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AVIATION

Claude Grahame-White

AVIATION

by

CLAUDE GRAHAME-WHITE

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PREFACE

Several courses are open to one who writes a book about flying. One can make it technical, for instance, and so appeal merely to the experts. In this way, one caters for a very limited audience. Or one can make it semi-technical, and endeavour to appeal to experts and to the ordinary individual as well. This I do not regard as a very happy compromise. Or the book may be made frankly non-technical, and so bid for the interest of all those readers who desire a knowledge of flying, but who do not wish any large amount of technical information.

From this third point of view I have written my book; and I hope that just the ordinary individual, who does not want to be bothered by stacks of facts and rows of figures, will find something in its pages that will really interest him.

If he does, I shall feel that my work has been amply repaid.

CLAUDE GRAHAME-WHITE.

London, 1912.

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FIRST SECTION

THE BEGINNINGS OF FLIGHT

I

No story is more fascinating than that which tells how men—after centuries of unavailing effort—learned to conquer the air. It has been the most romantic quest imaginable; and the tale is told here so that a grasp of the essential facts about flying may be obtained, the subsequent sections of the book being thus rendered easier of comprehension.

When one studies this story of the conquest of the air a particularly interesting fact emerges from all the others. It is this: England, which has certainly played no heroic part in the development of the aeroplane, might have led the way, if only she had shown enthusiasm and purpose. Just over a hundred years ago, when men all over the world were still dreaming about the conquest of the air, an Englishman worked out plans for an aeroplane; and when to-day we look back upon this man's ideas, we are amazed. What he did, all these years ago, with no practical data to go upon, was to indicate the building of a machine which, in many salient respects, actually anticipated the monoplane as it is flown at the present time. This Englishman was Sir George Cayley, whose name will certainly never be forgotten by those who study the problems of flight. A very accomplished engineer, he turned his attention to this question of flying, and soon obtained a wonderful grasp of the main points at issue.

In the year 1809 he gave a very remarkable lecture before the Institute of Civil Engineers; and he also contributed articles, upon the construction of aircraft, to the technical journals which existed at this time. What made his ideas so noteworthy was the practical form they took, as well as the really astonishing way in which he foreshadowed what aeroplane constructors are doing now.

For instance, he advocated the use of inclined lifting planes in the building of an aeroplane; and to-day—as I shall explain later—the use of a curve, or 'camber,' upon the planes we use is an all-important feature of their construction. Not only this, but Sir George Cayley was able to indicate just the type of aeroplane propeller we are now fitting to our machines. Considering that he worked out all his ideas without help of any kind, we should be proud that an English engineer, a hundred years ago, should have been able to outline correctly two essential features of the modern aeroplane.

Why did not he make a machine, and get it to fly? The question is an obvious one; and the reply is equally obvious. If Sir George Cayley had built his aeroplane, he would have had no satisfactory motive power with which to make it fly. In order to make an aeroplane fly you must have a light petrol motor; and there were no such motors in Sir George Cayley's day. This much, indeed, needs to be clearly understood. For many years before men actually flew, excellent designs for aeroplanes were procurable. But no attempt at flight could be really successful until the petrol motor—extraordinarily light and yet developing ample power—came ready to the hand of man.

All that Sir George Cayley could do, then, was to indicate how it might be possible to use some form of steam-engine in driving aeroplanes; but the weight of this form of motive power has always been against it in regard to its use upon aircraft. However, although he could not carry his designs to any practical issue, Sir George Cayley did pioneer work of the utmost value; and years afterwards, the Wright brothers—the great conquerors of the air—read all he had written, with the utmost interest, before they themselves began to plan an aeroplane that actually flew. Thus these modern navigators of the air did honour to the Englishman who, a hundred years ago, designed aeroplanes, but had not the engine with which to make them fly.

At the time he wrote and spoke, Sir George Cayley's ideas about flying created much interest; but nothing practical came of his articles or lectures. There remained the insurmountable difficulty of finding something with which to drive the aeroplane after it was built; so the years went on, and nothing was done. But what Sir George Cayley had written was not lost to mankind, as I have already indicated. Nor is it surprising, in view of the clearness of his ideas, that other enthusiasts should have endeavoured to carry on his work where he left off.

In 1842, for instance, two very patient and painstaking experimenters, Henson and Stringfellow, were busy with plans for aeroplanes, founded upon Sir George Cayley's conclusions. They did more than he had done—that is to say, in the way of practical work—because they built a very remarkable model, embodying their ideas of what an aeroplane should be.

This model aircraft was not allowed to be broken up, or lost; it is in existence to the present day, and can be seen in the Victoria and Albert Museum. Glanced at casually, it gives one the impression that it is very like the famous Antoinette monoplane, which the late Mr Hubert Latham was able to fly so finely. It has two wide-spread wings, a boat-like body, and a large tail. For a model made so long ago as 1842, it was a remarkable prediction of what the full-sized, practical aeroplane would ultimately be.

But, although their model was extremely interesting, Henson and Stringfellow proceeded no further, at this time, than the construction of this elementary piece of apparatus. They discussed the fitting of a steam-engine to their model, it is true, but nothing came of it. At least, nothing did at the moment; but Stringfellow continued to work at the problem, and, six years later, in 1848, he made a wonderfully ingenious little steam-engine with which to drive a model aeroplane.

This clever piece of miniature work had a single cylinder, a fly-wheel, a tiny boiler, and was beautifully constructed. Stringfellow fitted this motive power to a monoplane model —that is to say, one with two wings like those of a bird. It had two propellers, working behind the main planes, and behind the propellers was a bird-like tail.

With this model, in 1848, he was able to obtain a short free flight through the air—a triumph which will always keep his name in the minds of those who are interested in aviation. His little model did not fly far, it is true; its tiny engine would not run for long; but fly it did—and that was sufficiently remarkable. Henson, it should be noted, was not associated with Stringfellow in the construction of this steam-driven model, as he had abandoned research work at this time.

After this, for some years, nothing much was done in the way of aerial experiments—save that, in France, a naval officer named

Le Bris did some interesting work with a large form of kite, with which he attempted to make soaring flights. But no definite data was procurable as a result of his experiments.

Then we turn to England again where, in the year 1866, the Aeronautical Society was founded by a little party of enthusiasts. They had been studying the problem of flight for some years, and thought it would be useful to band themselves together in a society, and so carry on their work by the help of joint action.

Thus England—so backward when the actual conquest of the air did come—was able to register another step forward in the path of progress. The Aeronautical Society is, indeed, the oldest institution of its kind in the world; and to-day, brightened and energised in its internal working, it is still directing the scientific research of many minds.

At the opening meeting of this Society, in June, 1866, an exceedingly able and interesting address was given by F. H. Wenham, a man who had studied very closely the question of aerial navigation, and has left a very distinct mark upon the history of flying. It is curious to record what made Wenham take a practical interest in aviation. Like Sir

George Cayley, he was an engineer, and, several years before he addressed this first meeting of the Aeronautical Society, he had made a journey up the Nile. During this trip he watched very keenly the aerial evolutions of the birds flying within sight of the vessel, his interest in their manœuvres leading him to take up the subject of flight, and study it in all its aspects.

His research work culminated in his address before the members of the newly-formed Aeronautical Society. It is not my intention to go deeply into the points Wenham raised. What he had done was to sift all the data available, and present it in terse, carefully-arranged fashion. Looking back upon his address to-day, we see that it was chiefly remarkable for the fact that he indicated, very clearly, the lifting value of a long, narrow plane. Elaborating this point, he suggested the building of an aeroplane with two or more planes fitted above each other, so as to obtain ample lifting power. Really, he advocated the construction of the biplane, or triplane; and such machines—long afterwards—were actually built and flown. Thus we see how, little by little, men's ideas formed themselves into a path of progress, and paved the way for the construction of a practical aeroplane.

Not content with forming themselves into a society, these enthusiasts in the cause of flying decided to undertake a far more ambitious project. This was nothing less than the holding of an exhibition. Such an exhibition was actually arranged, and, in 1868, was held at the Crystal Palace. To those of us who are accustomed to the modern-type aeroplane, this display would have been a weird and wonderful affair. There were queer wings on show, by which their inventors aspired to flap their way through the air. There were balloons, kites, and strange constructions like flying fishes. Above all else, there was suspended, in a place of honour, a model built by the experimenter Stringfellow. It was a triplane of quite large size, fitted with two propellers, and a narrow, boat-shaped body. In adopting three planes, fitted one above another, Stringfellow was embodying, in a practical design, the superposed plane principle as advocated, in his lecture, by the engineer Wenham.

As an indication of the interest aroused in the conquest of the air about this time, it is interesting—and amusing also—to note that a sporting offer to would-be aviators was made by the Duke of Sutherland. He said that he would give a prize of £100 to any one who would make a flight to the top of Stafford House. I have not heard of its being won. To-day, it is worth mentioning, any airman would be precluded from attempting such a feat, seeing that the rules of the Royal Aero Club forbid a pilot to fly over towns or cities.

While speaking of prizes, it is interesting to record that the Aeronautical Society presented Stringfellow with an award of £100 for his wonderful little steam engine, which I have already described. It is quite clear, too, that the award was thoroughly deserved. John Stringfellow was, indeed, an enthusiast; and, apart from being the first to make a self-propelled model aeroplane fly, he assisted in a great many experiments carried out by the Aeronautical Society.

II

At about the time the Aeronautical Society came into existence, a notable figure among the English experimenters was Horatio Phillips. Phillips made a very deep study of the wings of birds, and he noticed the fact that these wings were curved, with a dipping front edge. This form of construction, in imitation of the birds, he suggested in the building of aeroplane wings, and he was an advocate also of long, narrow planes, such as Wenham had declared to be most effective.

Phillips built a model aeroplane. It was a strange machine, or so we should regard it to-day. He went one step farther than Stringfellow with his triplane, building an apparatus with a large number of long, narrow planes fixed one above another. It looked, in fact, very much like a venetian blind. Phillips did not meet with any great success, although, a good many years after his first experiments, one of his many-planed models actually lifted itself into the air while it was running round a circular track. Phillips, however, shared the fate of a good many other men at this time; he brought his experiments to a certain point, and could then get no farther.

We can now turn to the year 1871. In this year Otto Lilienthal, a German engineer, first began to make a study of flying. He began in a humble way, and though his tests ultimately led him to the goal of a very great success, for some years after he first began to study aviation little was heard of him. I shall have occasion to refer to his work a good many times, as we go further into the history of the aeroplane.

In 1874 Penaud, a foreign experimenter, invented a very clever little model aeroplane driven by elastic. When its elastic motor was wound up, this little model would fly quite well; it was, in fact, the forerunner of the many ingenious elastic-driven models sold in our toy shops to-day. Penaud's invention did not, however, lead to any definite results, but it is interesting, seeing that a modern toy was anticipated so many years ago.

Another keen student of aviation, Professor Montgomery, began his research work in 1884, and in the next year, 1885, Hargrave, an experimenter in Australia, also began a series of tests. Thus it will be seen that, once started, aerial research work was spreading to many lands.

In 1898, after studying bird flight, and having made a great many experiments with kites of various shapes, Otto Lilienthal, the German engineer I have previously mentioned, began to make a number of gliding flights, from the top of a hill, using a machine which had two wings, curved like those of the bird. These two wings were built upon a light wooden framework, and between the wings was a space through which Lilienthal could put his head and shoulders, grasping the machine with either hand. The span of the wings of Lilienthal's glider was not more than twenty-seven feet, and the area of surface varied from 100 to about 160 square feet. When built with willow wood, the glider weighed a little over forty pounds.

