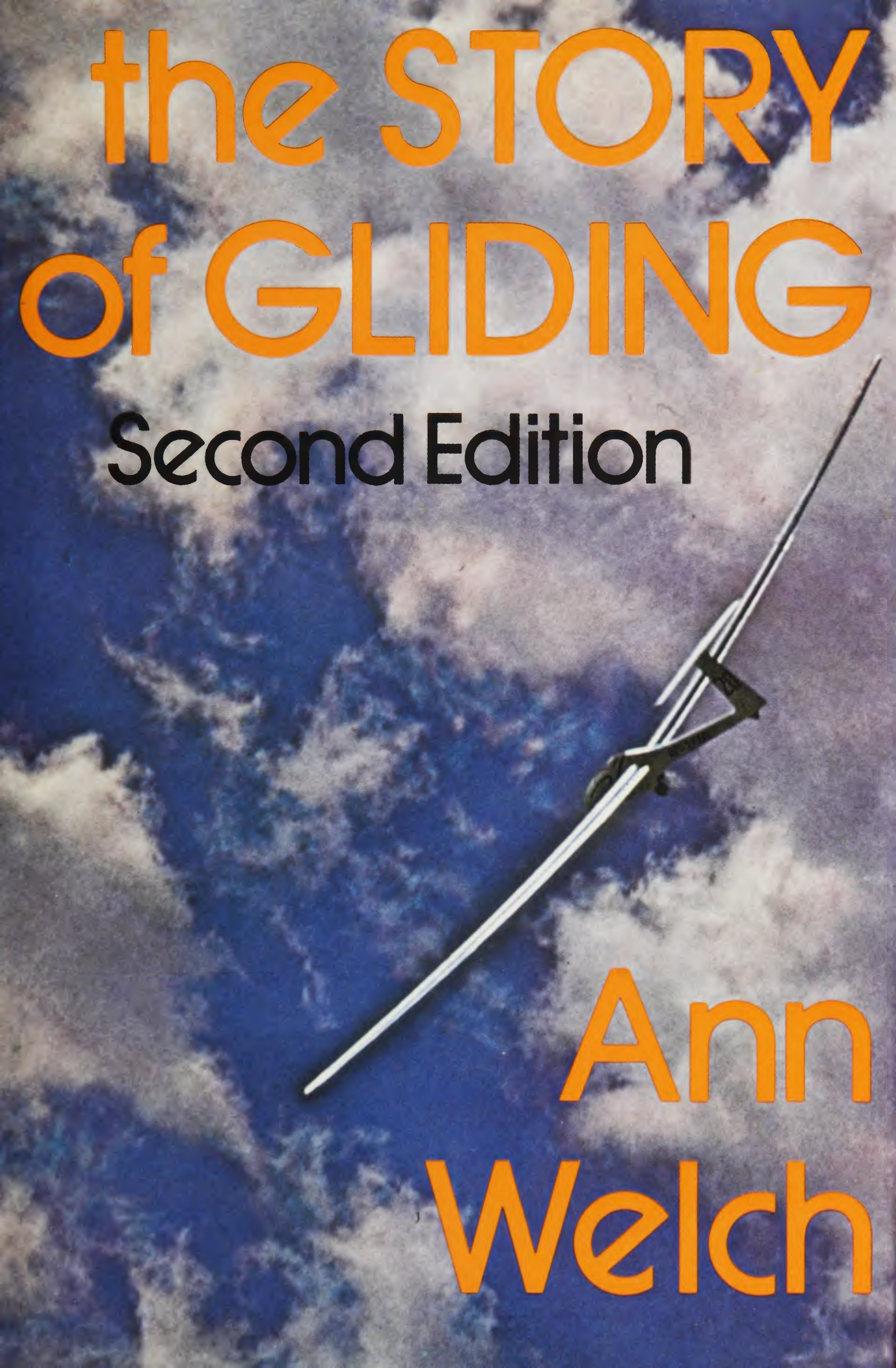
the STORY of GLIDING

Second Edition



Ann Welch

Gliding today is a high-technology sport. Without an engine gliders have flown 1,000 miles in a day and averaged speeds of 100 m.p.h. – more than is possible in many light aeroplanes. The modern sailplane is made of glass and carbon fibre, has a wing of up to 22 metres span, and is finished to almost perfect smoothness.

But it was not always like this. The pioneers flew with the classic materials of bamboo and cotton sheeting, and their followers used spruce and plywood, or metal, in the search for ever better performance. In the early days, gliders flew from hills, like hang gliders of today, soaring in the rising air over the ridge. Then, in the late 1920s, came the first tentative experiments with clouds and the discovery of thermals. Pilots tried to fly as far as they could, landing only when it was no longer possible to stay airborne, or climbed in thunderstorms without proper instruments or oxygen.

