two years later the secrets of ridge soaring had been learnt. In another four years—in 1926—a pilot made a cross-country flight in a thunderstorm and founded yet another tradition. In 1928 Kronfeld solved the mysteries of cumulus clouds and rode out a "street." By 1930 the existence of invisible thermals rising from the ground had been proved, and pilots were achieving great heights on cloudless days. During all this the British slept.

In 1929, as a result of letters which reached the editor of the *Aeroplane*, who himself had taken the trouble to go to Germany and see for himself what was happening, a lunch was held in London to which all who were interested in sailplanes were invited. The immediate result was the birth of the British Gliding Association, whose newly elected council started to frame rules and regulations for a sport which did not exist. While the legal minds were exercising their talents, a small group of men who were more interested in flying formed the London Gliding Club, to be followed immediately by the Kent Gliding Club. The B.G.A. were thus provided with the nucleus of the clubs which they were later to control, and much later to render through its work a service of tremendous value.

Meanwhile, those who had decided to fly instead of making rules became very busy. Their principal difficulty was finance, and a scheme was hatched whereby the public were to contribute to the funds through a meeting to be held near London. The preliminaries were already over and two gliders were assembled for the purpose when a Sunday newspaper gave away details of the dress rehearsal. The results were sensational. On a flat field at Stoke Park Farm, near Guildford, several thousand people assembled and eagerly awaited a display. The five pilots who were to mount the aircraft in turns were more than embarrassed, for not one of them had even flown a glider before. However, it was neck or nothing. The chance could not be missed, and it might be years before they could again assemble such a wealthy-looking crowd.

An elastic rope was laid out on the ground. The first aviator took his seat, and, with three spectators holding back the machine, twelve others stretched the rope to its uttermost limit. Those behind then let go.

"I think I blacked out," was the comment of the pilot. At any rate the acceleration was terrific, and the machine was catapulted right out of the field and into the next one. This pleased the crowd, and, moreover, excited the interest of the press photographers to fever pitch. Business was business, and a defensive ring was made round the aircraft until tribute had been paid and pictures were permitted. The London Gliding Club came out of the affair with over £300 with which to establish the sport on a firm and lasting basis. The date was March, 1930.

It was later in the same year that the Austrian ace Robert Kronfeld was induced to make a tour of this country, a visit which was only made possible by the generosity of Lord Wakefield, who had contributed £1,000 to the funds of the B.G.A. Kronfeld knew his business. He had soared cloud streets as early as 1928 and was well qualified to show what a sailplane could do in good hands. (He later became a naturalised British subject and served with distinction as a Squadron Leader in the R.A.F. during the war, winning the A.F.C.) Before the tour was over many new clubs were formed, including the Yorkshire Gliding Club, which became the centre of the sport in the north. Among those who saw him fly was Mr. F. N. Slingsby. His business dealt among other things in furniture, and he reckoned with good reason that he could make sailplanes. The proof of this emerged as the years rolled by and Slingsby Sailplanes became famous all over the world.

For the first three years of the rebirth of the movement British designers groped for the truth. They broke away from the tradition of the biplane and recalled first principles. They began to make aircraft which paid attention to drag and its relationship to speed and weight. Sailplanes appeared as high-wing-strutted monoplanes with four-sided or six-sided fuselages. Then the fabric covering was replaced by a stressed skin of plywood, with its contribution to strength as well as reduced skin friction. The square wing tip surrendered gradually to the tapered wing with an increasingly high aspect ratio. There was still the high drag of the struts and the inefficient wing junction, while an open cockpit and very little attempt at fairing showed that the designers had a long way to go.

By the standards of a few years later the aircraft had a mediocre performance, losing their efficiency at over 40 m.p.h. to a mounting element of drag. At the other end of the scale they would fly remarkably slowly, remaining under control at speeds as low as 25 m.p.h., and flying at their best a few miles an hour faster. Those aircraft with a claim to efficiency had been imported from Germany or were manufactured under licence. One of the most notable examples was the Professor, whose wing span of 51 feet and weight of 340 lb. made it a giant, both physically and in performance, as compared to the home-built lightweights of our own enthusiasts. Later on the German Grunau Baby and the Falke were to be added, both intermediate sailplanes on which a cross-country flight of 50 miles was within the reach of anyone who had the skill. But in 1931 the most interesting British machine was perhaps the Cloudcraft Phantom, whose 51-foot span, its weight of 250 lb., and its British-designed wing section (R.A.F. 34) classed it with the bigger aircraft on the Continent.

But the real bar to British progress was not, for all that, the inefficiency of the aircraft, either imported, cribbed, or home designed. It was the lack of a simple and inexpensive instrument which would tell the pilots when they were rising or falling. It was this lack of a variometer, coupled, perhaps, with a lack of enterprise, which stood between the soaring slope and the clouds, cutting them off from the thermal flying by which continental pilots were now accomplishing distances of 100 miles and over. At the beginning of 1933 the British record stood at 13 miles and the official height record at 1,750 feet (although unofficially pilots had been higher). Yet as long before as 1931 the world's distance record was 165 miles, and cross-country flights were being made at heights averaging 4,000 feet and over. There is proof here—if it is needed—that the human senses upon which our own pilots relied were not enough to diagnose the air currents through which they were flying. While I admit the possibility of an experienced sail-plane pilot recognising a thermal by the instability of a patch of air, he cannot estimate accurately its strength without some kind of a sensitive rate-of-climb indicator. The upward surge of a thermal is felt first at the base of one's spine—but, except for the initial impetus, there is nothing but the continued roughness of the air to give what might be called a "running commentary" on what is happening. The altimeter of those days was useless because the cheap type fitted would scarcely show a rise or fall of 50 feet. Some account of the first purely thermal British flight therefore deserves a place as a landmark of British soaring.

In July, 1933, a meeting was in progress at Huish, near Marlborough. A northerly wind was blowing down the hill—a tragedy for the participants, for slope soaring was impossible in such a wind. Balked of their sport, the pilots resorted to auto-towing along the flat top of the ridge, which gave the aircraft a height of some 600 feet, from where a normal glide back to earth occupied approximately 2½ minutes. But did it? One of the pilots, Mr. G. E. Collins, flying a B.A.C. two-seater, noticed that from time to time his descent appeared to be delayed. Without instruments it was difficult to tell exactly what was happening, but having studied the technique of the German experts, he had a shrewd suspicion. On Saturday, July 1, a friend lent him a sensitive variometer of his own design, and on being launched again Mr. Collins immediately observed that at one stage of his flight the instrument ceased to record a descent and actually suggested that he was climbing. He immediately began to circle, and found that he could stretch the flight from 2½ minutes to about 5 minutes. In the execution of these tactics he foreshadowed the basic procedure (as far as his own country was concerned) upon which the art of cross-country flying was to be based.

On the following Wednesday the conditions were identical, and at 1.21 p.m. Mr. Collins was auto-towed to 600 feet with his wife as passenger. A patch of unstable air was accompanied by a favourable reading of the variometer, and once again he started to circle. This time the aircraft climbed rapidly to 950 feet above the hilltop. Appreciating the latent possibilities of what was then a good height for a sailplane, he set off across country, passing over the leeward side of the hill and losing only a little of his precious altitude. A few minutes later another thermal was encountered and exploited by three or four more circles, and finally a third and last which restored all the altitude previously lost. Thereafter he was out of luck, and landed in a field near Devizes, a distance of nearly 6 miles from his starting-point. The first purely thermal flight had been accomplished, and Britain was on the road to new discoveries.

Within two months Mr. Collins had broken the British distance record, using both his new-found skill and particularly his new-found variometer. On this occasion he reached a height of 2,300 feet under a cloud which drifted across Dunstable Down, and with this altitude set off boldly to the south-east. He was still under the influence of the cloud over Ivinghoe Beacon, but as he turned away downwind he gradually lost height until close to Hemel Hampstead only 400 feet remained. There, however, he encountered and recognised another thermal in which he turned to circle. Climbing easily and comfortably to 1,200 feet, he went back on to his original course. Using the lift of further clouds, he completed a flight of 22 miles in a field near Potters Bar. He had provided a miniature example of the long flights which were to become almost everyday affairs in later years.

While the stage was now set for better things, it is sobering to observe that, as these experiments were being made, Peter

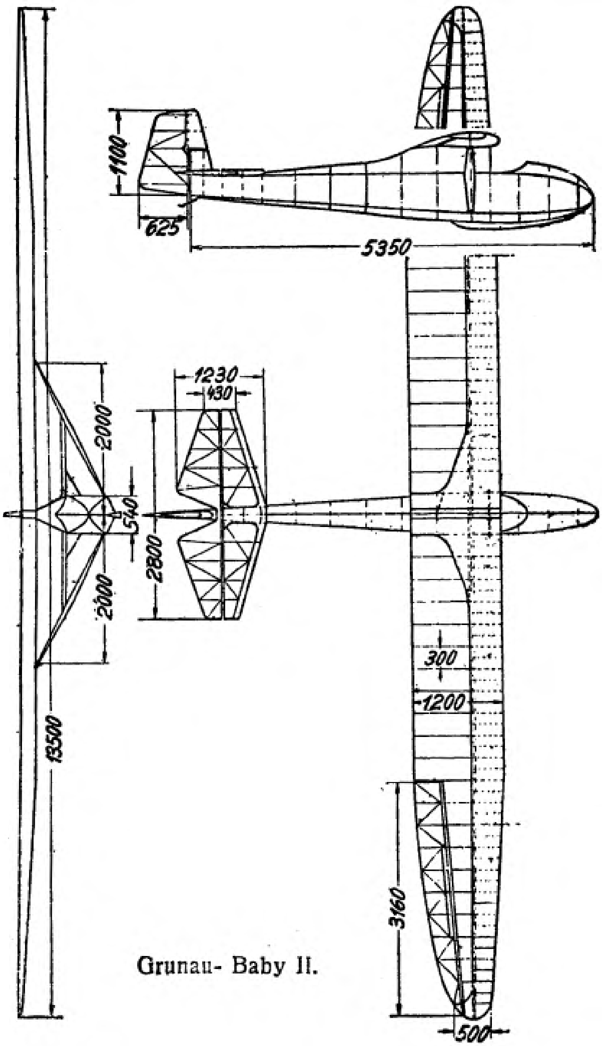


FIG. 58.—*The Grunau was one of the first successful German sailplane designs for an "intermediate" performance to be built in England. It first appeared here in the early thirties.*

Span 13·5 m. (44·3 feet).
Weight empty 112 kg. (246 lbs.).
Safety factor: 8.