Lilienthal's theory was that, if a man wanted to learn to fly, he must first carry out a great many gliding tests, quite close to the ground, so as to accustom himself to being in the air, and also to learn to make the balancing movements necessary to preserve his equilibrium.

His plan was to stand at the top of a suitable hill, holding his glider in his arms, and face whatever wind was blowing. Then he ran forward a few yards, and jumped into the air. The wings of his glider bore him through the air on a quick glide down the slope of the hill. The difficulty was to balance himself while he was thus in flight, and, to accomplish this, Lilienthal swung his body to and fro, and from side to side, as his machine passed through the air. Thus, after a great deal of practice, he was able to overcome any falling movement while in the air, and to make glides of several hundred feet in length. Naturally, he did not make any tests in high winds. What he needed was a steady, quite moderate wind.

Lilienthal's glides were necessarily restricted. Having no motive power, he was obliged always to glide downwards, the distances he traversed being governed by the height of his starting point. But his practical work was of the greatest value. He learned more than any other man about the actual navigation of the air, and was able to carry on his experiments for a number of years.

In the year 1890 attention was directed towards France, where an inventor named Ader constructed a machine driven by steam-engines, in which he was actually able to make a short free flight. Ader's machine was a monoplane, and its curved wings made it look very much like a bat. It was driven by two steam-engines, which developed twenty horse-power each. They actuated one propeller. Ader's short flight with this machine, which he called the *Avion*, attracted the attention of the military authorities, and his experiments were assisted financially, but he did not get very much further with his idea, the difficulty being to obtain satisfactory results from the steam-engines employed. However, Ader's work was extremely useful.

Now one comes to a name very well known in connection with the early history of flying. It is that of Sir Hiram Maxim. He had ambitious ideas with regard to aeroplane building. In 1890 he constructed a very large machine, arranged so that it would pass along a length of rails, with another set of rails just above its running wheels. By this device, Sir Hiram intended that the machine should be able just to lift itself off the ground rails, and yet be prevented from making anything except a very low flight by the checking rails above its wheels. The size of Sir Hiram Maxim's machine may be gauged when I mention that its total supporting surface was 4000 square feet, and that it weighed 8000 pounds. Its steam-engine gave 363 horse-power, and drove two propellers which were seventeen feet long. Although interesting and ingenious, no very practical results were achieved with this giant machine; but it yielded a great amount of data, and so served its purpose.

In 1891 Professor Langley, an American scientist, carried out a number of important experiments to show the lifting powers of various planes. He used, in these tests, a piece of mechanism now frequently adopted in aerial research. This was the whirling table. In this the model was placed at the end of a long arm, which revolved at stated speeds through the air, and permitted accurate readings to be made as to the lift of planes, or the power given by a miniature propeller. Professor Langley's investigations were published, and proved extremely useful to students of aviation.

In the year 1891 also, Lilienthal, the German investigator, was continuing his gliding tests with the greatest success. After using a monoplane glider, or machine with two wings, he built a biplane, or machine in which one lifting plane was fixed above another, his idea, in doing this, being to obtain more sustaining surface, and thus prolong his glides. He was also thinking, at this time, of fitting an engine of some kind to one of his gliders, and so making a power-driven flight.

Sir Hiram Maxim, continuing his experiments in 1893, had an accident with his big machine. While running along its rail, it made an accidental ascent, breaking one of the checking rails which passed above the wheels. The machine turned over, and was badly wrecked.

III

In 1893 important work was carried out by Hargrave, the Australian inventor previously mentioned. In his tests he designed the famous box-kite, which is flown so extensively to-day, and which is bought, in its small form, by so many schoolboys. Hargrave also built a number of very ingenious little machines with wings which flapped like those of a bird, these models making quite long flights.

But no practical success has yet been attained with a machine of man-carrying size which sustains itself in the air by a wing-flapping action. One of the great difficulties in applying this principle to a man-lifting machine, lies in the transferring of the power from the engine to the wings. Intricate mechanism, involving an appreciable loss of power, is required.

In 1895 Mr Percy Sinclair Pilcher, an extremely able experimenter, began working in England. He had been making a study of flying for a good many years; but in 1895 he commenced a series of gliding flights, on the same lines as those undertaken by Lilienthal. Pilcher's first gliders were about the same size as those used by Lilienthal, but he increased their area until, in 1896, he was using one which had 172 feet of lifting surface, and weighed fifty and a half pounds.

At first he started his glides in the same way as Lilienthal had done. He stood on the top of a hill, then ran a little forward with his glider, and jumped into the air. But, as he increased the size of his machines, he found it difficult to launch himself in this way; so he had his machines towed like kites by horses. In this way he attained the required altitude, and then released himself from the towing rope, afterwards making his glide to the ground.

Pilcher fitted wheels below his gliders to facilitate their landing after a glide. This was an improvement as compared with those of Lilienthal. He also set the wings of his machine at a small upward, or dihedral angle, in order to test the steadiness of this principle, but he found it of no advantage when gliding in a side wind.

While Pilcher was gliding in England, Lilienthal in Germany was also busy. In 1896 he effected some extremely long glides with a biplane machine. His skill, also, led him to experiment in higher winds. Occasionally, when gliding in a strong wind, a gust would get under his planes, and raise him up in the air higher than his starting point. At times, too, the wind would blow so strongly that he would hang poised in the air, like some big, soaring bird, without moving forward. For a novice, tests in such winds would have been most perilous; but Lilienthal had become extremely expert, and had learned the trick of balancing himself in strong winds.

So enthusiastic did he become, that he began to glide in winds that his friends considered dangerous. Lilienthal himself, however, knew no fear. One day, in 1896, he went to his test hill to make some glides in a wind which was gusty as well as strong. When nearing the end of a glide, an especially ugly blast upset the balance of his machine, which fell to the ground, quite beyond the pilot's control, Lilienthal receiving injuries which unfortunately proved fatal. But this pioneer's life was not given in vain. Indeed, so valuable were the practical lessons taught by his gliding flights, that he afterwards became known as 'the father of the aeroplane.'

Apart from the sad loss of this famous experimenter, the year 1896 was an important one in the development of flying. In America much significant work was done. Professor Langley, the famous scientist, made a number of very interesting model machines, but did not obtain success with a man-carrying aeroplane constructed to his designs. Octave Chanute, another man whose name, in the world of aviation, is not likely to be forgotten, also began experiments in America in this year. He first began with gliders similar to those used by Lilienthal, but afterwards, desiring that his machines should make longer flights, he constructed a biplane form of glider, having 134 square feet of lifting surface, and weighing 178 pounds. It was Chanute's test work, one should note, which later provided the Wright brothers with much useful data.

Next year, 1897, Ader, the French expert, whose work has been referred to before, was able to make some short flights, or rather 'hops' off the ground, with one of his steam-driven monoplanes. These were witnessed by

Government officials, and created a good deal of sensation. But Ader was not able to improve upon them to the extent of making practical flights.

A French military officer, Captain Ferber, who was destined to play a prominent part in the development of the aeroplane in France, first turned his attention to flying in the following year, 1898. He made many experiments with planes and propellers, and also carried out gliding tests with biplane machines on the French sea-coast.

In 1899 a sad calamity befell the flying movement in England. Pilcher, while practising with a monoplane glider which he called the *Hawk*, was overturned while in the air, and was dashed to death. His work, like that of Lilienthal, was of an eminently practical nature, and therefore of the utmost value. His glider is still an interesting relic in the possession of the Aeronautical Society.

One of the most celebrated men in the history of aerial science was induced to take his first interest in aviation in the next year 1900. This was M. Louis Bleriot, whose name has since become a household word. Before he designed the monoplane which was afterwards to become so successful, Bleriot held many theories regarding flight; and, as a matter of fact, some of his earliest experiments were directed towards the evolution of a machine with flapping wings. Indeed, he spent a great deal of money, and risked his life on many occasions, before he produced the Bleriot monoplane of the type we know to-day.

In the year 1900, also, two other famous men, Wilbur and Orville Wright, took up the study of aviation in America. These two brothers were of an intensely mechanical turn of mind, and had the quiet, painstaking, and persevering disposition necessary to solve any great problem.

Through reading a brief account of Lilienthal's life and work they were induced to take a definite interest in the conquest of the air; and their characters revealed themselves in the methodical way in which they began their investigations. They were not in a hurry. They did not immediately begin to build a machine. This was not their way. Instead, they made a most exhaustive study of all the literature which was available upon the subject, and which described the work of previous experimenters. In this way they were led to go very carefully through all the writings of the famous Sir George Cayley; and, as can be imagined, they collected every possible scrap of information about Lilienthal's gliding flights.

At first they made tests with kites; then having had previous experience, as engineers, of building printing machines and bicycles, they embarked upon the construction of a glider. There was much that was of interest in this first glider of the Wrights. Their method of launching it into the air was, for instance, noteworthy. The machine they built was too big for the operator to hold when starting a glide; and they did not care for Pilcher's method of having his glider towed as a kite. Therefore they got men to hold their glider at each end, and run forward with it. Then, when sufficient speed had been attained, the machine was released, and began its glide.

Particularly interesting was the method they employed for balancing their glider. The machine was too large for the pilot to be able to balance it, while in the air, by movements of his body, so they devised a new system of controlling mechanism. The operator of the machine, when gliding, lay at full length across the lower plane, and had in front of him, on wooden outriggers, a small subsidiary plane, called the elevator. This little plane could be moved up and down by the pilot, and so made to control the rise or fall of the machine. When tilted up, it raised the front of the machine; when tilted down, it caused the glider to dip earthwards.

For controlling the lateral or sideway balance of their machine, the Wrights invented a particularly ingenious device. They made the rear edges of the planes of their machine flexible at either end. These flexible edges were connected by wires to the point where the pilot controlled the glider.

The actual method of employing this wing-warping, as it is called, was as follows:—When the machine tilted down on one side, while gliding, all the pilot did was to pull down, or warp, the edges of the planes on that side of the machine which was depressed. The result was that the air, passing under this side of the plane, and acting upon these drawn-down edges, exercised a perceptible lifting influence. That is to say, there was more lift on the side of the machine where the plane edges were drawn down than upon the side where they were not, the effect being to bring back the machine into its proper flying position.

There was, also, a double action in this wing-warping mechanism. When one side of the machine was warped down, the other was automatically warped up. Therefore, when the machine was tilted over by a gust of wind, the pilot could lift the side that was tipping down, and at the same time pull down the side that was tilting up. In practice, this clever wing-warping device acted most admirably. It is, indeed, the method of Nature in her own flying machines—the birds. When balancing themselves in winds, they warp their wings from side to side in the same way as the Wrights sought to do with their flexible plane edges.

In their first biplane glider, built in 1900, the Wrights used 165 square feet of lifting surface. Then, in the next year, they built another machine which had 305 square feet of surface. This machine weighed 116 pounds. With it they were able to make glides through the air lasting for nearly half a minute, and over 600 feet in length.

While the Wrights were thus busy in America, Captain Ferber, the French military officer, was conducting a number of gliding tests. In some of these, he launched himself from a wooden platform, instead of a hill, and obtained good results.

After they had been gliding for several years, the Wrights decided to fit their machine with motive power, and attempt a power-driven flight. At the time they came to this decision, they were very much more fortunate than the earlier pioneers had been. Lilienthal, and the others before him, had to turn their thoughts, when designing power-driven machines, to engines of steam, or compressed air, or some equally unsuitable medium for flying purposes.