The Story of Gliding describes the pioneer efforts of the past and the great flights to achieve the present records. It explains how gliding has moved towards the highest possible performance; why hang gliding has become so popular; and shows why so many pilots find flight without power – and without noise and pollution – so attractive and challenging.

In this 2nd Edition there are 123 photographs and 34 figures.

Reviewing the 1st Edition in *Country Life,* Philip Wills wrote: 'This book is a brilliant success. The facts, the mood, the humour and the colour are authentic and in places moving; certainly in one reader the book has produced a most pleasant nostalgia.'

Jacket front: Finish of a race – Jantar 1 of S. Kluk, Poland, above Waikerie, Australia, 1974 *(photo by Ann Welch)*

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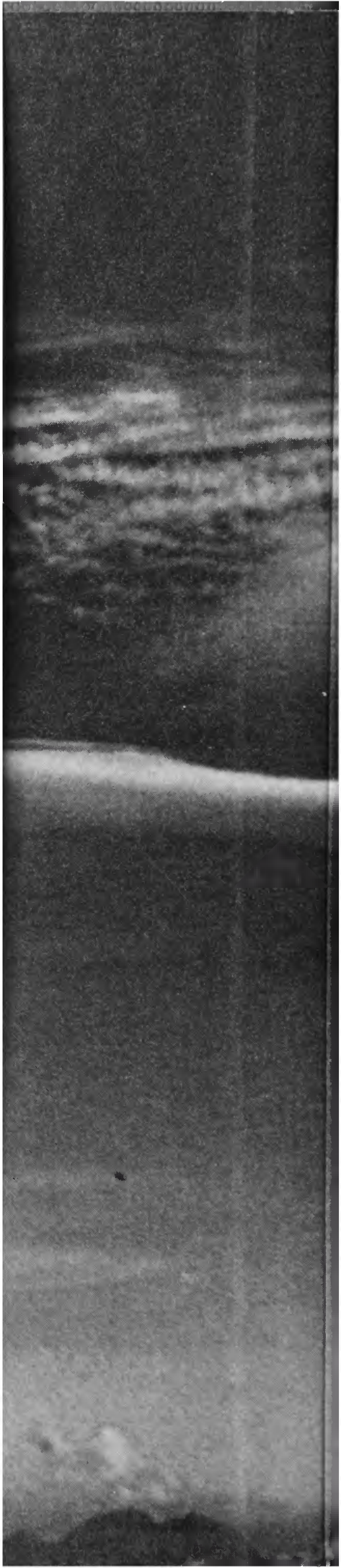

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ANN WELCH

to Wally

Best wishes

Ann Welch

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INTRODUCTION

This book is not intended to be a history of gliding, but a story about some of the people who wanted to fly in the same manner as the birds—on their own wings, using the energy of the sun and the wind.

Gliding did not, of course, start as a sport but as a stepping-stone in man's quest for flight. Lilienthal believed that much could be learnt from copying the birds and kept his gliders light enough to be foot-launched like the hang-gliders of today. The Wright brothers had no real interest in gliding. They wanted to develop powered flight, and although their first aircraft were gliders they were designed to carry the pilot and eventually an engine. By accepting the penalty of more weight, and launch complications, they could work directly towards the aeroplane.

Once the aeroplane was invented, running on your own feet with frail contraptions was of no further consequence, except to a very small number of individuals who still longed to fly as the birds did. It was from these few, wandering in the hills with their flimsy hang-gliders in the early 1900s, that led to the elegant and sophisticated fibreglass birds of today.

It is not only the aircraft that have changed over the years. To begin with the objective was to achieve controlled flight, and the sense of purpose needed was so demanding that it could be sustained by only a highly dedicated few. But when the first hang-glider pilots got together in the Rhön mountains they attracted like minds, and together they built better gliders. The objective now was not merely to fly—that was no longer a problem—but to soar; if the birds could do it there must be some way a glider could stay high in the sky.

Hill soaring, and later cloud and then thermal soaring, not only brought people together but welded them into an élite group, almost a sect; it did not matter that outsiders looked

on gliding as an odd sort of flying—although sometimes tinged with an envious glance—the pilots themselves simply knew that their brand of flying was the finest. In England, in the '30s, this 'same species' feeling soon manifested itself among pilots in that national feature, the club. But gliding clubs were no strongholds of tradition; they were enterprising self-help groups which became almost a way of life.