Area 14·2 sq. m. (153 sq. feet).
Aspect ratio 12·8.

Riedal landed in France after a flight commencing in Germany 152 miles away, reporting laconically that he had flown most of the distance at 7,000 feet. Robert Kronfeld in the meantime was soaring the crater of Vesuvius, as though it was necessary to play a hand with a volcano to lighten the tedium of distance flying.

"My soaring flight," said Kronfeld, "lasted 4½ hours. It was fascinating but at the same time frightening to find oneself so near to the fiery throat with nothing else for support but a 260-lb. aircraft. And yet the grandiose surroundings overpowered any feeling of danger. The principal crater of Vesuvius disappeared at times in thick clouds of smoke which, lit by subterrannean fire, was continually changing colour."

A journey between Dunstable and Ivinghoe Beacon (3 miles), then the measurement of British proficiency, seems small beer by comparison!

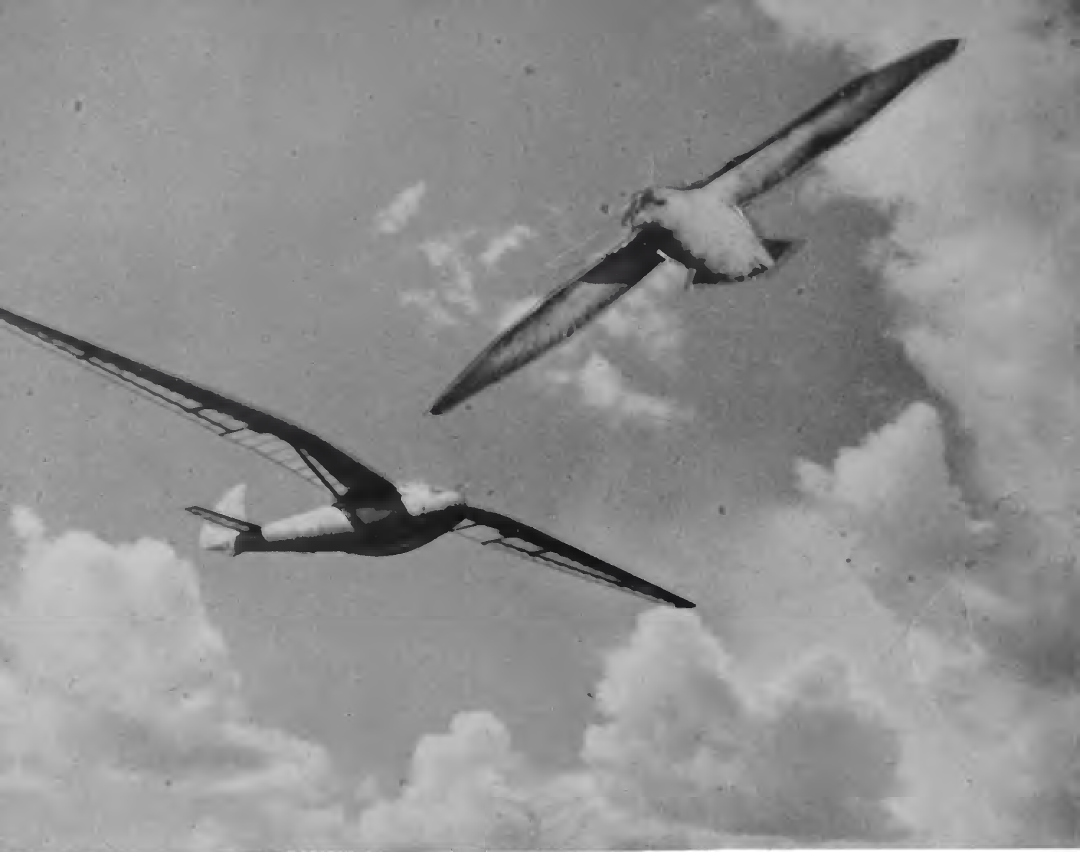
At the same time ridge soaring was practised by increasing numbers of pilots with a fair degree of proficiency. The old 1922 record of 3 hours 21 minutes was raised in August, 1933, to 6 hours 55 minutes by Flight-Lieut. Mole in a Willow Wren from Dunstable. In October this was beaten by Mr. J. Laver, who soared a Dorsling for 7 hours 22 minutes at Sutton Bank, making a night landing under difficult conditions. Mr. Laver's account included the following notable paragraphs:

"For some time the Dorsling was battling with a wind that can only be described as vicious, being repeatedly plunged into dives in which her speed went up to 65 and 70 m.p.h. before I could ease her gently out, working off the surplus speed in a zoom and then flattening out again into a normal glide. (On the ground they thought I was stunting to pass the time away.) At about 4 p.m. it was reassuring to observe the preparations which were being made for a night landing. Hurricane lamps were being placed to form three sides of a

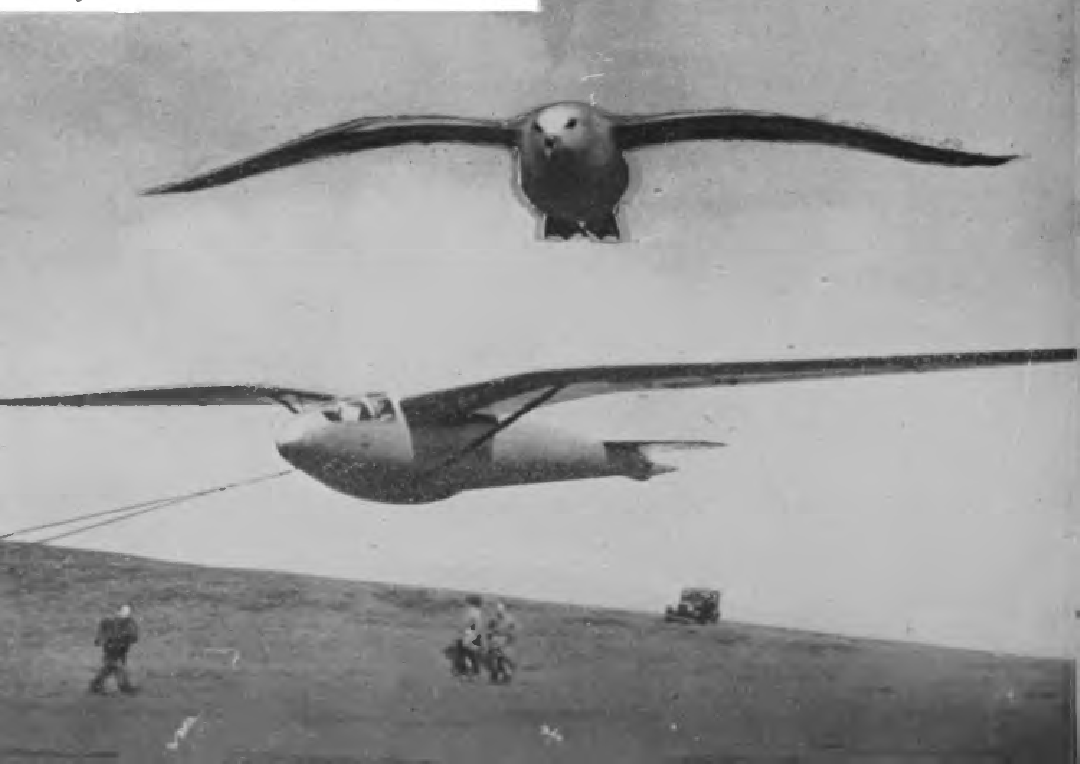
Opposite.—Top: The launching crew of a primary dive for safety as the aircraft overtakes them.

Middle: A square-wing Kirby Cadet, which is an excellent type of secondary trainer up to the slope soaring stage.

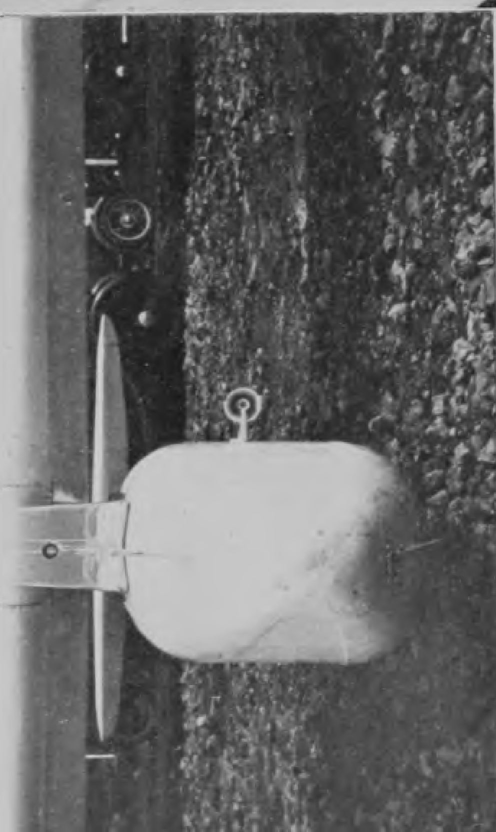
Bottom: The H.17, an intermediate type of sailplane with a performance similar to the Grunau.



A Kirby Gull sailplane compared with a Fulmar Petrel.



Top : A Kittihawk Gull and a Petrel sailplane.
Bottom : A Fulmar Petrel and a Viking sailplane.


rectangle, enclosing the landing spot and leaving the open side to leeward.

After dark, the sky still being overcast and there being no moon, I lost sight of the hill completely, steering a course by keeping one eye on the landing lights. This was my first experience of night flying, but I found it much easier than I had expected. On one occasion after making a turn I lost sight of the lights. They failed to show up in the quarter where I was looking for them, nor could I see them on scanning every direction within my line of vision. I had begun to wonder where I was drifting when a further half-turn suddenly brought them into view and I got my bearings.

Presently it came on to rain—not a passing scud, but steady rain that gradually got worse and looked like lasting. I was still able to see the lights, and therefore carried on as before; but after a while I found that my margin of height was getting narrow—the rain was evidently beating me down. Presently, however, the headlights of the cars on the hilltop were turned on and off in long flashes, and I took this to be the signal that the existing British duration record had been passed by the necessary margin. At this stage I was feeling quite fit, and had no intention of landing so long as the wind held and I could maintain a workable height. But before long there came a moment when I was so low that it was obviously inadvisable to hang on any longer; there was a risk of being forced below the hilltop with the inevitable crash of a blind landing below.

So, without further ado, I turned over the brow of the hill and, making a wide arc to take me clear of where, from earlier observation, I had placed the trailer, I landed in the inky blackness some distance to the rear—unable to beat back against the wind to the lights."