But the Wrights, when the time came for them to consider the important question of a practical motive power, found the petrol engine, as applied to the motor-car, already at their command; and it is the petrol engine—so wonderfully light for the power it gives—which makes flying possible. A petrol motor for aeroplanes will give one horse-power of energy for a little over three pounds in actual weight.

When they set about equipping their glider with an engine, however, the Wrights did not find any piece of mechanism exactly suited to their purpose. The motor-car engines that were available were too heavy for flying; so they decided to build a special motor in their own workshops. Being first-class engineers, they were well able to undertake such a task.

The motor they produced was quite a simple piece of work. It had four cylinders, and developed less than twenty horse-power. Subsequently, when French experts saw the Wrights' motor, they did not think much of it. It was certainly not to be compared, in the matter of fine workmanship, with the French engines produced about the same time. But the Wrights knew what they were about. Although their engine was not a very highly-finished looking article, it answered its purpose, and with it they were able to make the first practical aeroplane flights.

IV

December 17, 1903, is a very memorable date in the history of the aeroplane, because on this day the Wrights, having fitted a motor to their machine, were able to make their first power-driven flights.

The exact methods employed in driving and controlling this motor-driven Wright biplane I shall find it more suitable to describe, together with details of other early-type aeroplanes, in the third section of the book. So all that I shall do here is to deal with the actual results the brothers achieved.

Facing their biplane into a light wind which was blowing at the time, the Wrights were able to achieve several brief power-driven flights on this historical December 17. Of course, as compared with what we are accustomed to in the way of flying at the present time, their first performance was insignificant; but we must remember that they were absolute pioneers.

With their engine driving two propellers, and gliding their machine along a rail to give it sufficient impetus to take the air, the Wrights were able to effect a flight which lasted for just fifty-nine seconds. This, as I have said, was in 1903; and to-day we are not surprised to hear that a man has been able to fly, without once descending, for more than twelve hours. Thus has the art of flying progressed.

Naturally, the work the Wrights had done with their glider was of the greatest value to them when they came to handle their motor-driven machine. They were, for instance, quite accustomed to being in the air, and this made it possible for them to carry out several short flights with their power-driven biplane, without damaging it, or themselves, in any way.

Turning again for a moment to France, we find that in the next year, 1904, the indefatigable Captain Ferber was very busy with gliding flights, having the co-operation of the brothers Voisin, who afterwards became famous throughout the flying world for the building of their Voisin biplane. Using a biplane type of glider built for him by the Voisins, Captain Ferber made some long glides from the sandhills at Berck-sur-Mer. But France at this time could not produce anything like the successful results which had been attained so quietly in America by the brothers Wright.

Continuing in 1904 their experiments with their power-driven machine, the Wrights were able to record very distinct progress. For instance, it was Wilbur Wright who, flying in a big circle, was able to remain in the air for five minutes seventeen seconds. This, at such an early stage of the development of flying, was a most remarkable performance. But the Wrights were not yet satisfied with their skill; they went on practising, quietly and assiduously, to improve their flying. Other men, less self-repressed, would have told the world they had conquered the air, and would have revelled in the honour and the glory that would have followed such a declaration. But the Wrights were of sterner stuff. They worked steadily on in silence.

Naturally, seeing that the flight of an aeroplane was so great a marvel, stories leaked out about what they were doing. But their experiments were carried out far away from any centres of population; and, when vague news of what they had accomplished drifted in to the large towns, it was greeted with disbelief. The newspapers, for instance, did not believe that the Wrights had actually flown; and in Europe, when tales of their doings became circulated, there was considerable scepticism.

The Wrights, however, did not care at all what people thought. They were not out for honour or glory; their intention was to perfect their aeroplane and make it a practical machine. Thus they toiled on, working in secret, and the world did not know the wonder that had been achieved.

In France, in the year 1904, a new experimenter joined the ranks of those who were striving to do what the Wrights had already done. This was M. Esnault Pelterie, an enthusiastic young Frenchman who began, as others had begun, with the flying of gliders, and whose name afterwards became associated with a successful monoplane. Then, in 1905, we come to another triumph recorded by the brothers Wright. Working quietly and steadily at their machine, they were able so to improve it that, by the summer of this year, they made a flight which lasted for just over thirty-eight minutes.

Now, as might be expected, definite news of what they were doing began to be printed in the American newspapers; but the two brothers were not communicative, and so many experts still expressed doubt as to the genuineness of their feats. In Europe, too, and especially in France, very few people believed that these two unknown brothers had actually conquered the air.

While this scepticism existed, a very remarkable announcement was made in London before the members of the Aeronautical Society. The maker of it was Mr Patrick Y. Alexander, a prominent member of the society, and a personal friend of the Wrights. Mr Orville Wright had written a friendly letter to Mr Alexander, describing something of the progress they were making with their aeroplane. This letter Mr Alexander communicated to the members of the Aeronautical Society, and what he was able to announce created a tremendous sensation.

Orville Wright had told him, in fact, that he had flown in their biplane for a distance of over twenty-four miles without once descending. The remarkable effect of this statement, coming from one of the inventors, may be imagined. The papers dealt extensively with the subject; but still there were men who doubted that this wonder had been accomplished. The Wrights themselves rather encouraged the disbelief by temporarily abandoning their flights about this time, and packing away their machine. Their reason was that they were busily negotiating with various Governments for the sale of their secret, and while this bargaining was on foot they did no more flying.

The most likely purchaser for their invention, with a view to its military importance, was France; and the French Government actually sent Captain Ferber over to America to see the Wrights, and report on the value of their invention. This Captain Ferber did, and recommended that the French Government should buy the rights of the machine, for purposes of war, for the sum of £24,000. There was, however, a hitch in the negotiations, and after some delay the affair fell through. In other directions, also, the Wrights met with no definite success: it is clear that what they required at this critical period was a good business manager.

In one way and another they wasted a great deal of precious time; and at that moment each day's delay in reaping the fruits of their invention meant a great loss to them. While they were preserving their secret, and refraining from demonstrations, their rivals in France were making rapid progress towards power-driven flights; the result being that, through the failure of their early negotiations, the Wrights lost much of the advantage they should have obtained from being so far ahead of all others in the production of a practicable aeroplane.

In dealing with the year 1905, reference should be made to some very interesting tests carried out in America by Professor Montgomery. Constructing a gliding machine resembling a double monoplane in the arrangement of its planes, Professor Montgomery adopted a novel plan for demonstrating its stability and soaring powers. Instead of arranging for glides to be made from the tops of hills, he sent up his glider with an operator seated in it, below a balloon.

The operator allowed the balloon to raise him several thousand feet into the air. Then he detached himself, with his machine, from the balloon, and commenced his glide to the ground. In this way a number of very spectacular gliding flights were obtained, and the natural stability of Professor Montgomery's machine was shown to be very great. But, in connection with one of these demonstrations from a balloon, there was a regrettable accident, a man named Maloney, who was employed to operate the glider, being killed.

In ascending with the glider below the balloon, he accidentally damaged one of the planes of the machine, through getting it entangled with a rope from the envelope of the balloon. He did not notice the mishap, with the result that, when he released himself from the balloon, the glider, thrown out of equilibrium by its damaged plane, made a bad descent, its pilot being fatally injured.

After this, little seems to have been done to promote Professor Montgomery's invention, and no full-sized machine designed according to his ideas seems to have been built.

V

In following the further development of the aeroplane, we shall need to turn to France, where a large number of keen experimenters were now at work. In 1906, after making a great many flights in balloons, and also in dirigible balloons, a rich young Brazilian named Santos Dumont turned his attention to the aeroplane. At first he had built for him a big glider. The brothers Voisin constructed this machine, which was so made that it would float on the water. Santos Dumont's idea was to have the glider placed on the River Seine and then to tow it behind a fast motor-boat, and so make it rise into the air.

This experiment was actually carried out, and the glider, after moving along the water for some little distance, rose from the surface, flying behind the motor-boat like a big kite. After this, Santos Dumont gave orders for the construction of a power-driven aeroplane.

It was fitted with a fifty-horse-power motor, and was of the biplane type. The new machine was taken to a suitable flying ground at Bagatelle, not far from Paris, and here Santos Dumont began a number of tests.

After many delays, owing to difficulties with his motor, he actually made a short flight through the air, which was officially observed by members of the French Aero Club. What the machine did was just to make a big 'hop' off the ground, during which it traversed about eighty yards. But, upon those who saw it, this flight made a very deep impression. The biplane ran along the ground upon two bicycle wheels, and then rose a few feet into the air, and made the short, wavering flight just mentioned. In landing, Santos Dumont damaged the running gear of his machine, but this was very quickly repaired, and not long afterwards he very greatly improved upon his first flight.

At this second attempt he flew in a straight line for 160 yards; and then, in another flight upon the same day, he flew for 230 yards without touching ground. These two flights were naturally hailed with great enthusiasm in France. Although they were comparatively insignificant when compared with what the Wrights had done, it must be remembered that Santos Dumont's performances were vouched for by the French Aero Club, whereas much doubt still existed as to the exact achievements of the two American aviators. It is not surprising, therefore, to find that Santos Dumont became a popular hero in France.

He was not, however, able to make further progress with this first biplane. Engine troubles, and certain defects in the machine itself, prevented him from obtaining longer flights; and so it was that another year passed before any notable performance was recorded in France. Then, when the next step was taken, it was a very definite one. All this time, it should be noted, the Wrights had kept their biplane packed away, and had made no further flights. They were still negotiating for the sale of their secret, and were meeting with no practical success.

With a new machine, built by the Voisins, the next big step forward was taken in France. Having built a large biplane, which was a distinct improvement upon that used the previous year by Santos Dumont, the Voisins arranged with a famous racing motorist, named Henry Farman, to act as their pilot.

Farman was greatly interested in aviation, and so was very glad to have an opportunity of testing this machine. It was taken to the military parade ground at Issy-les-Moulineaux, close to Paris; and here Farman went to tune it up ready for flight. The machine, however, was big and heavy, and needed the full strength of its fifty horse-power motor to get it off the ground. For some time, not being able to obtain the best results from his engine, Farman was only able to run the machine up and down the parade ground. It obstinately refused to rise into the air.

At last, however, on October 14, 1907, Farman got his engine well tuned up, and flew for just over 300 yards, thus beating Santos Dumont's 'record' at Bagatelle. On October 27, he improved upon his first flight, and covered a distance of over 800 yards. After this, some months were spent in making improvements on the machine; and then, in January, 1908, Farman made a flight lasting just upon two minutes, during which he covered more than a mile. This was acclaimed as a tremendous triumph, and crowds of people went out to Issy to see the airman and his machine.

A few days after his mile flight, Farman made an attempt to win a flying prize of £2000. This was offered for a flight of one mile, during which the airman was called upon to make a turn while in the air, and then return to his starting point without having touched ground.

Farman performed this flight quite easily, and so won the prize. Afterwards he made a number of other flights, proving to those who did not believe the stories of what the brothers Wright had done, that flying with a heavier-than-air machine was perfectly feasible. Soon after Farman began to fly, a second Voisin biplane was acquired by M. Delagrange, an aviator who subsequently became famous. In April, 1908, Delagrange was able to remain in the air for more than nine minutes; and thus it can be seen that flying was at last becoming an accomplished fact in France.

About this time the brothers Wright had their affairs taken in hand by a business syndicate, the result being that they emerged from their obscurity, and set about the task —so long delayed—of showing the world what their machine could do. Orville Wright remained in America to demonstrate before the military authorities, and it fell to Wilbur Wright's lot to journey to France, with another machine, and confound the sceptics in that country. This he did most effectually.