This enthusiastic approach to flying, where every soaring flight was still a voyage of exploration, lasted almost into the '60s. There were competitions, of course, because gliding is a form of flying which lends itself to really satisfying contests, but these still retained an element of the unexpected and even the unknown. With gliders still made of wood some entrants arrived with brilliant new aircraft still in the course of construction, and feverish hammering would continue all night.

But it was competitions, or rather the concentration and prestige that was heaped upon them, that shifted the emphasis from the exploratory, migratory soaring of the birds to the closed-circuit racing of the car, the horse or the sailing dinghy. As gliders became heavier and faster, so as to be able to compete at higher speeds, they became less able to slope soar, be hand- or bungey-launched from hills, or to be afforded by young pilots. And so the simple delights, such as circling with a buzzard, or just wandering high above a cloud-dappled landscape, became harder to obtain. At the same time much of the identity of purpose in soaring dispersed. Gliding became specialised, polarised by its top pilots into a demand for more performance at almost any price.

A few glider pilots stayed out of the mainstream and flew solely for the simple pleasure of being in the air, often in a carefully restored vintage glider. Others added a little engine, a paradox that gave them the independence to fly as they wished. Then in the late '60s the new hang-glider appeared, bringing with its crude and rustling sail a long-overdue opportunity to fly in an unsophisticated, unregulated way. The demand, unsatisfied by current gliding or any other

existing form of flying was enormous. In less than a decade there were 60,000 hang-glider pilots in the world and as many hang-gliders. These pilots, as their forebears had done, became an élite pioneering group.

Now there is gliding and soaring at each, extreme, end of the spectrum. There is the expensive fibreglass glider with its fantastic performance and the computerised thinking required of its pilot. At the other end there is the simple soft-wing, achieving its effective performance largely from its ability to be flown slowly with good physical co-ordination.

What is needed now is for these two magnificent means of soaring to find a link, so that there will no longer be a gulf between them. There is need for a new light simple glider to be pioneered, and a need to accept that there is delight for some pilots in every variety of soaring.

In the first edition (1965) the measurements were given in feet and inches and weights in pounds, etc. In order to minimise alterations to the existing text and drawings, the same units have been continued. However, in the new glider data table at the end of the book all units are metric.

I am most grateful for the generous help given to me, in the reading and checking of the manuscript, the loan of photographs and for agreement to reproduce excerpts from other publications. I am especially indebted to George Benson, Hugh Bergel, Paul Bikle, Terence Boughton, Peter Brooks, Charles E. Brown, Max Gasnier, Dick Georgeson, Nick Goodhart, Tony Goodhart, T. Heimgartner, Frau E. Hirth, Gordon Hookings, Frank Irving, Bernard Koszewski, Bill Kronfeld, Eric Nessler, Dick Schreder, Doc Slater, Philip Wills; to the Editors of *Gliding*, *The Sailplane and Glider*, *Sailplane and Gliding*, and *Soaring*; and not least to my publisher.

Part I

TO FLY LIKE THE BIRDS

Chapter One

MYTHS OR MADNESS

It is probably true to say that man has wanted to fly ever since he first saw a bird; but how much has he wanted to? Whereas 2,500 years have gone by since he showed himself capable of logical engineering thought, it is only just on a century since he first clambered uncertainly into the air on his own wings. For several hundred years before that, human gliding flight was possible, but dilatoriness and lack of enterprise in getting airborne has indicated that flying was clearly not one of mankind's more serious desires.

Three thousand years ago, the Chinese flew kites which were fundamentally sound aircraft, requiring speed through the air to maintain themselves just as aeroplanes do. Some of their kites were shaped like birds, and some were even big enough to carry people. The Chinese understood at what point on the kite the string should be attached to make it fly well, or climb steeply. If, instead of holding the kite at an angle to the wind so that it went up, they had removed the string, weighted the nose suitably, and launched it off a cliff so that it glided down, it would have flown just as effectively as the aircraft of the 19th-century experimenters. But flying kites high in the bright sky was fun, and merely throwing a beautifully worked kite down into a valley was senseless. With its competitions and its craftmanship, kite-flying was sufficient in itself.

As the art moved slowly over the centuries from China to India, and then to Europe, it must have stimulated the thoughts of many hundreds of people. But the kite did not become translated into a glider. Perhaps it was because kites were captive, and so did not fill the imagination with thoughts of flying as a means of travel. But even if going anywhere in

them was impossible, the most surprising thing is that they do not even appear to have been used as observation platforms. In 2,000 years there is no record of a kite having been used to watch out for invading fleets, spy into besieged castles, or even to make signals. The first occasion on which these simple flying machines were used other than for pleasure was probably the Franco-Prussian war of 1870.