During the next twelve months sensational progress was made. In March, 1934, Mr. P. A. Wills flew a distance of 56

Opposite.—Top : A Viking I, showing the size and position of the spoilers.

Bottom Left : The nose of the Scud III. The engine is retracted behind the wing and is invisible.

Bottom Right : The tail plane of the Scud III positioned high on the fin so as to be in the slipstream when the motor is in use. (*See page* 285.)

miles. In August Mr. Collins, who had now acquired a German high-efficiency sailplane, showed that British pilots were rapidly becoming the equal of those on the Continent by flying 95 miles from Dunstable to the Norfolk coast. It will be seen from this that the art of thermal soaring had at any rate been mastered by this pilot. After an initial climb to 2,200 feet, he recognised a cloud street, and, appreciating its significance, flew straight down it from Dunstable to Ampthill. Later, after a period of circling in a series of small thermals, he made contact with another cloud street whose proportions expanded as he flew towards it. In this he was sucked violently up to cloud base and flew at 4,800 feet straight across the Fen country to the north-east of Cambridge. Later on he was down to 1,500 feet, but he soon showed that he had solved the elementary problems of thermal flying. Looking for a likely source of upcurrents, he found it in a sunwashed patch of sandy heather, and in 25 minutes he was back at 4,200 feet, flying in the direction of the coast, now only 20 miles away. Before he reached the sea another thermal had lifted him to just under 5,000 feet. The combined properties of a high-efficiency aircraft, proper instruments, and his own soaring skill, had made the flight almost inevitable.

The publicity following flights like these was reflected in the growing number of men and women attracted to the sport. While at the beginning of 1930 there had been approximately 20 pilots holding a "C" certificate—that is, pilots who had proved themselves capable of soaring for a modest 5 minutes—and only 50 by the beginning of the following year, the numbers increased substantially from then onwards.

They rose first from 85 to 105 and then to 150. Between 1935 and 1936 they jumped to 250. Some of them failed to maintain their original enthusiasm, but for every pilot who fell by the wayside four more qualified, and in 1935 there arrived like a rich uncle from Australia—after a long succession of lean years—another reason for the growth of the movement.

For many months the British Gliding Association, now finally accepted as the governing body of the sport, had been endeavouring to enlist the financial sympathy of the Secretary of State for Air. Gliding had only survived on faith, hope, and private charity—and not very much of that. It had been permanently in debt, and many clubs carried on under primitive conditions.

The Government interest was hardly overwhelming. An annual subsidy of £5,000—or one-twentieth of the cost of one bomber—was granted. No public money in the long history of British administration was made to do more during the ensuing five years. Somehow it built hangars, purchased aircraft, erected bunkhouses for week-end pilots, converted motor-cars for winching, rented mountain-tops—or released other money to do so. In fact, it performed the miracle of the loaves and fishes. If the B.G.A. and the treasurers of the dozen clubs or so who benefited cared to reveal how the miracles were achieved they would put to eternal shame the economics of the nation.

Encouraged by this official recognition, defunct clubs were resurrected and new clubs were formed, while untried hills were prospected far and wide. In theory at least Britain should soon have had several hundred expert sailplane pilots. In practice she had the pilots but not the experts. Only a score or so would have ranked with the best on the Continent. The rest remained slope-soarers who seemed content to gape at the cross-country *maestri* like children at a conjurer. They hadn't yet realised that thermal flying was only another trick and that the necessary "sleight of hand" was easy to acquire.

Nevertheless, shortly after Mr. Collins had set up the new record several flights were made from the northern centre at Sutton Bank which a few months previously would each have created minor sensations. Dr. J. P. Dewesbury flew 37 miles, landing near Bridlington on the coast. He had used cloud and thermal lift on the way, proving that he too had entered the ranks of those who understood the inner mysteries of soaring flight. From the same ridge Mr. Wills in the meantime created the first of his many height records with a flight to 5,100 feet.

Then Mr. Collins again came on the scene with the first British flight to be made in a cold front. Flying his Rhönadler, he rode the leading edge of a storm which swept over Dunstable and landed after it had blown itself out 25 miles away.

Soon afterwards Mr. Collins was killed, and the sport suffered a loss which it could ill afford. He had done so much in such a little time that his death was more than a personal tragedy to his friends. He had been aero-towed to 3,000 feet, from where he was to give a display of aerobatics. While executing an outside loop, a wing collapsed, and although he was wearing a parachute, he did not bale out.

Collins was made of the same fine stuff as the pioneers of the high hills and the polar deserts. It would be true to say that he had rescued British Gliding from the stagnation into which it had drifted, inspiring other pilots as restless in spirit as himself to new things. Among his achievements had been the first British thermal flight and the first cold-front flight, while on numerous occasions he held both the British height and distance records. His name will long be remembered in soaring history.

* * * * *

From 1930 onwards it had become a custom to hold an annual soaring meeting to which the representatives of the clubs were invited. The entries consequently gave a fair picture of the position which British designs occupied from year to year. The most significant of these meetings from the point of view of progress was that held at Sutton Bank in 1935.

There were 9 distinct German types among the entries as compared with 8 British. The German aircraft were all British owned and were mainly of ancient design, but even the Professor, produced in 1928, was ahead of most of our own built 5 years later, while the Rhönadler, with its 57-foot span, 365 lb. weight, and sink of 2 feet per second, was better than anything else at the meeting.

Several things could be noticed at once about the German high-efficiency types. They were a great deal heavier than the British, better streamlined, had a bigger aspect ratio, a higher flying speed, and in spite of it all a more economical rate of sink. There was one exception—just one ewe lamb in the British fold which was different. It was so completely different that it didn't look British at all. It was the first of a new race in conception, performance, and design. But

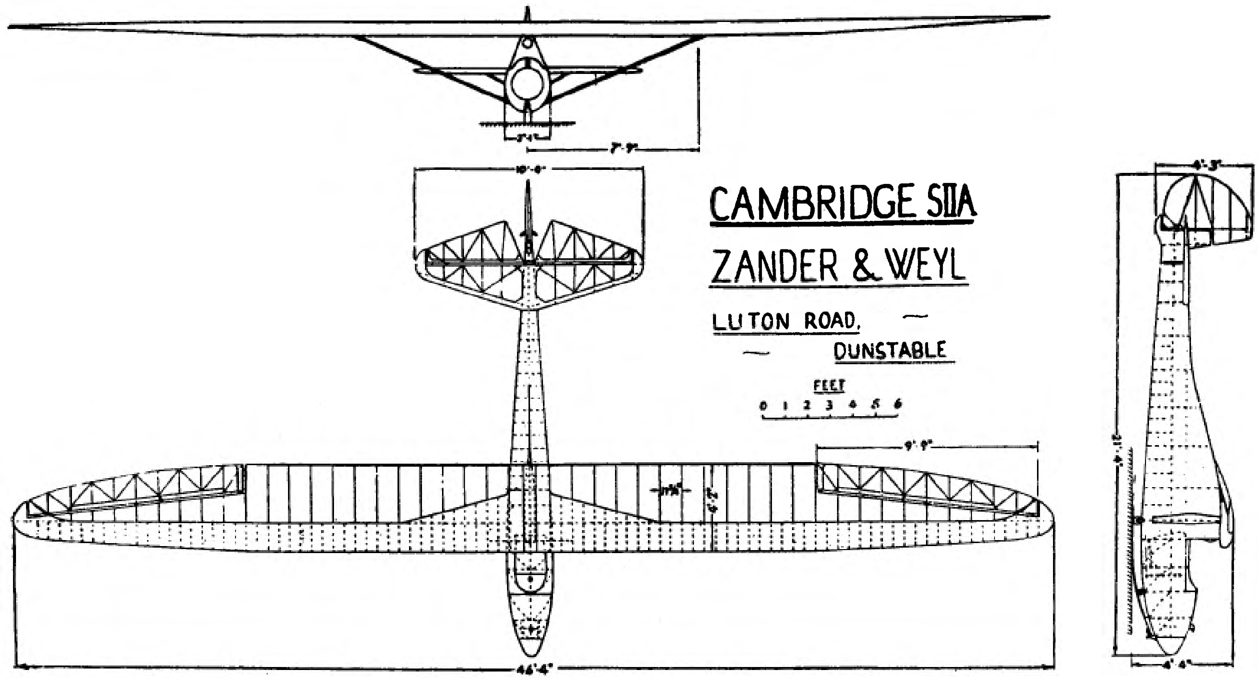


FIG. 59.—*The 1936 edition of the British-designed Cambridge sailplane.*

Weight 260 lb.
Span 46½ ft.

Wing loading 2·8 lb.
Stalling speed 26 m.p.h.

Rate of sink 3 ft. per sec. at 30 m.p.h.
Rate of sink 6 ft. per sec. at 50 m.p.h.

before dealing with this newcomer, let us look for a moment at the other British aircraft, for they represented what had been achieved since the rebirth of the British movement in 1930—and it was an achievement which was not inconsiderable.

The most significant was the Tern, for it had been designed as long ago as 1931, and was actually the first aircraft which was ever turned out by Airspeed Ltd., a company which was to become famous in the world of aviation. Its two-spar cantilever wing of 50 feet mounted above a stressed plywood fuselage, and its light wing loading, gave it a performance which was first class in every respect except "penetration," the quality of flying fast. It had been the best of the early sailplanes, and was still really good in light winds.

Two others dated back to the same year and had reappeared from time to time with various modifications. They were the Wren and the Scud—both of them typically British conceptions with a very light wing loading, light construction, and a small span (40 feet). At the same time they had proved themselves delightful to fly, easy to manœuvre, and, except for the quality of being able to fly efficiently at only one speed, there was little to criticise about them. Mr. G. M. Buxton, flying the Scud II the year before, had raised the height record to over 8,000 feet, riding out a thunderstorm and proving that his aircraft could " take it" in spite of its light construction. A fourth British type, the Cambridge, was in a similar class, although its wing loading of 2·8 lb. and its span of 46½ feet suggested that it should be slightly faster.