At first both he and his machine made a poor impression. He had little to say, and his biplane was regarded by a good many French engineers as a crude and clumsy piece of work. Wilbur was unfortunate, too, in regard to his motor. This proved very refractory at first, and he was prevented from flying. Such delays, of course, rather played into the hands of his critics, and it was freely declared that the stories of the flights which the Wrights had made in America were fabrications.

But with Wilbur Wright it was a case of 'better late than never.' When at length he did get his machine into trim, he began to make flights that took everybody's breath away, and made the feats of Farman and Delagrange appear very insignificant indeed.

Only two of the flights which Wilbur made in France, and which vindicated so triumphantly the claims made for the Wright biplane, need be mentioned. On December 18, 1908, he flew for one hour fifty-four minutes; then, on December 31, he remained in the air for two hours twenty minutes. Apart from these two sensational performances, he ascended to a height of 400 feet, and carried up a number of passengers with him in his machine. In fact, he demonstrated beyond question that the Wrights had really conquered the air. As a result of his wonderful flying, the French Government became very interested in Wilbur Wright's biplane, and several machines of this type were ordered for war purposes from the syndicate which was controlling the airmen's affairs. The Italian Government, too, gave orders for machines; and Wilbur Wright also obtained some pupils anxious to learn how to fly.

In connection with his teaching the art of flying, it is interesting to record that many experts, at this time, declared he was an 'aerial acrobat,' and he would not be able to impart his trick of flying to any other man. Such statements, however, were soon proved to be ill-founded. Two of Wilbur Wright's first pupils were the Comte de Lambert and M. Tissandier—the latter a well-known balloonist. Both these men, after careful tuition by Wilbur Wright, learned to fly remarkably well; and, subsequently, at aviation meetings, gave an exceedingly good account of themselves.

Thus we see that, after long and wearisome delay, the Wrights were able to substantiate all the claims made for their machine; and, what is more important, the syndicate which was handling their affairs soon began to exploit very successfully the commercial possibilities of the invention.

It should be mentioned that, while Wilbur Wright was flying in France, Orville, in America, was also meeting with success in his demonstrations before the military authorities. Unfortunately, however, his tests were marred by a very sad accident. He was flying one day with a passenger—a Lieutenant Selfridge. Suddenly, quite without warning, one of the chains driving propellers of the biplane broke ; and, although Orville Wright exercised all his skill, the machine fell, and was wrecked. The pilot sustained a broken thigh, while poor Selfridge was killed.

Now, having seen how, after centuries of effort, men actually learned to navigate the air, let us proceed to the second section of the book, which will deal with the subsequent flying feats of the great pioneers, and will also give some idea of what manner of men they were.

SECOND SECTION

THE PIONEERS OF AVIATION: THEIR PERSONALITIES AND FLIGHTS

I

So far, our history of the development of the aeroplane has taken us to the end of the year 1908; and we have dealt with the practical flying work accomplished by the Wrights, by Santos Dumont, and also by Farman and Delagrange. The way, then, is clear for us to deal with the most fascinating period of aerial development—that is to say, with the flying season of 1909, when men ceased to be content with circling round aerodromes, and set themselves the task of flying across country and even of passing over seas. We shall also note, in this section of the book, the emergence into fame of some of those men who first identified themselves with the practical uses of the aeroplane.

In the memorable flying season of 1909 the world was amazed by the feat performed by M. Louis Bleriot, when he crossed the

Channel from France to England in a small, low-powered monoplane, thus winning the prize of £1000 offered by the *Daily Mail*. In July, 1909, Bleriot began to meet with definite success with his monoplane. Previously he had built and broken up a number of these machines. But at last he constructed one—it was his eleventh—which flew very well indeed with a twenty-five horse-power motor. After making several short flights with this monoplane, Bleriot succeeded, on July 13, in effecting a cross-country journey flight of twenty-five miles—an astonishing feat at this time; and it was then he was induced to come to Calais with his machine and make an attempt to fly across the Channel to Dover, and win the *Daily Mail* prize.

Already on the scene, however, he found another airman, the late Mr Hubert Latham. Mr Latham had come to Calais quite early in July with his Antoinette monoplane. This was a beautifully constructed aircraft, with a long, boat-shaped body, and with two very large sustaining wings set at a slight upward or dihedral angle. The machine was driven by a fifty horse-power eight-cylinder engine.

At this time, after a period during which it had not met with success, the Antoinette had been flown remarkably well by Mr Latham, who was already recognised as a pilot of exceptional ability. Before coming to Calais for the cross-Channel flight, he had remained in the air at Mourmelon for over an hour; and the Antoinette, a most imposing, bird-like machine to watch when in flight, was regarded as one of the most scientifically-devised of existing aeroplanes. Latham, however, had bad luck. On July 19, he started to fly to Dover, but had not got quite half-way across the Channel when his motor failed, and he had to glide down into the sea. He was rescued by a torpedo-boat destroyer, but his monoplane, in being salved by a steam-tug, was very badly damaged. Another Antoinette was sent for from the works in Paris, and Mr Latham made up his mind to make a second attempt as soon as he could. At this juncture M. Bleriot arrived on the scene; and on July 25, starting at sunrise, he crossed the Channel in a thirty-seven-minute flight, and won the £1000 prize.

Latham, in a most sportsmanlike way, insisted upon making another attempt, despite the fact that the prize had been won. He started away from the French coast, for the second time, on July 27, and had got within a mile or two of Dover when his engine stopped, and he had again to alight on the water. In doing so, he had the misfortune to be thrown forward from his driving seat against an upright spar, cutting his head rather severely. Everybody sympathised with him in his bad luck; but he was able, soon afterwards, to make some splendid flights.

The effect of Bleriot's cross-Channel flight upon the development of the aeroplane was most marked. For instance, a large number of orders came to him for replicas of his successful monoplane, and he soon had a factory working at high pressure in the production of such machines. He also found that many men wanted to learn to fly the Bleriot monoplane. Thus, in addition to his factory, he was able to start a flying school at Pau, where he soon had many pupils.

Another important result of Bleriot's great flight was that the military authorities in France, and other countries, began to take a serious interest in the development of aircraft.

Thus, in the beginning of August, 1909, aviation in France was in a most hopeful state. Apart from Bleriot's activities, the Voisins were busy building machines, and Henry Farman was equally well occupied in the construction of an improved biplane, embodying his own ideas. Then came the world's first flying meeting, held at Rheims in August. To this travelled enthusiasts from all parts of the world; and, flying the earliest practicable aeroplanes in actual competition against each other, appeared that handful of expert pilots who first demonstrated what the aeroplane could really do.

The famous Wright brothers, having an aversion to aviation meetings, did not take part in the contests themselves, but several of their biplanes were to be seen in flight. The pilots of the Wright machines at Rheims were the Comte de Lambert and M. Tissandier —pupils I have already mentioned—and also a third flyer, M. Lefevre. The last-named, a bold, dashing pilot, electrified everybody by his dips and dives while flying near the grand-stands. He may, indeed, be said to be the first airman who really studied the art of what is now known as 'exhibition' flying —that is to say, piloting an aeroplane in all sorts of evolutions to interest and amuse a concourse of people.

M. Lefevre, a keen, dark young man who knew no fear, did some really remarkable things with his Wright biplane, demonstrating in a very conclusive way how extremely sensitive this machine was to the movements of its controlling planes. Some time after the Rheims festival, poor Lefevre—meeting with a very bad fall while testing a new machine—was fatally injured.

The two other Wright pilots, de Lambert and Tissandier, were rather overshadowed at Rheims by Lefevre's brilliant flying, but they were extremely capable men none the less. De Lambert, for instance, was a cool, quiet flyer, who thought out everything he did very carefully indeed; but once he had decided that a flight was possible, he carried it out with great precision. He did nothing very memorable at Rheims; but not long after this meeting, he made a sensational flight over Paris, circling round the Eiffel Tower.

Tissandier was a small, dark, agile little man, who piloted his biplane with rare judgment, and although he—like de Lambert—did nothing very noteworthy at Rheims, he proved himself, on many other occasions, to be a sound and capable pilot.

While mentioning the Wright biplane, one ought to refer to another American-built machine which had by this time appeared upon the scene. Its inventor and pilot was Mr Glen H. Curtiss. He and his two mechanics afforded a marked contrast at Rheims to the somewhat excitable Frenchmen. Nothing perturbed them; they just brought out the biplane, and Mr Curtiss got in it and flew off. There was no fuss or bustle about this airman or his helpers. They knew what they were doing all the time, and did it—quietly and without ostentation. Mr Curtiss's machine was a very light racing-type biplane, which flew so fast that it beat M. Bleriot's monoplane in the speed race, and won the Gordon-Bennett International Trophy, averaging a speed of forty-seven miles an hour. This was, in those days, considered very fast indeed; and yet, at the present time, we are not very surprised to hear that a monoplane has flown at more than 100 miles an hour.

Mr Curtiss represents, as a type, the thoroughly competent, go-ahead American engineer. After his triumph at Rheims, he returned to America, and built a number of machines, some of which were acquired by the American Government. Recently he has built successful hydro-aeroplanes—but this is a subject to which reference will be made later.

II

Among these first flyers of aeroplanes as we saw them at Rheims was M. Bleriot. Dark, with a prominent nose, and keen, penetrating eyes, Bleriot looked the veritable 'bird-man.' His enthusiasm, in the cause of flying, knew no bounds; and at Rheims he flew magnificently. He had by this time devised a new type of monoplane capable of carrying a passenger. In it the pilot and passenger sat side by side below the planes, with the motor immediately in front of them.

I know this first passenger-carrying type of Bleriot monoplane rather well, seeing that, when at Rheims, I met M. Bleriot, and ordered one of these machines from him. It was upon such a two-seated Bleriot, as a matter of fact, that I first learned to fly. My first attempts were made at Issy, near Paris; and I managed to fly with the machine early one morning, after only one or two preliminary runs along the ground, during which I accustomed myself to the controlling mechanism. Driven by a fifty horse-power motor, this first two-seated Bleriot was a very speedy machine. The one I had was so fast, indeed, that M. Bleriot himself pronounced it dangerous.

This was at Pau, where I took the machine from Issy to continue my flying practice.

M. Bleriot, coming out to the flying ground one morning, said he would take the machine for a spin with myself as a passenger. In making a turn, the monoplane proved so fast that it got the famous airman into temporary difficulties, and we finished up in a hedge. It was then that M. Bleriot declared the machine to be too rapid in flight. To-day, however. we should think very little of the speed that this particular machine attained.

At Rheims, Bleriot strove very hard to win the speed prize; but, as I have said, Curtiss, the American, just beat him. Bleriot tried all sorts of dodges to increase the speed of his machine, using propellers with two blades and also with four, and even trimming pieces off the edges of his wings. But Curtiss won the prize, and so the Gordon-Bennett Trophy went to America. M. Bleriot, however, had his revenge next year—as an aeroplane constructor—for in 1910, at Belmont Park, New York, I won this annual race, using a Bleriot racing monoplane with a 100 horse-power engine.

Another prominent figure at Rheims was Henry Farman. Farman is small, quick, and eager in his movements. He seems the ideal airman, with eyes that see everything, and hands that move with the greatest delicacy. No man has worked harder for aviation, and no man has won greater or more honourable success. Prior to the Rheims meeting, Farman had been quietly at work building a biplane which he intended to be an improvement upon the Voisin he had first flown.