It was much the same with balloons. Since primeval times the smoke of fires had risen into the air, but not until the 18th century did people learn how to make practical hot-air balloons.

Enough knowledge to build an artificial bird existed at the time of the Armada in 1588. Leonardo da Vinci had started thinking about aerodynamics, and defined the difference between soaring and flapping (or powered) flight. Among the ship and coach builders adequate knowledge of structures existed, but da Vinci never actually built an aircraft and no shipwright wanted to fly.

It is strange, this dream of flight, which no one succeeded in turning into reality. Even in the age of the great navigations, when there was a flowering of the whole civilised world into the realms of exploration, nothing happened. People were prepared to go out to find new worlds, even though many still thought that the lands did not exist and that the earth was flat. The determination to discover was so strong that they were not deterred. In the heat of this vast activity better ships were built, new navigating instruments designed, and new skills learnt. But not one-hundredth, or even one-thousandth part of all the energy in this age of new things was spent on trying to fly.

It would be interesting to try to discover whether this disinterest was due to a huge feeling of material impossibility, or to a mental prohibition, which involved religious principles or fear of black magic, or whether there was just a natural inborn instinct for man to stay connected to the good earth. Whatever it was, it was sufficiently strong to delay the possibility of gliding or soaring flight by some 300 years (and powered

flight by fifty or so). Perhaps the key to this puzzle lies in the lateness with which the art of the simple experiment appeared. To us this often seems the obvious way of investigating how to overcome a problem, but the concept is comparatively recent. By the 16th century, not a great deal of experimental activity would have been needed to produce an artificial bird which was sufficiently near the right basic principles to have given some indication of the way ahead: it was quite within the scope of people living at the time. But there was no passionate desire to get into the air. Even today, among some, there still lingers a sort of unconscious guiltiness, even a dislike of flying.

There were, of course, a few prospective aviators throughout history. They attempted to fly for nearly every reason possible —except the right one, and their efforts showed an almost complete lack of logical thought. If we are to believe the legend, they started with the well known and dutiful son, Icarus, the wax of whose wings melted as he neared the sun. Imprisoned with his father, a 'cunning artificer', the pair naturally wanted to escape, and made some wings using wax as the rather improbable adhesive. Whether they both flew, or whether Daedalus slipped out while his son sacrificed himself, will never be known. In the excitement of seeing the unlucky Icarus hurtling towards the sea from the ramparts, shedding feathers in all directions, the guards could easily have missed a creeping figure.

Escape seems to have been one of the main motives of early attempts at flight, one of the most successful being that of the Chinese Emperor Shun, who as a boy escaped from captivity by 'donning the work clothes of a bird'. Presumably no one actually saw him in the act, otherwise he is likely to have been recaptured. There is, however, some mythological evidence that the boy, who could have been small and skinny, used a couple of large reed hats, which are known to have been anything up to three feet in diameter, as wings, and in the few seconds of his descent became the unknowing inventor of the parachute.

There are many more accounts of attempts to fly, almost

all fatal. Men dressed in feathers, and shrouds stiffened with withy wands, continued to hurtle from towers, and people believed that witches really could get airborne on that most unsuitable device—the broomstick.

Possibly the first account of anyone who approached the problem of real flying with any likelihood of success was an Italian mathematician from Perugia, called Danti. He is said to have constructed a flying machine in about 1490, and flown over Perugia, as well as, according to legend, Lake Trasimeno. Although there is no evidence, it is possible that Danti knew of da Vinci's work, which was taking place less than 50 miles away, and had even seen some of his drawings. In any case he knew that it was necessary to have wings proportionate to the weight of the operator. This was an improvement on the designers of cherubs, who had divine faith in the power of the ridiculous little pink wings that adorned the plump bodies of their creations. The hissing supposedly made by Danti's device in flight led some to believe that it may possibly have been an ornithopter with flapping wings, but the noise was probably not dissimilar to the sound made by a primitive high-drag glider. The mention of iron stays to the wings lends strength to this theory.

The type of glider which someone of Danti's time was most likely to have built would have consisted of wings only, which the operator would fix to his upper body and arms, and from which he would hang when in the air, like a basic hang-glider. Legend says that Danti made flights over the lake; if he made them at all, he may have deliberately chosen this location in order to end in the water, and avoid having to run on landing. There are more windless days in Central Italy than in many parts of Europe, and so his arrival speed on to hard ground could have been inconveniently high. The one flight for which there seems to be real evidence is the flight over Perugia itself. Watched by a crowd of people, one of the iron wing stays unfortunately collapsed, and he severely injured himself falling onto the roof of St Marius's church.