The Kirby Kite, appearing at the meeting for the first time, was a further advance on three of the four previously mentioned. It had just been completed by Slingsby Sailplanes Ltd. (whose founder, Mr. F. N. Slingsby, has already been mentioned as one of those who were so impressed by Mr. Kronfeld's 1930 tour). The Kite did one thing if it did nothing else. It provided a sailplane of medium efficiency and reasonable price (it cost about £150) which was to be made in large numbers and to enjoy a success right up to 1939. Although its lovely oval-section fuselage suggested that it should have great powers of penetration, it was not actually much more efficient than the others. But it set a new style, was

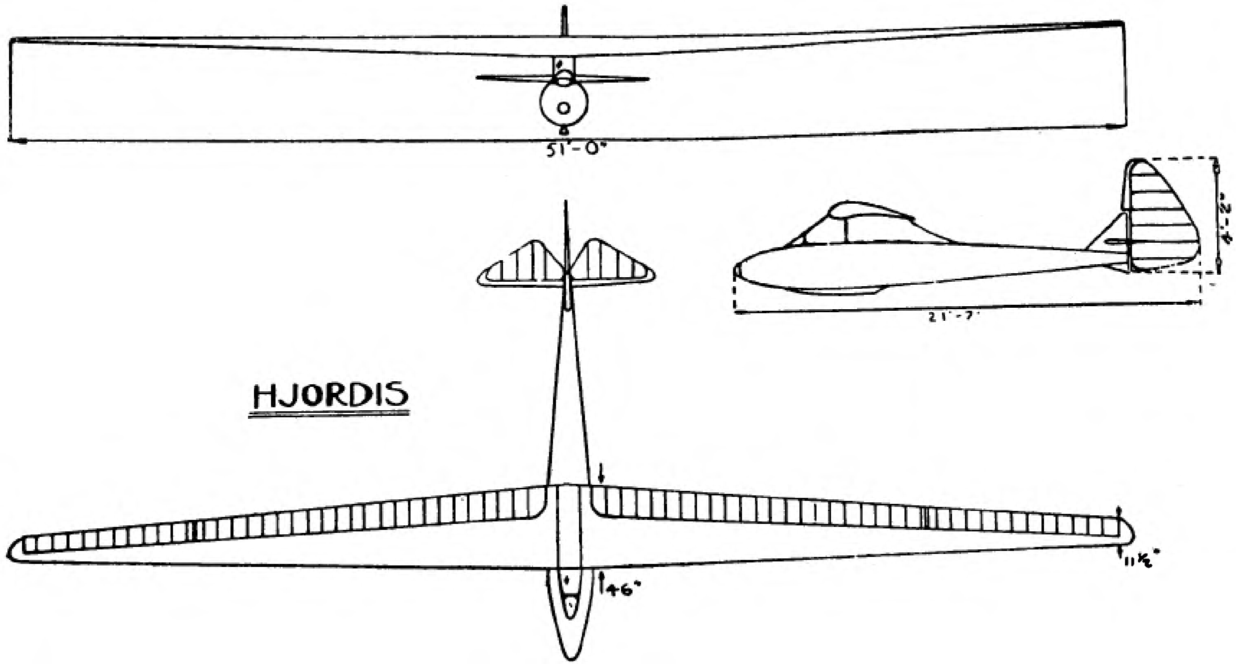


FIG. 60.—*Mr. G. M. Buxton's Hjordis of* 1935, *the first British high-performance sailplane.*

Span 51 ft.	Wing loading 4·1 lb.	Stalling speed 31 m.p.h.	Rate of sink 2 ft. per sec. at 35 m.p.h.
Weight 310 lb.	Wing area 124 sq. ft.	Aspect ratio 21.	Rate of sink 6 ft. per sec. at 56 m.p.h.

extremely strong, and its strutted wing of 47 feet and its rate of sink of about 3 feet per second classed it as an advance on most of the others.

But beside all of them the sixth machine was a stranger.

The Hjordis, designed by Mr. G. M. Buxton, was by far the most advanced British design which had ever appeared. It even surprised the Germans when they heard about it. It had a cantilever wing mounted on a high neck into which the enclosed cockpit was fully faired, while a streamlined fuselage of perfectly round section was cleaner in appearance than anything which had gone before it. But it was not so much in these details that it differed from everything else. Its wing loading was nearly twice that of the Tern, Wren, Cambridge, and Kite. It had been designed for speed. The old standard by which the quality of a glider had been judged—a light wing loading—had been abandoned. The new god of speed had taken its place, and Hjordis became the first of a line which was to pay tribute to this new and more generous deity.

The effect in performance can be seen at a glance in the comparative tables for other popular sailplanes of the day.

Type.	*Weight (lb.).*	*Stalling Speed (m.p.h.).*	*Min. Sinking Speed (in. per sec., approx.).*	*Span (Feet).*	*Estim. Flying Speed (m.p.h.) at 2 m. per sec. sinking speed.*
Scud II ..	220	26	35	40	45
Grunau Baby I	240	24	30	45	45
Grunau Baby II	280	26	35	47	45
Cambridge ..	285	25–6	35	47	45
Kirby Kite ..	270	25–6	30	47	45
Falcon I ..	280	25–6	35	41	40
Falcon III (2-seat)	380	25–6	34	58	40
Rhönbussard ..	305	29	29	48	55
Hjordis ..	310	31	24	51	58
Rhönadler ..	375	26	23	57	60
Rhönsperber ..	360	38	29	53	67

The last aircraft in the list was perhaps the best German aircraft which had been produced up to that time, and the table suggests that the Hjordis was in the same class. Apart from minor teething troubles, this was largely proved in practice during the ensuing months.

What Mr. Buxton had done was to marry a high-lift wing section of high aspect ratio to a clean cigar-shaped fuselage, accepting the greater weight brought about by the necessity for structural strength as an advantage (the wing loading was 4 lb. to the square foot). A second version of the same aircraft was on the drawing board before the end of 1935. It was to eradicate the minor faults and inconveniences of the first. It had been found, for instance, that while the Göttingen 652 wing section had given her as low a rate of sink as 2 feet per second at about 35 m.p.h. (in spite of the high wing loading), the characteristics of the same airfoil caused the sink to go up with a leap after 60 m.p.h. What was needed was perhaps a slightly lower wing loading to maintain the low speed performance with a "faster" airfoil, the latter looking after the performance at really high speeds.

As with the prototype of many aircraft, the sweetness and balance of the controls had room for improvement. The wheel arrangement in place of the ordinary stick was an advantage in that it made easier a rapid exit from the cockpit, but there was not quite that "snap" in the reaction to the ailerons which is expected of the best. The rectification of such points is invariably the result of trial and error, and there was nothing in the basic design which denied her promise.

Her exceptional performance on test, which showed a sinking speed of only 2 feet per second, immediately created a difficulty not previously encountered by British sailplanes. Her reluctance to "sit" when landing repeatedly brought the pilot face to face with horrible obstructions at the farther side of large fields. Her qualities of float engendered by the clean lines made her difficult to put down in the chosen place. Modifications were therefore carried out almost immediately. She was fitted with lift spoilers—slats which could be raised to an angle of 90 degrees one-third of the way down the cord and 6 feet out from the wing roots. Although they measured only 3 feet by 3 inches, their effect was remarkable. They so effectively destroyed the lift over that part of the wing that the sink was increased to that of a secondary type of glider, and no further difficulties were encountered (see Fig. 61).

In the meantime, Hjordis acquitted herself well in competition with some twenty other sailplanes. In the hands of Mr. Wills she reached an altitude of 5,400 feet—the highest of the meeting—and won the out-and-return competition with a flight of 24 miles from Sutton Bank to Arncliffe Hall and back.

The second newcomer—the Kirby Kite—did similarly well by winning the cross-country contest with a flight of 54½ miles. Both aircraft founded a reputation which was to grow.

Meantime the successor to Hjordis was taken in hand, and in due course emerged under the name of King Kite. The old high neck of the prototype was dropped and the new aircraft emerged with a shoulder wing of faster wing section fully faired into the fuselage (see page 129). Apart from the slope of the streamlined cockpit, which gave her the appearance of having a hooked nose, she was a thing of beauty. Flaps had been fitted instead of spoilers, and for an exceptionally fast aircraft these had an advantage over the latter in that the stalling speed was reduced from 40 m.p.h. to 35 m.p.h. (The action of spoilers is to raise the stalling speed.)

The principal dimensions and the performance of the aircraft were as follows:

Span, 51 feet.
Aspect ratio, 18·5 (as compared with 21 of Hjordis).
Gliding angle, 1 in 25 (1 in 13 with full flaps).
Sink, 2·7 feet at 45 m.p.h.
5·5 feet at 65 m.p.h.
Stall, 40 m.p.h. flaps up.
38 m.p.h. flaps half down.
35 m.p.h. full flaps.

She was by far the fastest British sailplane yet produced, and compared with the fastest German designs. At 70 m.p.h. her sink was 2 metres per second, which compared with Rhönsperber's speed of 67 m.p.h. for the same figure—and the 'Sperber was herself a very fast machine. She had put on 12 m.p.h. over the original Hjordis, and had paid for it in her performance lower down the scale. Hjordis stalled at 31 m.p.h.,