At Rheims this new Farman biplane, piloted by Farman himself, appeared in public for the first time. Its success was remarkable, and it laid the foundation-stone of the reputation that the Farman machines have since won. I shall have occasion to describe this machine, with others, in another section of the book; so all I need say here is that the Farman biplane, when compared with its predecessor the Voisin, was a lighter, neater-looking, and more speedy machine.

Above all, it was equipped at Rheims, for the first time, with a wonderful aeroplane motor, which was revolutionary in its actual method of running, and also in its effect upon the flying industry. This engine was the Gnome. In its action it differed altogether from any other aviation motor. Other engines had fixed cylinders and a revolving crank-shaft. In the Gnome the cylinders flew round and the crank-shaft stood still. To explain, in non-technical terms, just what the advantages of this engine were is not an easy task; but I will endeavour to make matters clear.

With aeroplane motors, before the Gnome was introduced, the difficulty had been that, through being obliged to run at a very high speed, they showed a tendency to become over-heated and stop working.

Some of these motors were air-cooled, as it is called; that is to say, the cylinders were cooled by the rush of air, when the machine was in flight, being caught by metal plates or fins round the tops of the cylinders. But these early air-cooled engines soon got very hot when they were driving an aeroplane in flight, and so they gave much trouble.

In flying, I should explain, a motor has to do much harder work than the engine of a motor-car does. The motorist, as he drives, is constantly changing his gears, and so gives his engine a rest every now and then. But with an aeroplane the engine needs to run at a high speed from the moment the machine leaves the ground, and has to keep it up all the time the aeroplane is in flight. What the aeroplane motor has to do, in fact, may be compared to taking a motor-car and making it climb one long hill all the time. To add to the difficulties of the makers of aeroplane motors, the engines had to be built as lightly as possible; and so it can be imagined what trouble there was in the early days.

Other engines were fitted with a system of water-cooling. By this plan, water was pumped through jackets which enclosed the tops of the cylinders. But this necessitated the use of radiators and tanks, and added appreciably to the weight of the engine. The radiators, having to be made very light, showed a tendency to leak; and, altogether, the water-cooling method had distinct disadvantages.

And now came the Gnome—an engine built specially to meet the difficulties encountered in fitting aeroplanes with motive power. By a very ingenious system of construction all its seven cylinders were made to spin round the crank-shaft. The result was that the engine automatically kept itself cool, and so did away with the drawback of over-heating.

This, of course, was a tremendous boon. Another great advantage of the Gnome was that it was extremely light. Also, by its revolving action it gave a smooth, very even thrust to the propeller, with the result that it proved highly efficient when actually driving an aeroplane through the air.

The Gnome was, however, a strange looking engine, and its mechanism was certainly most intricate. Therefore, many experts who saw it first declared that it would not prove reliable. But Henry Farman had great confidence in this engine, and was quite ready to fit it to his biplane.

That his confidence was not misplaced was shown during the Rheims meeting. Ascending one evening in an attempt to win the long-distance prize, he flew on and on until at last darkness compelled him to descend. Then it was found that he had remained in the air for three hours four minutes, creating a world's record. During this long flight the new Gnome engine ran perfectly; and since its first great triumph it has played an extraordinarily prominent part in all the important contests. Recently, however, a good many improved fixed-cylinder engines have been introduced, and quite a number are now fitted to aeroplanes, but the Gnome is still used very extensively.

Those who saw it, are not likely to forget

Farman's splendid three-hour flight at Rheims. He flew very low all the time, sweeping round the big course with remarkable precision, his Gnome engine roaring away all the time with a perfect rhythm of sound. It was, indeed, a most impressive demonstration of man's conquest of the air. When he descended from this wonderful flight Farman seemed only slightly tired, and very little elated. He took all such successes quite as a part of the day's work, and he was not at all cast down when any new idea proved a failure. Always, as his chief aim, he has had the evolution of a practical, every-day aeroplane, which shall be safe in the hands of an ordinary man. At the present time, he and his brother Maurice are working in co-operation in the production of biplanes which find much favour for military use.

III

In describing these pioneers of aviation, as we saw them at Rheims, the magnificent flying of the late Mr Hubert Latham must not be forgotten. Piloting his big, hawk-like Antoinette in gradually ascending circles, he rose until he was 500 feet above the ground. This, in those early days, was considered a tremendous height, and Latham won the chief prize.

This aviator, whose death in a hunting accident we mourned not so long ago, had a fascinating personality. He was slight and dark, with a pale, serious face; and he stood with sloping shoulders, looking more like a student than an airman. When he spoke his voice was quiet and low-toned, and he had habitually rather a bored, listless manner. But this air of boredom hid a spirit which, for sheer, reckless daring, has probably never been equalled in the brief history of airmanship. In these early days Latham flew in winds in which no other pilot would have dared to ascend. He took his life in his hands with a quiet, rather weary smile. His handling of the Antoinette, and the way he made its wide-spread wings bank over when he was circling round an aerodrome, provided a magnificent spectacle.

Another airman at Rheims who flew wonderfully well, and who subsequently became world-famous, was Paulhan. This cheerful, smiling young Frenchman owed his introduction to aviation to the fact that he won a Voisin biplane in a competition, and afterwards obtained financial assistance from his friends in order to fit a motor to it. On his prize biplane he flew splendidly at Rheims. Afterwards he carried out a great many exhibition flights; but his name will be chiefly memorable for the fact that he won the great £10,000 prize offered by the *Daily Mail* for the 183-mile flight from London to Manchester.

In this contest, it may be remembered, I entered the lists as a rival of the French airman; but on the two occasions when I attempted the flight, the high and gusty winds in the Trent Valley brought me to the ground. In those days I was a comparative novice at flying, while Paulhan was an airman of wide experience. Thus, in regard to this historic contest, as I have always said, 'the best man won.' One piece of very bad luck, however, fell to my lot. This was when, after getting as far as Lichfield on my first attempt, the wind blew my biplane over while it stood in a field, and damaged it very severely.

The repairing of the machine delayed me considerably in making another attempt, and so enabled Paulhan to appear upon the scene. Indeed, if it had not been for this unfortunate accident, a different tale might, perhaps, have been written about the London to

Manchester flight. However, Paulhan won, and he richly deserved his prize. The winds were high and gusty; and Paulhan himself confessed afterwards that he had never before been through such an ordeal. Paulhan won a great deal of money in flying prizes, and subsequently became a constructor of aeroplanes. More recently he has been turning his attention to the development of the hydro-aeroplane.

Another very fine flyer at Rheims was Rougier, who was a racing motorist before he took up aviation. Rougier flew a Voisin, and after the Rheims meeting took his machine to the south of France, where he gave many exhibition flights. When flying at Nice, his biplane fell into the sea, and the airman, besides being injured, was nearly drowned.

As one of the prominent men at Rheims, one must not forget to mention Delagrange. He, as may be remembered, first began to fly upon a Voisin biplane. But afterwards he learned to pilot a Bleriot monoplane, and upon this machine, soon after the Rheims meeting, he made a speed record of fifty miles an hour through the air. On this flight, it is interesting to note, he used a Gnome engine for the first time upon a monoplane.

Soon afterwards, while flying in France, with this same machine, Delagrange met with a fatal accident. One of the wings of his monoplane crumpled up while he was in flight, and the machine fell like a stone. This directed attention to the need for great strength in the construction of monoplanes fitted with powerful engines.

After the excitement of the Rheims carnival had died down, a great deal of interest was displayed in a couple of flying meetings—the first of their kind in England—which were held at Blackpool and Doncaster. At Blackpool, a flight that will never be forgotten was made by Mr Latham. Rising in a wind which blew at the rate of nearly forty miles an hour, he made a couple of circuits of the aerodrome. His monoplane stood still in the air once or twice when facing the wind; and then, when it turned and flew with the wind, attained a speed of nearly 100 miles an hour. Such a daring performance had certainly never been seen before.

This flying season of 1909 was brought to an end by some remarkable feats. Wilbur Wright, for instance, flew with a passenger for a hour and a half. Henry Farman, in an attempt to beat his long-distance record, as made at Rheims, actually remained in the air for four hours seventeen minutes; while Hubert Latham, attempting another height record, ascended 1640 feet.

Before completing our review of 1909, it is necessary to refer to the work that was being done in England. On Laffan's Plain, for example, Mr S. F. Cody, afterwards to become famous with his big biplane, had already made several short flights. Mr J. T. C. Moore-Brabazon, a young Englishman who had distinguished himself as a racing motorist, bought a Voisin biplane, and flew with it both in France and in England. Another experimenter who was beginning to win success was Mr A. V. Roe. He was an advocate of the triplane form of machine, and succeeded in making a flight with an engine which developed only nine horse-power.

IV

Now, in the story of the work of the pioneers, we come to the year 1910. It was remarkable, at the beginning, for the number of cross-country flights which were made. Aeroplane engines were rapidly becoming more reliable, and pilots were growing more confident in their own skill and in the stability of their machines.

Thus it was that 1910 was a great cross-country flying year, one of the most significant feats to be accomplished being the winning of the £10,000 prize for the flight from London to Manchester. I have already referred to Paulhan's success; therefore all I need do here is to cite one or two facts and figures. For instance, in my first attempt to win the prize, I covered 113 miles with one stop; then Paulhan, with one halt *en route*, flew the 183 miles from London to Manchester in a flying time of four hours twelve minutes. In my second attempt, when I started from Wormwood Scrubs on the afternoon of April 27, soon after Paulhan had left Hendon, I got as far as Roade, and was then obliged to descend on account of the darkness. I was some distance behind Paulhan, and so made up my mind to try to catch him by making a flight during the night. It was the first time that a flight across country had been made during the night-time, and the risks of undertaking it were pointed out to me by many of my friends. But I was extremely keen upon overtaking Paulhan, and I had great confidence in my machine and motor.

So I got away from a small field while it was still quite dark, and then flew on above the railway line, being guided principally by the lights from the stations.

I kept on in this way until it got light, and was then rapidly catching up Paulhan, who had not yet started from the place where he had landed overnight. But, unfortunately, the wind rose at dawn, and I received a very bad buffeting while flying through the treacherous Trent Valley. In fact, the wind became so bad that it twisted my machine almost completely round in the air, and I was at length practically beaten down. This destroyed my chance of winning the prize, as Paulhan managed to fly on in one more stage to his goal at Manchester. I had the satisfaction, however, of showing that an Englishman could, at least, put up a fairly good struggle in a flying contest.

After the London to Manchester flights, very keen interest in aviation was aroused in England. People were eager to see aeroplanes in flight, and I was busy for some time giving demonstrations with my Farman biplane. I gave several exhibitions, for instance, at the Crystal Palace, at Brooklands and Ranelagh, and also in the provinces. After showing much apathy, the people of England were, indeed, beginning to display some genuine concern as to the conquest of the air.

In May, 1910, a very interesting event was the second crossing of the Channel by aeroplane. The machine used was another Bleriot, this time fitted with a Gnome engine, and the aviator was M. de Lesseps. Another remarkable flight, made about this time, was that accomplished by the American, Mr Glen Curtiss. With only one halt he flew from Albany to New York, a cross-country flight of 150 miles.

About the middle of the flying season of 1910, aviation schools began to spring up everywhere, and the number of airmen grew by leaps and bounds. Whereas in 1909 one could count the really fine pilots upon the fingers of two hands, the flying season of 1910 saw the ranks of really clever airmen swelled until they could be numbered in hundreds. In England, flying schools were soon in operation at half a dozen places; while in France they were dotted about all over the country.