If he did fly, and there is reason to believe that he probably

made more than one serious attempt, Danti was the first glider pilot.

Time went on, and a few more adventurers experimented. They did themselves no good at all, until about 150 years later, when John Wilkins (1614–72), Bishop of Chester, applied the glimmerings of modern scientific thought to the problem. His main contribution, as well as sorting out ideas into a rational form, was to realise that flying was not a pursuit in which success could be expected first time. He advocated the flyer, having made and attached his wings, not to take the usual spectacular leap from a high tower, but to run along the ground, endeavouring to extend the length of flight. He wrote that it was possible to 'step constantly ten yards at a time', which although not up to the same level of audience appeal, was clearly more profitable for the operator. One can visualise clearly the public image created by some white winged figure taking flying leaps across a field in the hoped for privacy of moonlight.

In Italy, at this time, a Neapolitan called Borelli, ignorant of da Vinci's works, produced a conclusion which although negative, contributed in the long term to the sum of useful knowledge. He concluded that, because a man's pectoral muscles are a much smaller proportion of his total weight than are a bird's, 'it is impossible that men should be able to fly craftily by their own strength'. Thus Borelli could have saved much useless work on ornithopters if his writings had been available, and accepted.

During the great ballooning era of the 18th century nothing was done towards heavier-than-air flight. The problems were by now sufficiently well understood to have reduced the leaping-off-a-tower fraternity to almost nil, but no one person really knew enough to get going. Not only did insufficient background knowledge exist for the inventor to draw on, but there was no usable source of power, and none in prospect. Gunpowder was seriously considered as a possibility, but its success in a structurally unsound aircraft covered in feathers would have been problematical.

Flight without power was possible; birds with still wings soared above the cliffs, the waves and the deserts, flaunting their simple superiority to any human who cared to look. But not until the beginning of the 19th century did men start to give sufficient calculating thought to the problem for progress to be made. Sir George Cayley (1773–1857), of Scarborough, improved the foundations of aeronautical knowledge to such an extent that the way became open, not only to more thinkers, but for the first practical experiments by ordinary people. Cayley did what the Chinese could have done; he weighted the nose of a paper kite and flew it as a glider. He found that 'if pointed downward in an angle of about 18°, it would proceed uniformly in a right line for ever with a velocity of 15 feet per second. It was very pretty to see it sail down a steep hill, and it gave the idea that a larger instrument would be a better and safer conveyance down the Alps than even the surefooted mule, let him meditate his track ever so intently.'

FIG. 1. Cayley's 1809 model glider.

During his long life, Cayley experimented with aerofoil sections mounted on whirling arms, learnt how to obtain lateral stability by setting the wings at a dihedral angle, and longitudinal stability with a tailplane. He realised the importance of streamlining, and made and flew many models. By 1850 he was building full-sized aircraft, one of which had carried a boy; in 1853 he produced a man-carrying aircraft. It had a large wing composed of a sail attached to a wooden framework, which took up its aerofoil section only in an airflow, as does the rogallo hang-glider of today. Control was intended to be achieved by deflections of a small cruciform sail on the end of a long lever operated by the pilot, who sat sideways inside a wooden fuselage. The intention

was correct but the skill required to get it right was considerable, and not at the time possessed by the 'pilot'. Because Cayley was nearly eighty years old he felt unable to attempt the flying himself so ordered his startled coachman on board, and had the aircraft launched over a small valley in Brompton Dale. The flight was brief, and in the silence which followed the crumpling noises, the coachman could be heard withdrawing his labour in no uncertain terms.

Chapter Two

THE LONELY MEN

A Frenchman, Jean-Marie le Bris, was sailing the Southern Ocean at the time of Cayley's great work in the early years of the 19th century. For a long time he had been interested in the idea of flying; but he knew nothing about it, nor of experiments that others had made. From his ship, however, he could watch the long-winged albatross, one of the finest soaring birds in the world. He saw it fly hour after hour without effort, using the wind blowing over the wave ridges to stay airborne. The beauty of its flight had stimulated more men than le Bris. What did the bird possess that allowed it this beautiful sweeping flight? Was it the power contained in the creature or its feathers, or in the air alone, or in the air which was disturbed by the waves? Le Bris wanted to find out, so one day, risking the ridicule of his fellow sailors, he fixed the wings of a dead albatross in the flying position, and holding it against the wind that streamed past his ship was delighted to find that the heavy body tended to lift, and became convinced that he could reproduce this ability to fly in a man-made device.