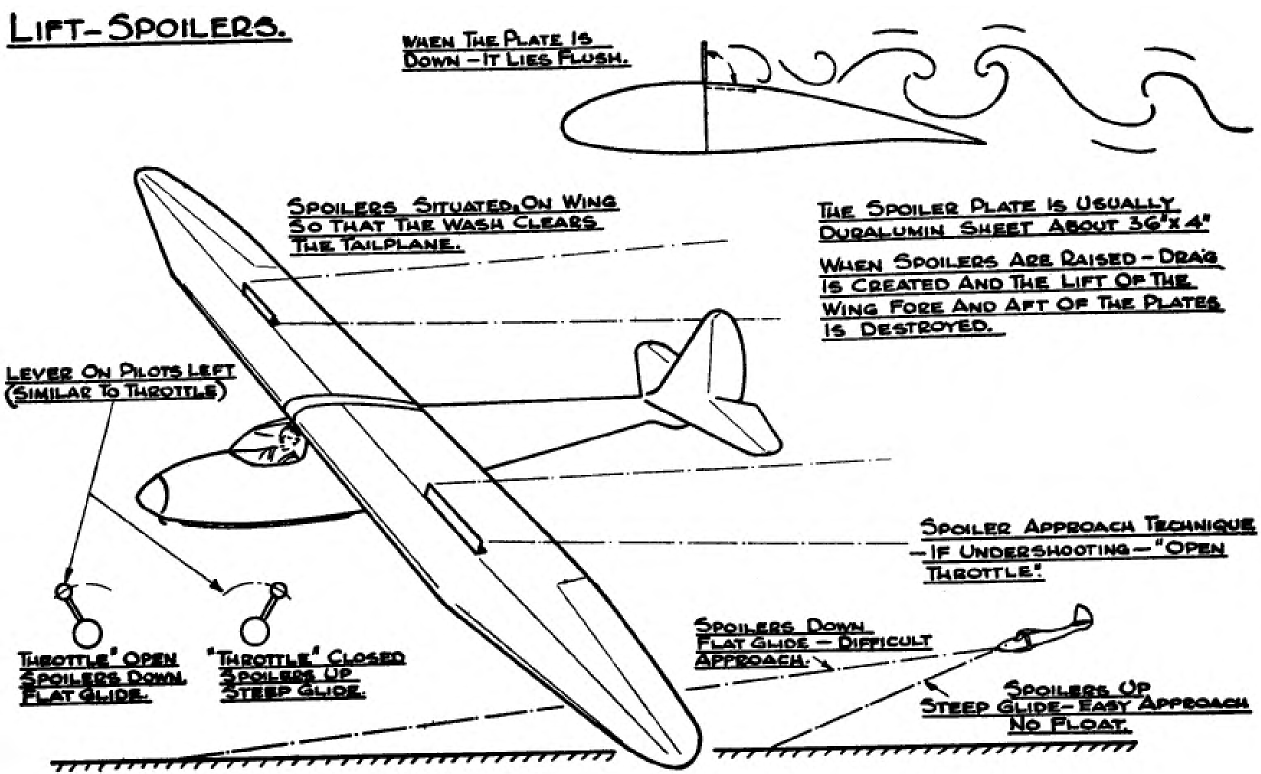

LIFT-SPOILERS.
WHEN THE PLATE IS DOWN – IT LIES FLUSH.
SPOILERS SITUATED ON WING SO THAT THE WASH CLEARS THE TAILPLANE.
THE SPOILER PLATE IS USUALLY DURALUMIN SHEET ABOUT 36" X 4"
WHEN SPOILERS ARE RAISED – DRAG IS CREATED AND THE LIFT OF THE WING FORE AND AFT OF THE PLATES IS DESTROYED.
LEVER ON PILOTS LEFT (SIMILAR TO THROTTLE)
"THROTTLE" OPEN SPOILERS DOWN. FLAT GLIDE.
"THROTTLE" CLOSED SPOILERS UP STEEP GLIDE.
SPOILER APPROACH TECHNIQUE – IF UNDERSHOOTING – "OPEN THROTTLE."
SPOILERS DOWN FLAT GLIDE – DIFFICULT APPROACH.
SPOILERS UP STEEP GLIDE – EASY APPROACH NO FLOAT.

FIG. 61.

and at 35 m.p.h. had a sink of only 2 feet per second. She was, therefore, not the perfect sailplane for which everyone had been looking, although she represented the second real advance in British design. I must now add, for those who remember the King Kite, that she had a strange and inexplicable tendency to flick into a spin if stalled. Tell it not in Gath, publish it not in the streets of Askelon . . . but a workman had given her wings 1 degree of positive incidence instead of 1 degree of negative washout—an error which was not discovered until 1942 !

As was inevitable sooner or later, an engine had to be fitted to a sailplane. A genius for tinkering and a very real desire to do away with the elaborate apparatus needed for a launch were its sponsors. When it did come out it was a very good one, a modified design of a sailplane which had already done well. Sir John Carden designed an ingenious system whereby a Villiers two-stroke engine complete with propeller was retracted into the fuselage just behind the wing of a Scud III. The first, and as far as I know the only, example was completed in 1935. The details are of some interest, for apart from the glider pilot's professed horror at having anything to do with petrol, it did seem to fill a need without detracting from the soaring qualities of the machine.

The Scudd III was a cantilever monoplane of 45-foot span with an aspect ratio of 16 to 1. Its wing loading, with pilot, parachute, engine and fuel for half an hour was 4·2 lb. for an all-up weight of 500 lb., of which engine and fuel accounted for only 50 lb. With engine retracted, the gliding angle was as good as 1 in 24, and at 35 m.p.h. the sinking speed was a mere 2·2 feet per second. In theory at least the perfect aircraft had arrived.

Although the engine was nominally rated at 2¾ h.p., it gave 7 h.p. at 3,300 revolutions, with a maximum for take-off of 9 h.p. at 3,500. On test this enabled it to get off the ground after a brief run on its single recessed wheel and climb to 2,000 feet in about 10 minutes. From this height the engine was retracted into the fuselage by the pilot operating a crank in his cockpit, and the aircraft was then soared like any other sailplane. The device was most ingenious, and when the engine was "down" it was automatically covered in by flaps which made it impossible to tell at a glance that it was there (see page 273).

But like the dry-fly purist of the chalk streams, the average glider pilot considered the whole affair rather indecent. It was like fishing the Test with a wet cast or a bunch of worms. Although Scud III held out much promise—a tantalising promise of more flying—the idea was never developed.

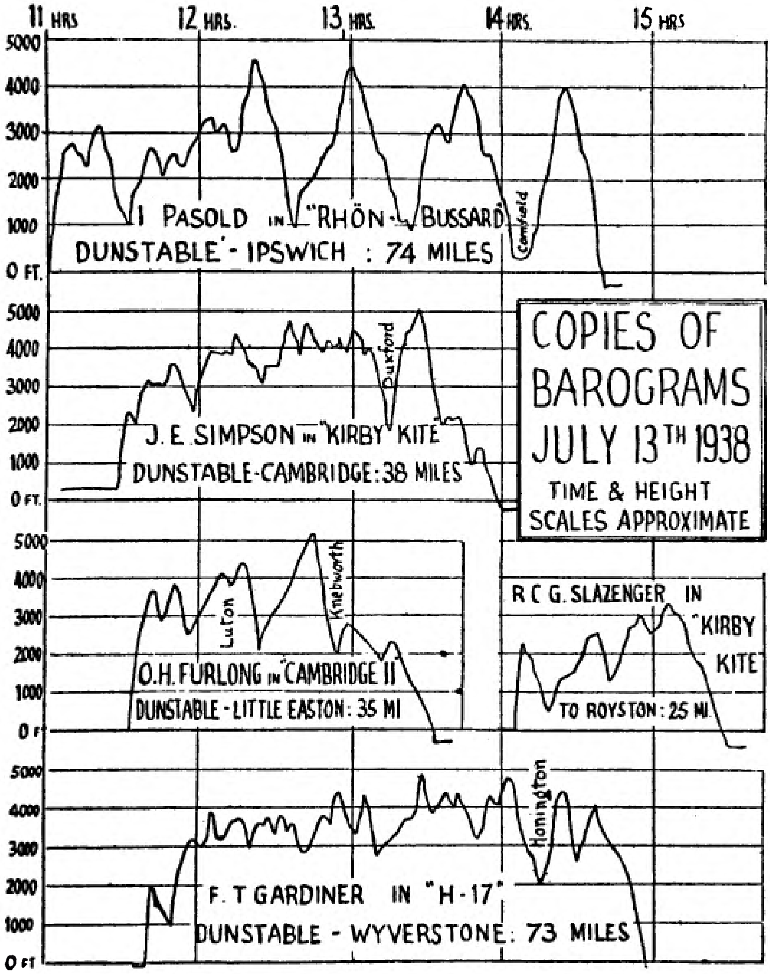
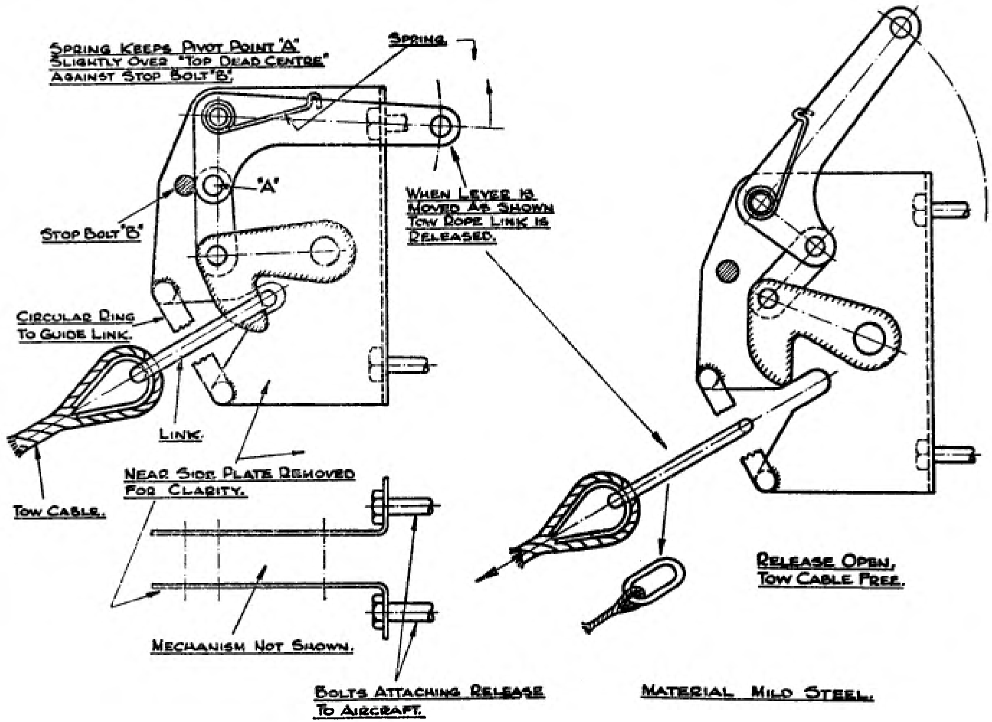


FIG. 62.—*Many notable cross-country flights were made in 1938. A typical day's performances are illustrated in the copies of barograms reproduced above.*



DIAGRAMS SHOWING MECHANISM AND ACTION OF RELEASE.

FIG. 63.—*The efficiency of the cable release gear was repeatedly improved until this one-time source of accidents was eradicated.*

In the four years between the national competitions of 1935 and the outbreak of war all the records were repeatedly broken. The height record went up from 8,000 feet to 10,500 and then to over 14,000. The distance record progressed by easy stages up to 209 miles, which in a country as small as ours is a remarkable performance, and an account of it forms a suitable epilogue to this book. The endurance record, admittedly dependent more upon stamina and the fortunes of the wind than skill, was raised to over 22 hours.

Simultaneously the number of pilots capable of something more than ridge soaring increased rapidly. During the national contests of 1937 cross-country flights totalled 1,489 miles. The average distance per flight for 26 pilots was 35 miles. Fourteen pilots had qualified for the international Silver "C" certificate out of a world total of 500. If this seems a poor proportion, it should be remembered that the world total itself was only 18 four years previously.