V

Many fine pilots began to emerge about this time from the ranks of the English airmen. Notable among them was the late Hon. C. S. Rolls, a famous motorist and balloonist, who first learned to fly as Lilienthal had done, by gliding from a hill-top, and who afterwards piloted with distinction a Wright biplane. Upon a machine of this type, on June 5, 1910, Mr Rolls started from Dover, flew across the Channel to the sea-coast near Calais, and then, turning round in the air, flew back again to Dover without once alighting —a feat which was quite rightly regarded as a memorable one. A month later Mr Rolls came with myself, and a number of other airmen, to fly at the Bournemouth meeting. On the second day of this festival, while he was flying near the grand-stand, the rear elevating plane of his machine suddenly gave way, and the biplane dived to the ground quite beyond control, with the result that the pilot was killed. Needless to say, every one in the flying industry in England sincerely mourned his death.

In August, 1910, a remarkable cross-country flight was made in France by an airman named Bielovucie—the pilot who recently crossed the Alps by air. Starting from Paris, he flew right through to Bordeaux, a distance of 350 miles. He made the flight in three stages, and was three days *en route.* His performance, as a practical illustration of what the aeroplane could do, created much interest, particularly as the airman had flown this long distance rather than pack up his biplane, which was a Voisin, and send it by train.

In August, too, M. Leblanc, a well-known pilot of the Bleriot monoplane, effected a series of astonishing flights while taking part in a contest known as the Circuit d'Est. In this competition M. Leblanc flew for 497 miles across country in a total flying time of twelve hours, eight minutes, twenty-two seconds, without mishap of any kind. He was using a Bleriot, fitted with the Gnome engine.

Next to attract general attention at this time was the late Mr Moisant, a rich young American, who bought a Bleriot two-seated monoplane in Paris, and, taking his mechanic with him as a passenger, set out to fly to London. His adventures while on the way were many, being due chiefly to the bad weather he encountered when flying from

Dover to London. However, after damaging his machine in several bad descents, he eventually reached a football field quite close to the Crystal Palace. Afterwards Mr Moisant, who was a keen, very daring pilot, made a number of good flights. Unfortunately, however, he met with a very bad accident while making a long-distance flight in America, and was killed.

After this came two important British flying meetings—those held at Blackpool and Lanark. At the latter a very excellent high flight was made by Mr Armstrong Drexel, a young American, who was an exceptionally fine pilot of the Bleriot monoplane. Flying a machine of this type, Mr Drexel rose over 6000 feet high, thus establishing a world's record. In ascending he flew through some clouds, and quite lost sight of the aerodrome below. The result was that, when he descended, he found himself near a lonely farm-house, some fifteen miles from the aerodrome. In planing down from this great height, Mr Drexel's hands became numbed by the cold, and he nearly lost control of his machine.

He was not permitted, however, to hold the record long. He made his flight in August, and early in September Morane, a very accomplished Bleriot pilot, rose at Havre to a height of 8469 feet. Even this was not allowed to remain as a record for more than a few days. Attempting to beat it at Issy, Chavez, the Peruvian airman, reached a height of 8790 feet. Chavez was the pilot who afterwards flew over the Alps, and met his death as the result of an accident when landing after this tremendous flight.

A very meritorious flight was made in September, 1910, by Mr Robert Lorraine, a well-known actor, who had learned to pilot a Farman biplane. Taking his machine to Holyhead, Mr Lorraine set himself the ambitious project of flying across the sea to Ireland, a distance of fifty-two miles. This flight he actually accomplished on September 11. His adventures in doing so were many. When he was about half-way over his motor began to misfire. He was about 1500 feet high at the time, and, looking down, he could see no vessel of any kind in sight.

Suddenly his motor stopped altogether. Nothing remained but to plane down and land in the sea, and this he began to do. Just as unexpectedly as it had stopped, however, his engine began to work again, and he was able to fly on. Several times more, before he sighted the Irish coast, Mr Lorraine's engine played him the same trick. Then, just when he was about to land, the motor did finally stop. Planing down, the airman just failed to reach the shore, and plunged into the water within a hundred yards of the beach. Fortunately he was able to extricate himself from his water-logged machine and swim to the shore.

VI

In France, towards the end of 1910, some splendid flights were made; indeed, the aeroplane had by this time become quite practicable, so far as flights from place to place were concerned. For instance, on September 29, 1910, a French military airman named Bellenger flew for 200 miles across country. Soon afterwards another airman, named Wynmalen, flew from Paris to Brussels and back, carrying a passenger with him. This represented a distance of 350 miles, which the airman covered in seven flights. The high-flying record was also increased during October, 1910, the same airman—Wynmalen—ascending at Mourmelon to an altitude of 9174 feet.

In the same month I visited America to compete in the Gordon-Bennett speed race; and, apart from my participation in this contest, I flew in a great many cities in America. So far as the Gordon-Bennett race was concerned, I flew over the 62-mile course at a speed of a fraction over sixty miles an hour, and had the honour of winning the contest for England. I shall not forget this flight, for the reason that the heat from the 100 horse-power engine driving my machine made some of the woodwork of the monoplane's body begin to smoulder. I smelt the burning wood as I flew round the course, and saw smoke beginning to blow back in the rush of wind.

Every moment I expected to see my machine burst into flames and fall to the ground. But to have descended, before the course was completed, would have been to lose my chance in the race, and so I kept on. The situation, however, was distinctly trying. Fortunately the woodwork only smouldered, and did not burst into flames, and thus I was able to finish the course without descending.

M. Leblanc, the French champion, who was competing against me in this race, had an extraordinary escape in a very bad smash. While he was flying round the course, at the rate of an express train, his petrol supply unexpectedly came to an end, and his engine stopped. In gliding down with his racing monoplane, he struck a telegraph-pole which, although it was as thick round as a man's body, was broken short off by the tremendous force with which the machine hit it. M. Leblanc was thrown many yards away from his machine by the shock of the impact, but, strange to say, he escaped with no worse injuries than a few cuts and bruises. His machine, however, was smashed to pieces, and his chance in the race was gone.

The end of 1910, from the flying point of view, was memorable for some wonderful high flights which were accomplished. On October 31, at Belmont Park, New York, Mr Armstrong Drexel, the young American, rose 9450 feet. Then, on November 23, another American airman named Johnstone, managed to soar to 9714 feet. This again was beaten on December 9, by Legagneux, who flew 10,746 feet high.

At the end of the year in England we had a number of pilots, using all-British machines, who were striving to make long-distance flights from the English coast into France, and win a £4000 prize offered by the Baron de Forest. The winner was Mr T. Sopwith, who started one morning from Eastchurch, in the Isle of Sheppey, and made a flight of 169 miles across the Channel into Belgium. I had intended to try for this prize myself, and arranged to pilot a Bristol biplane. While testing this machine at Dover, however, I had a 'side-slip' in the air while passing low over the cliffs near Dover Castle. As a result the biplane was badly smashed, and I myself received injuries which, although not serious, prevented me from taking any further part in the contest.

Many of us will cherish gloomy recollections of this particular competition, seeing that it cost the English flying world one of its most brilliant members. This was Mr Cecil Grace, an airman who was piloting a biplane built by Messrs Short Brothers, the aeronautical engineers of the Royal Aero Club. While flying back from Calais to Dover, after an unsuccessful first attempt in the de Forest competition, Mr Grace was caught in a sea fog, and apparently lost his way. At any rate the unfortunate airman never reached land, and neither he nor his aeroplane was ever seen again. A cap and a pair of goggles, identified as his, were washed ashore near Ostend. It is presumed that he fell into the water in the fog, through his engine failing, and, sinking with his machine, was drowned.

VII

So far as the years 1911 and 1912 are concerned it is unnecessary to go into detail. The army of airmen has grown until there are now more than 2000 fully-qualified pilots in the various countries of the world. Flying schools have multiplied amazingly; while the military use of aeroplanes has increased to such an extent that it must be dealt with in a special section. Reference should certainly be made, however, to such an event as the flight round Great Britain, in the summer of 1911, for the second *Daily Mail* £10,000 prize. In this air race of 1010 miles, seventeen competitors started, the pilot 'Beaumont' (really Lieut. Conneau, of the French Navy) being the winner. He flew a most exciting race against M. Vedrines, eventually winning on time by a little over an hour. His success was largely due to the fact that Vedrines, losing his way on two occasions, thus sacrificed much precious time.

Another notable air race in 1911 was that from Paris to Madrid, a distance of 874 miles. Vedrines was the victor in this contest. I should mention also the race of 815 miles from Paris to Rome, the winner of this being Lieut. Conneau. Yet another important contest in 1911—the year of air-races—was what was called the European circuit. This race covered, altogether, a distance of 1031 miles. In its course the competitors passed across the Channel from Calais and flew to Hendon. Here, again, Lieut. Conneau was successful.

The triumphs in 1911 of this French naval airman were due, primarily, to the fact that he was thoroughly competent in every department of flying. He had studied aeroplanes and engines with the utmost care before he began to fly. He had also studied atmospheric conditions and the question of flying in winds; and finally, he was an absolute expert at finding his way across strange country by means of a map and compass. Furthermore, he had an ideal disposition for a racing airman. He was quiet and collected, and never flurried by trifling accidents or delays. Vedrines, 'Beaumont's' rival, is a great contrast to him in disposition. He is impetuous and excitable —faults, rather than virtues, as regards the airman. But he has wonderful courage, tremendous determination, and very great natural skill.

These contests of 1911 proved the growing reliability of aeroplanes, and particularly of aeroplane engines. They showed, too, what an increase had taken place in the practical skill of airmen. 'Beaumont' and Vedrines flew their monoplanes across all sorts of country with the regularity of express trains, steering their way from one landing-place to another with remarkable accuracy. Added to this, they made innumerable landings, without mishap, on all sorts of ground.

And now as to the progress of aviation in 1912. Its two most salient features—the improvement in war-planes and the evolution of the hydro-aeroplane—have been set down for description in subsequent pages of this book. Therefore I need not go into these subjects here.

In this section I have described the principal achievements of the pioneers of flying. I now turn to the next subject, which is to describe, in a non-technical way, the method of operating an aeroplane.

THIRD SECTION

NON-TECHNICAL DESCRIPTION OF THE FIRST AEROPLANES

I

One of the first questions the ordinary person asks is: 'How can an aeroplane, with a heavy engine and the weight of a man to carry, fly through the air?' It is possible for any one to understand quite readily how the gas in a balloon keeps the craft in the air. But there is no gas-bag with an aeroplane. So how is it done?

The first thing I try to convey to the mind of an entirely non-technical inquirer is the fact that much support, in reality, can be had from the air—invisible as it is—if one only goes to work in the right way. If a man is unfortunate enough to fall off the roof of a tall building, he does not get much support from the air, I grant, on his way down to the ground. But he is not the right kind of object to obtain any sustaining effect out of the air: he is heavy, and presents a small surface to the air, which, therefore, does little to check his fall. To obtain support from the air you must strike it hard with some large, light surface. In fact, if you want to be sustained in the air, you must compress as much of it as possible, by squeezing it down with a big surface such as is provided by an aeroplane wing.

That there is this resistance in air, when it is suitably gripped, or compressed, can be demonstrated by a test with an ordinary umbrella. If you open one and hold it out at arm's length, and then suddenly give it a pull towards you, you will find that there is appreciable resistance, or solidity, about the air. The man who descends from a balloon with the aid of a parachute is using what is really a big umbrella. What the parachute does is to make a sort of cushion of the air which it imprisons under its surface, and so checks and steadies the man's fall. If you take a long, thin strip of wood and swing it round in the air, you will again feel the resistance of the atmosphere. We should remember, also, that a high wind, or rather a gale, will sometimes blow down buildings. The power is there all the time, although it is an invisible one.