As soon as he had obtained enough money to afford to take some time off, he returned to France to build an artificial albatross, starting work near Douarnenez. His first bird had a span of 50 ft and a length of 25 ft, almost the exact measurements of today's Standard class glider; the weight, however, was only 110 pounds instead of 450 pounds. The fuselage, which was huge, he shaped like a canoe, and in the cockpit installed two levers which were continuations of the wing spars; with these he proposed to flap the huge wings, still not having fathomed the way in which the albatross flew.

The great ship was at last finished in the autumn of 1856, and le Bris took it to the empty beaches nearby, followed, as can be imagined, by a crowd of spectators. To obtain flying speed, he intended to use a horse to pull a trolley on which the albatross was mounted. When all was prepared, le Bris climbed up on to the trolley and stood in the cockpit grasping the levers. The glider-bird was attached to the trolley by a

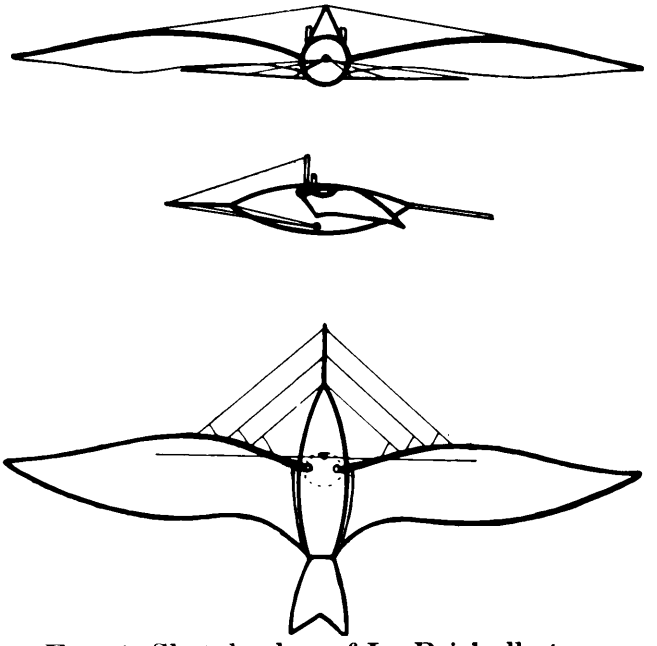


FIG. 2. Sketch-plan of Le Bris' albatross

long tether rolled up on a drum, the end of which was fixed near the coachman who would drive the horse. The whole equipage was faced into the wind.

It must have been a magnificent moment. The sea wind blowing across the great flat sands; the watchers, curious or fearful, standing close together for moral comfort; the coachman (clearly a hazardous occupation in those days) concerned only with the technicalities of driving his precious horse, and le Bris upright in his winged canoe, thinking of his dream to fly.

He gave the order to advance.

The horse broke into a trot, the trolley ran faster and faster on its hard wheels. At last le Bris decided that the moment had

arrived when his vast albatross, shaking and vibrating, had enough speed to fly. Inclining his wings to the wind so that they would provide the greatest lift, he released the cords holding the aircraft to the trolley. Silently the great albatross started to rise, kiting on the strong sea wind. Overcome by astonishment the crowd stared as the rope tethering the bird to the trolley slowly unreeled; it rose higher and higher, and higher, until it was far above their heads, like a bird of prey ready to pounce. At this dramatic moment in history the rope caught round the neck of the unfortunate coachman; continuing to unreel, it took him inexorably aloft. It is a commonplace in aviation that an accident never takes place as the result of a single cause, and at this instant in time a situation unusually pregnant with total disaster existed. But quite remarkably everyone lived to tell the tale. The horse, deprived of the coachman's professional patter, slowed down instead of galloping into the sea, the half-stalled albatross, poised at 300 ft, sank or glided back to the ground—clearly its flapping wings had never flapped. The strength of the sea wind and the softness of the sand took care of the coachman's downfall, and the albatross, still with le Bris upright, touched down, swung round and carried out the first ground loop in history. The fate of the trolley is not known.

Encouraged by his success le Bris decided to continue, but using a different launching system, consisting of a great gallows from which the albatross hung like a pendulum. Standing in his canoe facing the wind he got it oscillating like a swing; at the moment he reckoned the speed was enough to fly, he released the albatross; unfortunately, the glider was still stalled, and it pitched nose down, hitting the ground before le Bris had gained control of any sort. The pilot was taken from the debris with a broken leg, cuts and bruises.

This did not discourage the remarkable inventor, and two years later he built a new albatross. It was better than the first, slightly bigger, stronger, and at the same time lighter. Everything looked hopeful but unfortunately, although the

aircraft made a few short flights without the pilot on board, le Bris was continuously troubled by impatient spectators, and at the mercy of unsuitable weather and launching methods which did not prove as satisfactory as he hoped.