There were now four new aircraft on the drawing boards of British designers. The first was Mr. F. N. Slingsby's Kirby Gull, which appeared at the beginning of 1938, and at a price of £188 set out to supply a high-efficiency sailplane at something under the cost—if also slightly under the performance—of the best German types. It was based on the Kirby Kite which had already done so well, but the lines had been generally cleaned up, while a new gull-shaped wing of 50-foot span was much more efficient than that fitted to the earlier aircraft. It gave it a useful cruising speed of about 40 m.p.h., at which the rate of sink was in the neighbourhood of 3 feet per second, and a useful maximum of approximately 55 m.p.h. Like all the newer designs, its weight had increased and was 320 lb. This tendency was to become more and more marked.

The next aircraft was the Viking I, designed by Mr. Roy Scott. Its performance was on a par with the King Kite and Hjordis, achieving 65 m.p.h. for only 5 feet per second sink, and at its best flying speed of 33 m.p.h. reducing this to as low as 2·5 feet per second. Once again the weight had gone up—this time to 370 lb. unloaded.

The Slingsby Petrel, produced just before the war, looked like being better than any of them. It remained under full control at only 29 m.p.h., and had a rate of sink of only 1·5 feet per second at 35 m.p.h. While in basic design it was reminiscent of the Rhönadler, the German design had been radically improved. Tests were incomplete before war stopped further soaring, but the British Gliding movement will hear more of this aircraft in the future.

Finally two new two-seaters were produced, each of them high-efficiency types and the first of their kind to be attempted in this country. They were the Viking II and the Gull II. Once again war put a stop to the tests; but in spite of their side-by-side seating arrangements, the streamline had been brilliantly preserved, while the few pilots who had the opportunity of flying them expressed the opinion that they were first-class machines really suitable for advanced dual cloud-flying. Their clean outline and general dimensions are illustrated in Figs. 64 and 65.

It is worth taking a brief look at the last of the German sailplanes to be produced before the war. Apart from a new type of metal construction which put up some remarkable performances in spite of its great weight, there were four new designs which were typical and illustrated that the limits of increased weight and span had not yet been reached. There was a new

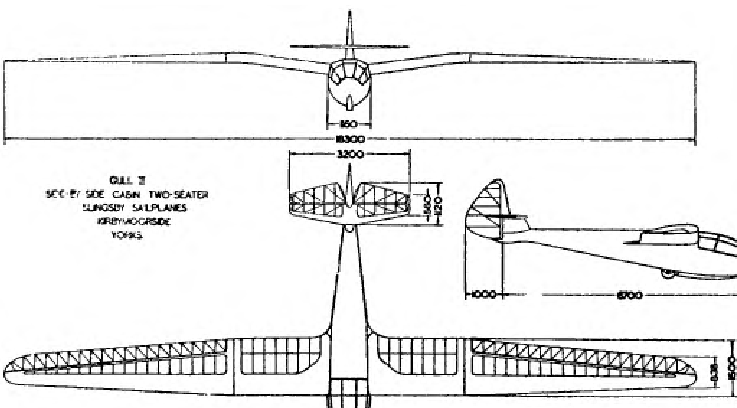


FIG. 64.

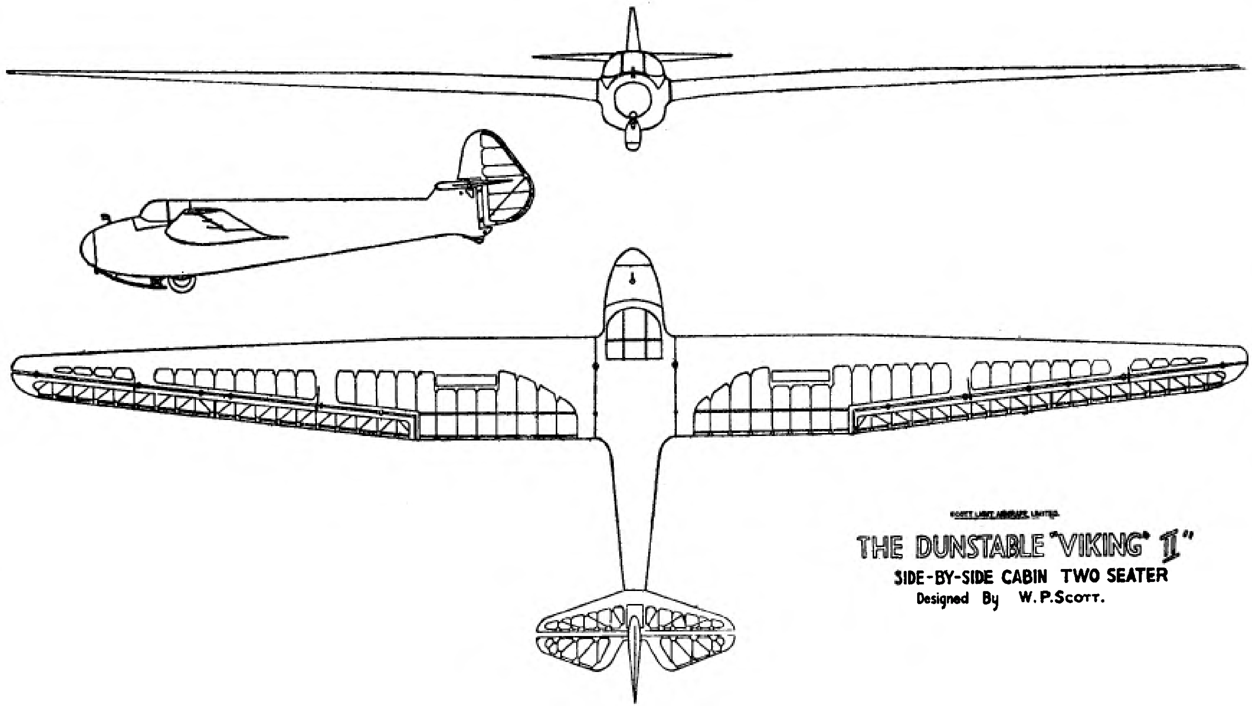


Fig. 65.—*Viking II: High-efficiency side-by-side 2-seater.*

Span 61 ft. Aspect ratio 16·3.

Wing loading 3·8 lb. Weight 510 lb.

Sinking speed at 40 m.p.h. = 2·4 ft. per sec. Gliding angle 1 in 24.

edition of the Condor which scaled 507 lb. for a wing span of 57 feet 7 inches, and yet retained a sinking speed of only 1 foot 8 inches per second at 34 m.p.h. The old Rhönsperber's speed of 67 m.p.h. for 2 metres sink per second had been improved to no less than 87 m.p.h.

The Reiher was another new German sailplane with a big span—this time 62 feet 4 inches, and in spite of its 485 lb. it retained a gliding angle of 1 in 33 at 34 m.p.h.—or, expressed in rate of sink, 1 foot 9 inches per second. The last German sailplane of special note was the Darmstadt 30, with the almost incredible aspect ratio of 33 to 1. Its wing was like a knife blade, but for all that it yielded a gliding angle of 1 in 36 and only 1 foot 7 inches sink at 38½ m.p.h. The span had

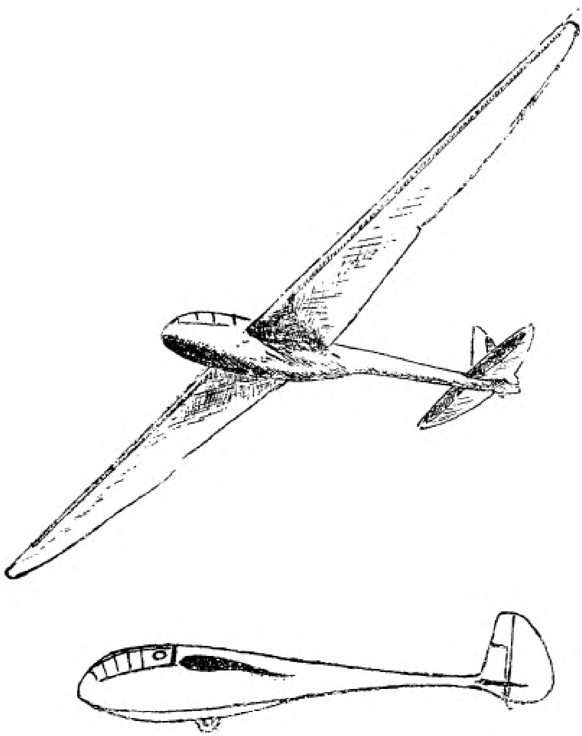


FIG. 66.—*The Nemire (Hungarian). A typical example of high-speed sailplane of Continental design. It has been cruised at 75 m.p.h. under a cloud street, and at 87 m.p.h. has a rate of sink of only 2 metres per second. At 43 m.p.h. it can be circled in 10 seconds.*

Span 65·6 ft. Weight 750 lb. Wing loading 3·9 lb. (with pilot and parachute).

reached a new record of 66 feet for an unloaded weight of 386 lb.

Meanwhile at home the national competitions of the summer of 1939 came and went. The improvement in British pilots was patent, and in difficult weather conditions 1,843 miles were flown across country, while no less than 13 out of 57 cross-country flights exceeded 50 miles. Now the German-designed aircraft were at last in declining evidence. Seventeen out of twenty-nine aircraft were of British conception, and third, fourth, and fifth places in the open contest were held by a Gull, a Kite, and a Petrel. The best performance of the meeting was put up by Mr. Kit Nicholson, who flew 162 miles from Bradwell Edge in Derbyshire to Southend in his Rhönsperber. But if Mr. Nicholson had been flying any of the best British machines the result would probably have been the same.

There was now an increasing awareness throughout the Press that this new-old thing was perhaps worth taking seriously. Whereas it had once provided occasional stories of the stunt variety, and even from time to time yielded a banner headline in the strain of "Glider pilot last seen in thunder-flash," it was growing aware that it was becoming good "circulation." Many people were driving out on Sunday afternoons to watch it, and it had almost reached the point of the popular Press printing the results of the national competitions. The more enterprising travel agencies had already realised the possibilities, and as early as the summer of 1937 were advertis-

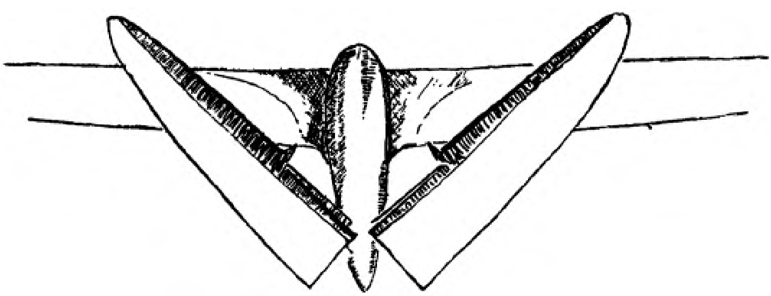


FIG. 67.—*The American Nomad, an unorthodox design in which the tail surfaces are set at 90 degrees and act as both elevator and rudder, dispensing with the fin. It is reported as stable, and has been soared to 17,264 ft.*

ing a trip to Austria for £19 18s., inclusive of an elementary glider training course.