Then, of course, we have the illustration which Nature gives us in the birds—particularly when they are soaring or gliding through the air, with their wings practically at rest. They are then obtaining support out of the air by the action of their curved wings upon it. The curve upon the bird's wing enables it to glide, and, similarly, the curve upon the planes of an aeroplane enables it to fly.

Early experimenters, such as Lilienthal, examined the wings of birds with the utmost care. They found them curved or arched from front to back. This curve, they also discovered, was more accentuated towards the front edge of the wing, which dipped perceptibly downwards. Then it curved away smoothly, in a gradual arch, to the rear of the wing. Experiments having been made with models which had curved wings, just like those of the bird, it was found they exercised a distinct upward lift when the air passed under them. Thus the planes of the first flying machines were made with a curve from front to back, in imitation of the bird's wing.

II

Let us now see how an aeroplane wing sustains a machine in the air. Imagine the wind, as the machine passes through the air, rushing in under the curved front edge of the plane. In doing so the air is thrust down or compressed, and then it moves back, in a smooth, swift stream, under the sweeping arch of the wing. What the curved wing really does is to obtain a grip of this elusive medium, the air, holding or imprisoning it while it passes under the wing, and pushing it steadily down. In doing so, the plane obtains a distinct upward lift out of the air.

Another effect is obtained with a curved wing. The air rushes over the top of the plane, forming a vacuum as it moves across the downward droop which occurs at the rear edge of the wing, and this vacuum exercises a distinct upward pull. Therefore, the planes of a flying machine are pushed up from below by the rush of air, and also drawn up from above.

If you build an aeroplane wing with a suitable curve, and are able to calculate just how fast you can propel it through the air, you are able to estimate what actual lifting influence each square foot of your plane surface will exert. As a simple instance, one may take the case of the early gliding machines upon which men launched themselves in flight from hill-tops. An average man's weight is reckoned at about 140 pounds. That weight, therefore, has to be supported through the air by the wings of the glider. Lilienthal, the famous German, made his wings with approximately 150 square feet of lifting surface; and he calculated—and his calculation proved correct—that each square foot of his two wings would sustain a weight, while gliding, of just over a pound.

Of course, he was only gliding, and his machine travelled through the air comparatively slowly—slowly, that is, in comparison with a power-driven machine. Therefore his wings would not sustain any great weight. With a modern aeroplane moving through the air at high speed, a much heavier load for each square foot of surface is possible. Indeed, a fast-flying modern monoplane will carry eight pounds to the square foot of its plane surface when in flight. Such, then, is the system. The aeroplane builder knows what the total weight of his machine will be, and he then provides a sufficient amount of lifting surface in his planes, the result being that, if the machine passes through the air at the requisite speed, its wings raise it in flight.

III

Now one can turn to a description of some of the early-type aeroplanes; and the first I shall take, naturally, is the Wright biplane. A biplane is a machine with two long, narrow supporting planes fixed one above another by the aid of wooden struts arranged in a girder form of construction. This biplane method of building has several advantages. It is strong, and it permits the builder to arrange a good deal of lifting surface within a reasonable space.

In front of the main planes of the Wright biplane, fixed on wooden outriggers, were the elevating planes—two small planes, placed one above another, as in the case of the main planes. Behind the main planes, supported on another set of outriggers, was the rudder, made up of two vertical planes fixed side by side.

And now we come to the pilot's position, a wooden seat near the centre of the front edge of the lower main plane. Beside the pilot—with an intervening space for a passenger—was the motor. This had four cylinders, and developed twenty-four horse-power at 1200 revolutions a minute. Its weight was 200 pounds. This motor drove two wooden propellers fixed behind the main planes. Each propeller was eight feet six inches in diameter, and made to revolve in opposite directions by means of chain gearing from the engine.

It is not easy to describe how an aeroplane propeller is made to work, but I will endeavour to do so. The propeller bores its way through the air with a screw motion just as the marine propeller forces its way through the water. One may take as an instance the ordinary gimlet. As you twist it round, it moves a certain distance into a piece of wood at each turn. So, also, does the aeroplane propeller screw its way into the air at each revolution; and, being fixed to the aeroplane, it carries the machine through the air with it. The air being a much more intangible medium to work in than water, an aeroplane propeller needs to be large, and also has to revolve at a high rate of speed.

Now we come to the method of controlling the Wright biplane. The pilot, as he sat in his driving seat, had two levers before him. One of these, when moved to and fro, actuated the elevating planes and made the machine rise or fall. The other lever, when moved to and fro, operated the rudder of the machine and turned the biplane from side to side. By a sideway movement, also, this same lever actuated the wing-warping movement which I have already described, and which was employed to maintain the lateral or sideway balance of the machine when struck by wind gusts.

The Wright biplane weighed, altogether, 1100 pounds, and its supporting surface contained 500 square feet. It flew through the air at the rate of forty miles an hour. The starting mechanism which the Wright brothers employed to launch their biplane into the air was extremely ingenious. They could not, of course, start their power-driven machine like a glider. So they designed a piece of machinery which launched the aeroplane into the air as a ship is launched into the water. The apparatus employed was as follows: a wooden rail 70 feet in length; a small carriage or trolley, which could be fitted below the biplane and which would run along this rail; a wooden tower, and a heavy weight to fall from it.

This was how the starting mechanism was made to work :—The machine was put on its rail, then the weight was drawn up to the top of the tower and released. In its fall, by a system of ropes and pulleys, it drew the trolley and aeroplane along the rail. The propellers of the machine, before starting, were made to revolve. In this way, by the help of the falling weight and the action of its propellers, the biplane was made to pass along the rail at a good speed. At the end of the rail the trolley remained on the ground, while the aeroplane glided off smoothly into the air.

The French pioneers of aviation did not adopt the launching rail. Instead, they fitted wheels underneath their machines, and made them run along the ground in order to obtain the necessary impetus for flight. This method meant that greater power was necessary in regard to the engine.

The Wrights, for instance, were able to do with twenty-four horse-power—owing to their starting rail—what French makers, with their wheeled machines, needed fifty horse-power engines to effect.

But there were disadvantages about the Wright starting system. For instance, if a machine came down some distance away from its starting rail it was helpless, and had to be put on a trolley and towed back to the rail; whereas, provided the ground was moderately smooth, a wheeled machine could descend and rise again without any starting machinery. Nowadays, it is interesting to note, the launching rail has gone out of use. The fitting of wheels to aeroplanes has, indeed, become almost universal.

IV

The next machine I shall describe is the Voisin biplane. This was the aeroplane designed and built by the Voisin brothers in 1907. On it Mr Henry Farman made some flights at Issy. Afterwards, this type of machine was flown in practically all parts of the world. The Voisin biplane weighed, with its pilot, 1270 pounds. In supporting surface it comprised 525 square feet. It flew at a speed of nearly forty miles an hour. The engine fitted to it developed fifty horse-power and weighed 380 pounds, this weight including that of the radiators used in connection with the water-cooling. This engine, it can be seen, weighed appreciably more than that of the Wrights; but then, it must be remembered, it was giving considerably more power.

The Voisin machine was driven by one propeller which had two blades. This propeller was coupled directly to the engine, being fixed to a continuation of the crank-shaft. It was considered then, as it is now, that one propeller was quite as effective as two. The use of one propeller also does away with any system of gearing, thus saving weight, as well as avoiding any complication of machinery. In using two propellers it is also considered that there is an element of danger. This lies in the fact that, if one of the propellers or any part of the gearing broke, the propeller which was not put out of action would go on revolving, and turn the machine over, owing to its unequal thrust.

Of course, under such circumstances, the pilot would stop his engine; but he might not be able to switch off quickly enough to prevent his machine being overturned by the twisting influence of the one propeller. It is but fair to the Wright machine to mention that only one accident has been attributed to the use, on this biplane, of twin propellers and chain gearing. This was the disaster which befell Orville Wright in 1908, when he was flying in America with Lieut. Selfridge as his passenger. On this occasion a chain gave way, and the machine became unmanageable. Lieut. Selfridge, it will be remembered, was killed, and Orville Wright badly injured.

At the present day, it is interesting to note, at least one successful aeroplane—the Cody biplane—is fitted with a system of chain gearing. Mr Cody uses a very large propeller, and drives it at half the speed of the engine by means of a chain-gear running on sprocket wheels. This system of gearing, in his case, proves quite reliable.

The one propeller fitted to the Voisin machine, which was seven feet six inches in diameter, was made of metal—unlike those of the Wright machine, which were built of wood. In the early days of the aeroplane, metal propellers were very largely employed, but latterly wood has been used almost to the exclusion of any other material. With the use of metal a danger was quickly recognised, this being the risk of a propeller breaking while in motion. The metal of propellers, it was found, showed a tendency to become 'tired,' and to fracture easily after a certain amount of use.

The danger of a propeller breaking when revolving at more than 1000 revolutions a minute can be imagined. On one occasion when a blade did break off, it buried itself several feet in the ground. Apart from the danger of a broken propeller striking some onlooker, when an aeroplane is being tested on the ground, there is also the risk of one breaking when a machine is in flight. In such a case, a portion of the propeller, in flying out with tremendous force, might strike and wreck some portion of a machine. On a biplane, for instance, which has the propeller behind the main-planes, the four outriggers supporting the tail are all fitted outside the propeller, and, so to speak, enclose it.

Thus, should a propellor blade fly off, there is danger of its striking and breaking one of the outriggers. If it did so, the tail of the machine would most probably collapse, with disastrous results. One terrible accident, which was due to the use of metal propellers, befell the French airship *Republique.* While making a flight, one of the propeller blades of the airship flew off. Unfortunately it flew straight upwards, and pierced the gas-containing envelope. The result was that the gas-bag burst and the airship crashed to the ground, the crew being killed.

Great skill is shown in the manufacture of these aeroplane propellers. They are built up from layers of wood glued together, and then shaped with the greatest accuracy to the curve laid down. Nowadays, so skilled have the propeller makers become, that the breakage of one through faulty construction is an almost unheard-of thing.

V

TURNING again to the Voisin biplane, I should now mention its chassis, or landing carriage. Unlike the Wright machine, the Voisin biplane was fitted with a system of permanent running wheels, upon which it passed along the ground, and which it carried up into the air with it. The wheels resembled those of a bicycle, having pneumatic tyres, the shock of landing being absorbed by springs fitted above the wheels. Of course, such a chassis was an appreciable weight, as compared with the simple wooden skids fitted to the Wright machine. As a matter of fact, the Voisin chassis weighed 250 pounds—or, one may say, almost the weight of a couple of passengers.

In its method of control, the Voisin biplane was simple. In front of the pilot, as he sat in a covered-in body placed along the centre of the lower main-plane, was a wheel like that of a motor-car, only arranged vertically instead of horizontally. By pushing this wheel forward or drawing it back towards him, the pilot operated two small horizontal planes, set side by side, which projected on a sort of prow in front of the machine. A manipulation of these planes lifted the machine off the ground or caused it to descend. By a side to side motion of the wheel, the pilot steered the machine, operating a rudder fitted in the centre of a square, box-kite form of tail, which was carried on outriggers behind the main-planes.