Le Bris volunteered for the army in the 1870 war, and the next year joined the police, which unfortunately resulted in his assassination.

At the same time that le Bris was experimenting at Douarnenez, another Frenchman, Louis Mouillard, was working on the possibilities of flight at the other end of France. Born and living in Lyon, Mouillard was fascinated by the flight of birds, and not only observed them with care, but recorded in great detail their vital statistics, weight, changes in wing plan when flying slow and fast, as well as the wind speeds in which they would fly. He discovered that only high aspect-ratio birds, those with long narrow wings like the albatross, would fly when the wind was strong, and that eagles would stay on the ground if it exceeded 26 m.p.h.

About 1860 Mouillard moved to Algeria, which he found to be a fascinating place for continuing his work. In the heat of the day the gold-blue haze of the sky seemed filled with soaring vultures. Each morning as the sun grew strong they would appear silently and seemingly from nowhere, circling endlessly on their still wings, rising higher with the power of the sun until they vanished into its glare. Almost since the beginning of calculable time these birds had followed the same pattern of flight, waiting to devour the wreckage of life. Mouillard watched them for hours until his eyes were dazzled; from the dancing heat of the sand he watched them and longed to fly. He worked out how big the wings should be to carry his weight, and in considerable detail the shape of the craft he would have to make. But he did not know or understand how a bird actually flew, whether feathers were necessary, or that a minimum airspeed was needed to support the wings. Then there was the problem of materials. This was much greater than is often realised, since no one else needed to use materials which were both light and strong. Ship

builders, for example, obtained greater strength simply by using heavier scantlings. There was the difficulty of fixing the members together; nailing bamboo is impossible, glues were unreliable, and lashings too flexible. Mouillard was very able, but he found the problems of building a flying machine accumulating the more he thought about them, so he was forced to curtail his dream, and to tackle the problem a little bit at a time. He started by building himself simple wings, crude affairs which fitted on to his shoulders, and from which his body would hang down in flight. There was no fuselage and no tail: he would first just try to find out how a wing worked, and how it could best be made.

With his first efforts Mouillard achieved a flying leap of 15 seconds, in which he travelled 50 yards. This success was tempered by an almost desperate complication, when Mouillard found that his experiments would be subject to the uncompromising derision of his family and his neighbours. After the first one or two leaps made against a background of shrieks of scorn and ribald barracking he attempted to fly only when he could get rid of everyone, having to go to enormous lengths to find excuses for doing so. On one of his secret flights he was caught by an unexpected gust, and flung heavily on to rocky ground. As he lay recovering his breath and feeling for broken limbs, he must have wondered whether it was all worth while. This setback, combined with some illness which afflicted him and the sheer size of his lonely problem, proved too much, and for some time he gave up any attempts to fly.

After a while he moved to Cairo. Again the vultures rose above him circling into the deep sky, and his enthusiasm returned. Here he worked on a book which was to contain the results of his calculations and study, and into which he poured his immense knowledge of bird flight. Once again he tried to fly. With his slowly growing knowledge he built his third and fourth pairs of wings, the latter of over 50 ft span, with an area of 350 sq. ft, and a weight of 100 lb. He became hopeful of success, but before he could get airborne his health finally broke down and in despair he was forced to abandon

his attempts. While he was ill he spent much of his time writing, so that others might achieve what was denied to him. His great book, called *L'Empire de l'Air* was published at last in Paris in 1881, and was to become a great inspiration to Lilienthal and the Wright brothers—as yet children. This monument of original work was the result of thirty lonely years during which the author never met a single person who would understand or admit the principle that human flight was possible without power.

When his book was published, Mouillard discovered that he was no longer on his own, for disciples and pupils wrote or came to him, not only from France but from distant America; no longer working alone with only their hopes, they could argue, and be encouraged. During the last ten years of his life Mouillard must have realised that these friends would now carry on where he could not, and that they would succeed. So he started producing writings for their guidance on such subjects as 'a programme for safe experimenting', the employment of barometers as altimeters, and even on the training of pilots, and the use of parachutes.

Although his mind was still far ahead of his contemporaries, his body was failing. At the age of sixty-three, paralysed and exhausted, Mouillard retired to a small lodging house and cut himself off from the world. Many of his friends believed him dead, and ceased to write him letters. He finally died alone and without money in 1897.