The British clubs themselves organised training camps of their own, varying in cost from five to nine guineas for a full week's instruction, including board and lodging. These courses were always full, and it was rare for less than 90 per cent. of their members to return home without at least an "A" certificate. The rearmament programme, with its emphasis on the Air Force, brought flying into national prominence, and when war broke out and the Air Training Corps was formed there was an immediate interest in gliding, which was later to resolve itself into a practical scheme for elementary training. Many hundreds of Fleet Air Arm and R.A.F. air crews have had their first taste of the air in primary hops in a glider under the auspices of the A.T.C. Not by one hour could their Service training be cut short through such an experience. But the moral value was terrific.

There were 39 active clubs in September, 1939, of which about 10 were able to offer advanced soaring facilities. The number of pilots holding "C" certificates was over 600, but over 1,500 had qualified for an "A" by a glide of thirty seconds under the Air Defence Cadet Scheme, which was soon to be merged into the Air Training Corps. Many new pilots were being turned out under the auspices of the clubs every month of 1939. By the summer of this year over 50 silver "C's" were held by British pilots.

While it is difficult to see where major improvements will be made in the future, it would be ridiculous to suggest that the limit has been reached. Luxuries such as an artificial horizon which will not cost about half the price of the sailplane itself will be welcome to those who seek great heights in the toils of the clouds. Congestion of the air lanes may lead to restrictions on cloud flying—probably quite unnecessarily, for the type of clouds sought out by the sailplane pilot are those studiously avoided by the air lines. Nevertheless, a wireless receiver may be insisted upon as a measure to preserve control over cloud-flying sailplanes.

More certain methods of releasing the towing cable at the end of a launch (see Fig. 63), better stowage for a parachute, and possibly some sort of a trimmer which will enable the aircraft to be flown hands off with varying weights of pilot, will no doubt come as minor improvements.

We can in addition expect an adjustable flap by which a high speed wing section can be altered in flight to a low speed section. One of the great disadvantages of a fast wing is its lack of manœuvrability, entailing a much bigger turning circle than is possible with a low speed section. The lowering of a flap which might be placed inside the ailerons would possibly reduce the effective flying speed from 45 m.p.h. to 35 m.p.h., and this without affecting the minimum rate of sink. The turning circle would thereby be considerably reduced, and the chances of making use of small diameter thermals close to the ground correspondingly increased. A fast aircraft would no longer find itself at a disadvantage over the soaring ridge while endeavouring to 'get away.'

The increased costs of manufacture are more likely to be a source of concern during the years immediately ahead. The secondary trainer which cost £100 in 1939 could scarcely be sold for less than £200 in 1945, while high-efficiency types such as the Petrel and the Viking might well be found to cost nearly £500. As has been suggested elsewhere, the remedy may be a set of standard designs for mass production, filling the gap until such a time as individual experiment again becomes an economical proposition.

In aerodynamical efficiency we are approaching the practical limits of accepted designs. Possibly a tailless aircraft will emerge with greater potentialities, but most of us will be glad to enjoy for a few years the fruits of much labour which were so rudely snatched from our grasp in September, 1939.

GOING WEST

THE flight which won the first Golden "C" for a British pilot is recorded by its author in this, the last chapter. It was the third Golden "C" ever awarded, completing the distance qualification of a minimum of 186 miles, to which was added a height in excess of 3,000 metres (9,843 feet) previously obtained.

British experience gained the previous year (1937) at the international competitions in Germany had suggested that our pilots were not then the equal of the best of the German pilots, although they ranked above the representatives of half a dozen other nations. I think that Mr. Wills, the author of this account, has bridged the gap, and that he is closely followed by several others. After a long start, the Germans have been caught, just as they were caught in the more serious business of war, and with infinitely more unhappy consequences.

*   *   *   *   *

"The newspapers always call it Buchan's third cold spell. Be that as it may, I have personally noticed that in each of the past four years we have had, between March 20 and April 30, a spell of highly unstable north-east winds. In past years I have made plans to get a launch from the South Downs during this period—which have always come to nothing. But this year the advent of aero-towing at Heston, specially organised to be ready in time, made it easy, while the north-easterlies simultaneously obliged by blowing steadily for practically the whole period—to the confusion of farmers but the profit of sailplane pilots.

Going to the office on Friday, April 29, I looked wistfully up from the crowded city streets at the activity of a different sort going on overhead. It seemed too much to expect yet another such day to follow—but that evening the weather bureau said 'same again.' That meant a north-east wind, cloud streets forming as early as 9 a.m., with a tendency (in London, anyway) for the whole sky to cloud over later in the day. I asked whether this was not due to the influence of the North

Sea. The weather people agreed that it was likely, and added that I would probably be safe from Salisbury onwards. It looked, therefore, as if part of the problem would be to get to Salisbury (65 miles) before, say, noon. This meant early breakfast to be rigged and away from Heston by 10.30.

We spent a busy evening getting everything ready for an early start. I ruled out the line of flight on the map and studied the course as closely as possible. The conditions looked as though they might be very similar to my flight earlier in the month from Huish to Plympton, so I hoped I might find the same sea-breeze effect which I had then found so useful from Lyme Regis onwards. The course I mapped out, therefore, took me to Lyme Regis, thence out to sea and along the coast to Exmouth, then on towards Plymouth. As a matter of fact, on the actual flight I was seldom more than 5 miles off the course at any point.

On Saturday morning it didn't look very hopeful. The instability was there all right, but the wind was strong and far too northerly. We consequently left later than we had planned, said we'd be home to tea, and left behind luggage and money.

Arrived at Heston, the sky looked marvellous. Tremendous streets ran up and down wind as far as the eye could see, and although the surface wind was almost due north, the upper wind, judged by the line of cloud streets, was north-east. This was confirmed by the met. people as 0·50 above 1,000 feet (I should have to make good a track of 250 to get round Sidmouth Bay). Across a 20-m.p.h. wind this was better than I had feared, but was quite bad enough. However, I hoped first for the favourable sea-breeze effect already mentioned, and second that the wind might drop with the combination of the approaching evening and conflicting sea breezes. I hoped for the latter from Bridport to Plymouth—which I formally declared as my goal, Now, as it happened, both these preconceived possibilities came true. Let us therefore be optimists always.

A last point was that with the big veer in the wind it was clear that if I got into difficulties anywhere they would be increased by its northerly trend the lower I flew.

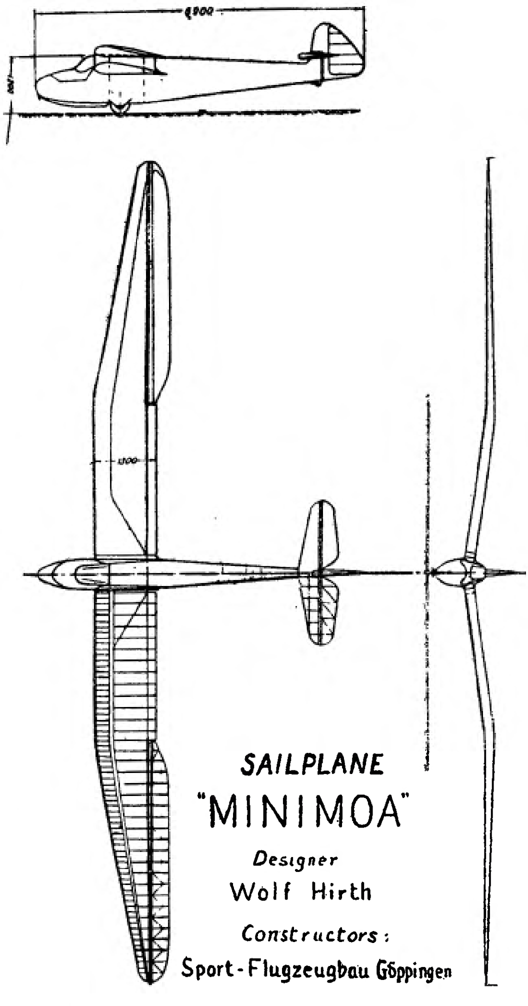


FIG. 68.—*The German built and designed Minimoa, in which Mr. Wills again broke the British height and distance records.*

Span 55 ft. 9 in.
Wing area 205 sq. ft.
Aspect ratio 15·2.
Wing loading 3·24 lb.
Weight 441 lb.
Gliding angle 1 in 26.
Sink at 40 m.p.h. 2 ft. per sec.

I make no apology for this long preliminary argument, because I am sure that previous planning of a long flight is of the utmost importance, particularly in England, where every really long flight must of necessity be in the nature of a goal flight.

As the result of delays and uncertainties, it was 11.05 by the time we actually took the air. I had asked to be towed upwind towards a cloud street over Harrow, but we had barely crossed the aerodrome boundary—only 600 feet up just east of the gasometer—when the aeroplane ahead jumped as if it had been shot. Instinctively I released, then cursed myself for being so hasty.

However, there was undoubtedly lift nearby, and after a little searching she took it fairly in the seat of the pants. The variometer jumped from 6 to 9, and a little bit later to 12 feet per second. We circled up, back over one corner of the aerodrome, into the base of a cloud at 3,600 feet near the Staines reservoir. I turned her nose north-west, put it well down, and struck off at 65 m.p.h. The battle was on.

North of Staines was another cumulus. I found the up-current beneath it at 2,500 feet showing 3 feet per second—but this was not enough. I now declared as a rule of the day that when over 3,000 feet I would not be content with 3 feet per second. If after a search I could not bring it up to at least 5 feet per second, I would go on. But I would never just circle in bovine content unless I got up to 9 feet per second. Until that point was reached I watched every circle, and manœuvred restlessly, searching for the 'meatiest' bits. Time was the essence of the flight, and to save it meant constant hard work. Lesser lift I used by flying through it as slowly as possible, only putting the nose down again when it was past.

I worked this second thermal up to 6 feet per second and then set off again. But this time further lift was hard to find. Virginia Water and Fort Belvedere slid beneath and I was getting dangerously low. I abandoned the cross-wind struggle and went straight downwind towards a large common short of Farnborough (Chobham Ridge). I was miserably reflecting that there was not a safe landing spot in sight, that there was a lot of luck in putting a sailplane down in one piece, and that I had wasted all my work, when suddenly we struck lift! I was 700 feet above my start and perhaps 500 feet above the common below. A last-minute save!

My pride over rates of climb quite gone, we struggled round and round and round. A while later we were up again at 3,900 feet just north of Farnborough, well off course and rather depressed.

However, this was the last shock for a long way. We got back on to our course at Basingstoke, flew along south of the road to Whitchurch, where we worked up a thermal to over 15 feet per second, along to Andover, with Southampton Water and the Isle of Wight in sight, and then Salisbury. The rolling country of the plain was, as expected, stiff with thermals.

Over Salisbury we had some fun. We found ourselves climbing at 6 feet per second up beside a large dense-looking cumulus cloud. The best lift seemed to be in a circle, of which the nearest point was perhaps 25 yards south of the wall of cloud. At 5,100 feet the lift declined, so I decided to go inside to try for more. We charged at the solid wall of cloud, hit it, and burst out on the other side as if through a pane of frosted glass. It could not have been more than 25 yards thick; then we were in clear air again in the most violent downdraught of the day—over 15 feet per second.

'You nibble a piece off this side,' said Alice, 'and you grow taller: off the other side and grow shorter. Curiouser and curiouser.' I went back and nibbled some more off the other side.

I had been carefully checking my average speed, and found that we had made 32 miles for each of the first two hours. This would get us to the proposed junction with the coast at Lyme Regis at about 3 o'clock. After that I expected to be able to increase speed. I reckoned on being safe until 3.30, so it might be a near thing to catch Brer Fox, which would take place, if at all, at Exmouth.

But I was wrong in my calculations. The big speed-up of the day was at hand. After passing Salisbury, we flew along the line of hills, past White Sheet Hill, to Shaftesbury, and in this third hour we covered 44 miles. Now came Blackmore Vale, which I had previously found on a flight to Plympton rather cold to strangers. It was once again. As before, near Yeovil, I gave up and turned north to make for the aerodrome. Again I spotted the same little sloping wood which had saved me before, and again it came to my aid. The conditions were extraordinarily similar to the previous occasion from now on to Exmouth.

We climbed thankfully to 3,800 feet, and then made no bones about it by fairly bolting downwind for the sea. Between Bridport and Lyme Regis was the same belt of coastal lift—formed from 1 to 3 miles out to sea by a south-easterly sea breeze cutting the north-easter. In this way we flew fast along the coast, over the blue sea, past Seaton, Babbacombe, Sidmouth, to Exmouth. Here the same strong thermal took us up to 5,500 feet, and after my last experience at this spot a new caution beset me. Our ground speed had increased greatly since reaching the coast, as I had expected. But the struggle at Yeovil had brought the fourth hour's kill down to 32 miles again. We put our first bird, Exmouth, in the bag and concentrated on the second—Plymouth.

The wind was now dropping, the clouds dissolving. From Exmouth we flew to a cloud beyond Newton Abbott, where I found an unexpected aerodrome. Weak lift from a seedy-looking thermal took us slowly to 4,000 feet again, and then a long glide found us heading down a river ending in an estuary and a cardboard conical island planted in its mouth—Bigbury. The fifth hour again saw 32 miles go by.

The prospect of getting enough height to cross the high land to the north and make Plymouth aerodrome seemed remote, although as we crossed one or two of the brown rocky spurs of Dartmoor with perhaps 500 feet to spare, I found weak lift over each. With a prevailing dearth of landing grounds, I was thinking of making a bid for the beach at Bigbury, so recently furrowed by the skid of the 'Sperber, when we came to the end of Dartmoor.

Just to the north I saw the textbook spot for a wind-shadow thermal. Dartmoor billowed down from about 1,600 feet in a series of rounded slopes facing the westering sun. The bulk of the moor to the north-east provided obvious protection

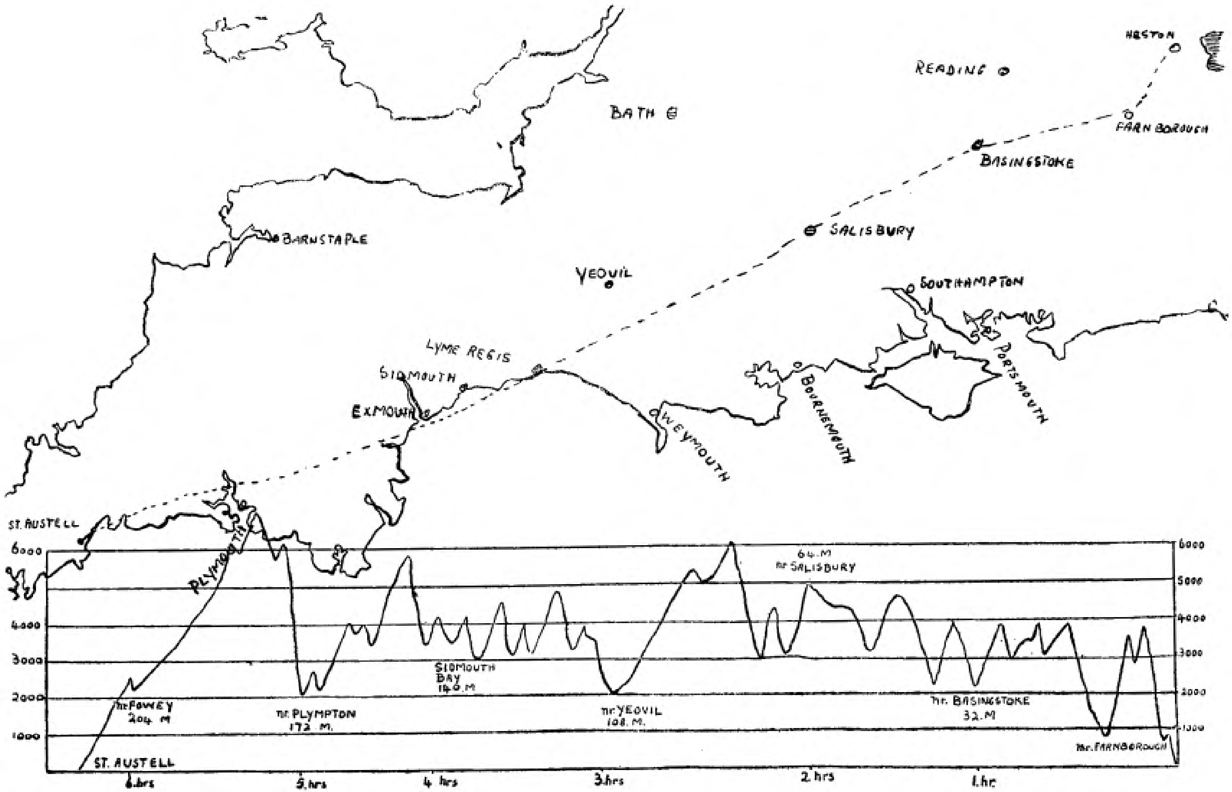


FIG. 69.—*Map and barogram of British distance record.*

against the north-east wind. So the quiet air over the slopes should have had every opportunity to warm up. I gave up my safety-first plan of Bigbury sands and reached a hopeful spot at 1,900 feet. Immediately I found lift—in no time Plymouth aerodrome was in the bag. A bit later I began to be torn between completing a 178-mile goal flight or going on while the going was good and trying for 200 miles—a nice round figure. Then I remembered the Golden "C" requirement—3,000 kilometres or 186 miles. By this time I was at cloud base 6,000 feet over Plymouth. Inside the cloud lift was strong but patchy, and at 6,900 feet I gave up the mental struggle and went on west. I came out of the side of the cloud and saw the irregular coastline of Cornwall ahead—the numerous inlets and rivers silver against the declining sun, the colours of the landscape darkening by silhouette.

I flew along the coast, finding dying lift here and there. The land and sea breezes both seemed to have gone. Smoke below was rising gently and vertically. Six hours—and yet again 32 miles covered.

Over the river running down to Fowey was again gentle lift. Farther on I could see St. Austell, a surprisingly large town, the hills behind it dotted with huge white pyramids of china clay. I remembered that this was the home town of Captain Phillips, where he used to land his Avro 504. How bucked he would have been with all this ! I reached St. Austell at about 1,500 feet, saw a sloping field behind a garage on a bypass, and circled down to a landing at 5.15 p.m.

I had caught a heavy cold and felt extremely ill. I had had nothing to eat since 8 a.m. But the task of keeping at bay the ravening hordes of small children until the Minimoa was safely packed away took another two hours.

The official distance by great circle course was 209 miles."

* * * * *

And what of the future? At a guess the record will be broken sooner or later by a pilot who soars along the line of the Pennine range, maybe from Hartside, and reaches the south coast. But whoever wins that honour, he will owe it to Philip Wills and a few others like him who pioneered the byways of the English sky and showed the rest of us how to do it.

INDEX

SWITZERLAND AND THE ENGLISH

By ARNOLD LUNN

Author of "Mountain Jubilee," "Come What May," "And the Floods Came," etc.

Demy 8vo. 260 pages. 16 illustrations. 15s. net.

The special character of Anglo-Swiss relations is not due to political factors, though Britain intervened on two occasions with decisive effect to safeguard Swiss independence, but to the influence which Englishmen have wielded in the discovery of the æsthetic, cultural and sporting possibilities of the mountain ranges of Switzerland. No historian has done justice to the fact that the British, who have to travel five hundred miles to find high mountains, have played so great a rôle in the development of the mountain cult, in the organization of mountaineering, and in the evolution of competitive ski-ing.

Mr. Lunn believes that æsthetic revolutions reflect philosophic revolutions. He traces the changing feeling for mountains from the Greeks and the Hebrews through the Renaissance and the Romantic Revival. He devotes chapters to the Romantic Movement (Byron, Shelley and Wordsworth) in its relation to Switzerland, and to John Ruskin, perhaps the greatest of mountain prophets. And when he comes to more modern times, he does not write as a mere chronicler of sporting achievements, for he believes that sport is a mirror of contemporary life. "Few institutions," he writes, "reflected more faithfully the Victorian ethos than the Alpine Club in its early days, and few things mirrored more accurately than ski-ing the ideological battles of the modern world between the two wars."

The book is superbly illustrated, partly by reproductions of the work of British mountain artists and partly by modern photographs. In this book, as in "Mountain Jubilee," Mr. Lunn gives poignant expression to that nostalgia for Switzerland from which her English friends have suffered during these long years of war and exile.