The problem of flight had now been studied sufficiently to indicate clearly that a man-carrying aircraft could be built, although it was not understood how height could be maintained. The soaring bird was known to need no engine, since it somehow extracted power from the air itself, but so far no one had studied the air to find how it could contain this mysterious power. This was not surprising since in a non-scientific world there could have been few people to devote their energy to such an abstract theme. However, the gap was filled by another Frenchman, Alphonse Penaud. He was about fifteen years old when le Bris nearly strangled his

coachman, and he died at the age of thirty, the year before Mouillard published his *L'Empire de l'Air*.

There is little information on how Penaud carried out his investigations, or what mental and observational processes enabled him to reach the conclusions he did. What is astonishing is that he discovered so much, as can be seen by the diagrams that he left.

Penaud realised that since the wind could not penetrate obstructions, it must either go round or over them, and following from this he deduced that if the obstruction was a ridge, the wind would blow up and over the top. This was confirmed by his observations of birds which soared, without flapping, so long as they stayed in the region of rising air on the windward sides of cliffs and hills.

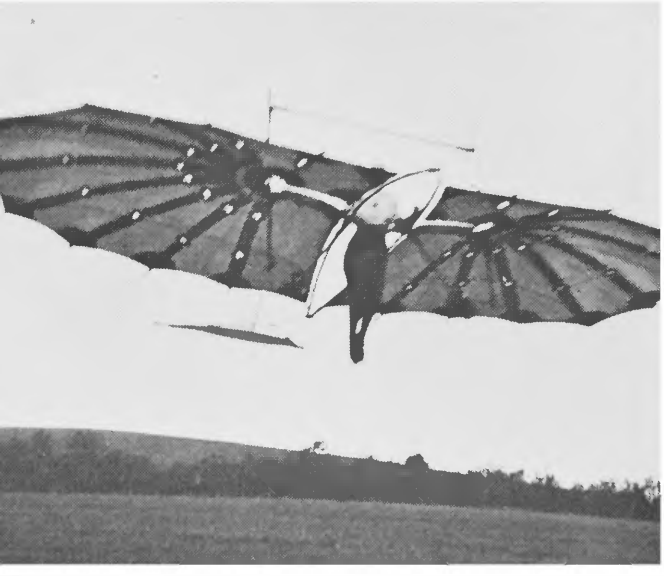
The understanding of slope lift is not difficult, but Penaud also realised that under some conditions atmospheric waves were set up to the lee of hills, in which birds could soar. He was not able to work out properly what happened, and his diagrams are not accurate by today's knowledge, but it is remarkable that he realised at all that waves could exist in the atmosphere.

His most interesting work was on thermals. He deduced that the vertical up-currents in which birds soared were caused by convection, and he produced diagrammatically his ideas of the structure of thermals, which he believed to circulate in the form of a vortex ring, or 'doughnut'. This theory, which is now generally accepted, was not propounded again until the 1950s. His writings contain clearer observations on thermal activity than are made by many pilots today, even with the knowledge which now exists.

Poor Penaud, he was unable to devise any means of getting himself into the air. He never met, and probably never heard of, le Bris or Mouillard, but like them he followed his lonely ideal beset with difficulties and frustrations from all sides.

The next step forward took place far from the civilised and beautiful land of France. America was a new country, bare and individual, but growing up fast. It was fully extended in

1 (a) Replica of Cayley's 1852 Riding Rudder glider, built by John Sproule; (b) & (c) Replica of Cayley's man-carrying glider of 1853, built by Ken Fripp and flown by Derek Piggott. It was just controllable by what became known as 'the influencer'



2 (a) The magnificent gannet. Span 6 ft, wing area 2.2 sq. ft, aspect ratio 16, weight 7 lb, wing loading 3 lb/sq. ft; (b) Percy Pilcher's Hawk which had a span of 25 ft. More than 50 wires were used to brace the wing and maintain its shape; (c) The general-purpose gull. Span 4 ft 2 in., wing area 2.2 sq. ft, aspect ratio 10; weight 2 lb, wing loading 1.2 lb/sq. ft. It normally flies between 20 and 35 m.p.h., as against the 45–50 m.p.h. of the higher loaded gannet

Photo by Christian Gad

Ann Welch began flying aeroplanes in 1934 and gliders in 1937. She was manager of the British Team at World Gliding Championships from 1948 to 1968. In 1961 she gained the British National Women's Goal Record and in 1974 was awarded the Lilienthal Medal. As well as being a gliding instructor, writer and sailor, she is also President of the British Hang Gliding Association and a Vice-President of the FAI.

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A lack of knowledge of operational procedures – Barbot in the Dewoitine at Itford in 1922 *Associated Newspapers Group Ltd*

Just over fifty years later, hang gliding demonstrates the deep-felt attraction towards the challenge of simple flying *Ann Welch*