Of any special means to control the sideway or lateral stability of the machine, there was none. The pilot kept his planes level by movements of the rudder alone. Of course, this early-type Voisin was not flown in any wind; if it had been, some method for controlling the lateral stability would have been necessary. In subsequent machines, the

Voisins attempted to make their biplanes laterally stable by fitting in between the main-planes a series of fixed vertical planes, or 'curtains,' as they were called. There were four of these curtains in between the planes, and the idea was that their influence, as the machine passed through the air, would hold it steady, and prevent it from lurching from side to side. The curtains undoubtedly did have a decided effect in the way that was intended; but they had disadvantages as well. For instance, when the machine was flying in a side-way wind, the pressure of the wind upon the curtains pushed the machine off its course, and made it move along through the air in a crab-like fashion.

The early difficulties with the Voisin machine lay in the fact that its fifty horse-power engine was only just sufficient in power to make the big machine rise off the ground; therefore, if the motor was not working at its full rate of 1000 revolutions a minute, the machine was sluggish, and refused to lift. When it was in the air, however, it flew very steadily—as those who saw the Voisin machine at Rheims in 1909 will remember.

A great deal of power, of course, is needed to drive an aeroplane along the ground fast enough to make it fly. When in the air, much less power is required. For instance, the Wrights estimated that, when they were flying their biplane, and it was well off the ground, only fifteen of their twenty-four horsepower was necessary to keep the machine in the air.

VI

I SHALL now describe the successful monoplane which, after the expenditure of much time and money, was evolved and flown by M. Louis Bleriot. It was this small monoplane, as operated by M. Bleriot, which first drew practical attention to this bird-like type of aircraft, as opposed to the biplane form of construction. The chief feature of the Bleriot monoplane was its extreme smallness. Its two wings were fitted to either side of a skeleton woodwork body—so narrow that it would only just accommodate the pilot—and were held in position by straining wires. The total lifting surface of the two wings of Bleriot's monoplane was only 150 square feet—or the equivalent of that used by Lilienthal in his glider. The Bleriot machine was designed to fly at a speed of thirty-four miles an hour, and its planes carried a load of a little over four pounds per square foot. The total weight of the machine, with its pilot and fuel, ready for flight, was only 633 pounds. It should be remembered, for the purpose of comparison, that the Voisin biplane weighed 1270 pounds.

The pilot sat in the narrow body, midway between the two wings, and just on a level with the rear edges. In front of him were the petrol and oil tanks, and the engine. The motor was fitted in a framework, right at the front of the machine. It was an Anzani, with three cylinders, and was air-cooled. It developed about twenty-five horse-power and weighed only 132 pounds. This engine drove a two-bladed wooden propeller, six feet eight inches in diameter. The woodwork body of the monoplane, which was twenty-six feet long, tapered away to a fine point behind the wings. Right at the rear of the body was a set of planes for controlling the machine. There was one fixed horizontal tail-plane, containing seventeen square feet of surface, and two smaller horizontal planes fitted on either side of the fixed plane, each of which had eight square feet of surface. These two planes were moved up and down to raise the machine into the air or to cause it to descend.

At the extreme rear of the body was a small vertical rudder containing four and a half square feet of surface. This steered the monoplane from side to side. The lateral or sideway stability of the machine was obtained by warping the two wings—in the same system as that employed in the Wright biplane.

The pilot worked the rudder of his monoplane by means of a foot-bar, which he twisted from side to side; the rise and fall of the machine, and also the wing-warping device, was operated by means of a single lever, fitted so that it was directly in front of the airman as he sat in the driving-seat.

The landing gear of the Bleriot consisted of two wheels under the front of the machine and one small wheel under the tail. There was a rubber shock-absorbing device above the front wheels, against which came the pull of the wheels when they met the shock of a landing.

A great feature of the Bleriot was its portability. The wings could be detached quickly and folded alongside the body of the machine. Then it could be wheeled along an ordinary road, or towed behind a motor-car. When Bleriot brought his monoplane to Calais for the cross-Channel flight it travelled on the railway on an ordinary truck, and from the station to the flying ground was towed along through the town at the tail of the airman's motor-car.

The Bleriot monoplane of the type that crossed the Channel certainly flew well and was very stable. But it did not achieve any very remarkable results—apart from the cross-Channel flight—until it was fitted with a Gnome fifty horse-power engine. Its earlier twenty-five horse-power motor did not seem to give it sufficient power. With the Gnome, however, it won a very large number of important contests, and was generally adopted for military use.

VII

Having dealt with the Bleriot, I can now turn to the Antoinette monoplane. It was the Antoinette, the reader may remember, which competed with the Bleriot in July, 1909, for the honour of being first across the Channel. The Antoinette was an extremely interesting monoplane. It was very large, very beautifully built, and extraordinarily stable in flight. Furthermore, it was a magnificent machine to watch in the air, its great wing-span and the way each plane was tilted up a little, giving it a truly bird-like appearance.

The body of the Antoinette was a striking feature of the machine. It was just like a long, narrow boat, coming to a fine point at the bow, and being just wide enough, near the centre, to accommodate the pilot. On either side of this graceful, boat-shaped body were the two big sustaining wings, which measured forty-six feet from tip to tip. How much larger the Antoinette was than the Bleriot can be estimated when we remember that the latter had a wing-spread of only twenty-eight feet. From this it may be gathered what a big monoplane the Antoinette was. Altogether, it contained 365 square feet of lifting surface, or more than twice that employed in the Bleriot. The weight of the Antoinette, with its pilot, was 1210 pounds. The lifting load on its planes was 3·29 pounds per square foot.

The wings, as I have mentioned, were tilted up a little at a dihedral angle. This slight upward tilt of the planes was considered to give the monoplane stability when in flight; and the Antoinette was certainly an extraordinarily efficient machine when flying in a wind. The big wings of the monoplane were built up in a very strong and ingenious way, the intricate woodwork used being arranged in a series of triangles. The system of construction, in fact, was like that employed in building the Eiffel Tower—the plan being to subject every part of the structure to tension and compression. The beautiful construction of this Antoinette wing may be imagined when I mention that, although each of the big planes contained nearly 200 square feet of lifting surface, the weight of it worked out at less than 100 pounds.

The engine used in connection with the Antoinette was constructed by the Antoinette Company itself. The motor, like the monoplane, was quite a wonder of lightness and strength. It had eight cylinders, was water-cooled, and developed fifty horse-power. So light was it in construction that it gave one horse-power for each 2·9 pounds of its weight.

Another wonderful motor, built by the Antoinette Company, had sixteen cylinders, and developed 100 horse-power; and yet it was so light, although developing such very great power, that an ordinary man could pick it up and walk along with it. The Antoinette engine drove a steel propeller which was placed at the bow of the boat-shaped body.

The steel arms of the propeller were fitted with aluminium blades. The propeller turned, when the machine was in flight, at 1100 revolutions a minute.

The landing gear of the Antoinette consisted primarily of a skid, which projected in front of the body, and two small running-wheels. A novelty in connection with these wheels was that they were not fitted with any rubber or spring shock-absorbing device; instead, the shock of landing was taken up by a cylinder fitted above the wheels and containing compressed air.

The chief controlling planesof the Antoinette were arranged at the rear of the main-planes, and formed a tail at the extremity of the slender boat-body. A set of fixed fins, like the feathering of an arrow, was fitted at the end of the body, to give the machine stability when in flight; and, placed as a continuation of these fins, were horizontal and vertical flaps or planes, which were used to make the machine rise or fall, or turn from side to side in the air.

In the early Antoinettes the lateral or sideway balance was effected by the up and down movement of small planes fitted, like flaps, to the rear extremities of the two wings; but after a few machines of this type had been built, these little flaps, or 'ailerons,' as they were called, were abandoned, and the wings were made to warp like those of the Wright biplane and other machines.

The method of controlling the Antoinette monoplane was decidedly novel—like other points of this interesting machine. As the pilot sat in his driving seat, which was placed a little way behind the rear edge of the main-planes, he had two wheels—like those of a motor-car—fitted one on each side of him. The right-hand wheel actuated the elevating planes. Turned forwards, this wheel made the monoplane descend, and vice versa. The left wheel, when turned forward or backwards, acted upon the wing-warping mechanism, and so controlled the sideway balance of the machine. To operate the rudder, the pilot had a convenient system of foot pedals. The speed of the Antoinette, in flight, was about forty miles an hour; but, with a racing type of machine, the late Mr Hubert Latham considerably exceeded this pace.

It is a curious fact, which is rather hard to explain, that the Antoinette—ingenious machine though it was—did not meet with any permanent success; and nowadays, with the exception that certain modern-type machines are founded upon its principle, it is never heard of. The machine certainly flew splendidly; but it was costly to build, it lacked portability, and it failed in several important contests through minor troubles with its somewhat complicated though very cleverly built motor. So it was that the favour of aviators seemed to be extended towards the lighter, more portable monoplanes—such as the Bleriot—which were in active competition with the Antoinette.

Another point which told against the Antoinette was the fact that it did not fly so fast as several other makes of machine. This was decidedly against it in regard to the many speed races organised for valuable prizes. Generally speaking, indeed, the Antoinette was not so good a competition machine as many of its rivals—although on several occasions, when piloted by Mr Latham, it ascended at flying meetings and combated winds which kept other aircraft in their sheds.

When Latham, its most brilliant exponent, gave up regular flying, the Antoinette lost much of its fame. Financial difficulties arose also in connection with its manufacture, and thus the machine gradually became less and less flown, until at last it ceased to be constructed. But the Antoinette taught many lessons to the builder of aeroplanes—and these lessons are bearing fruit even to-day.

VIII

Now I come to deal with what was certainly one of the most practical and efficient aeroplanes ever built—the Farman biplane.

It will be remembered that, after first flying a Voisin biplane at Issy, at the end of 1907, in collaboration with the Voisin brothers, Farman severed his connection with them, and began to design a biplane of his own. This was the machine which, fitted with the Gnome engine, performed so wonderfully well at the Rheims flying meeting of 1909. Farman's idea in building his biplane was to have a machine which was generally simpler and less cumbersome than the Voisin.

His machine, which was of the regular biplane type of construction as regards its main-planes, contained 420 square feet of sustaining surface. The span of the main-planes was thirty-two feet six inches. It had an elevating-plane fixed out in front of the main-planes which was fifteen feet long. The tail-planes, carried on four outriggers, consisted of an upper and lower fixed plane, with a rudder working in between them. In his biplane, Farman did away with all vertical curtains or side surfaces, and so prevented the machine from making leeway as the Voisin had done when flying in a side wind.

Farman did not employ any wing-warping method for the sideway stability of his biplane; instead, he used four 'ailerons,' or hinged flaps, which were fixed at the rear extremities of the main-planes. These ailerons acted in the same way as the warping of the planes of a machine. That is to say, when one side of the biplane tilted down the pilot drew down the ailerons on that side of the machine, and so caused it to right itself. Ordinarily, when not in operation, these ailerons flew out straight in the wind on a level with the main-planes.

The weight of the Farman biplane, with its pilot on board, was 1170 pounds. Its planes, in flight, sustained 2·79 pounds per square foot. It had a propeller which was eight feet five inches in diameter. This, driven by the famous Gnome motor, turned at 1200 revolutions a minute. I have mentioned the Gnome engine before, but it is interesting to note that this engine gave one horse-power of energy for each 3·3 pounds of weight.

In his landing-gear Farman effected a distinct improvement upon the device which had been employed on the Voisin. Under the main-planes of his machine he fitted two long wooden skids. Across each of these skids, near the front, was a short axle. This axle carried two small bicycle wheels with pneumatic tyres. The axle was held to the skid by a thick india-rubber band. When running along the ground, the weight of the machine was borne by the wheels; but if the machine made an abrupt landing the wheels were forced up by the yielding of the rubber bands, and then the skids took the force of the shock. Light and yet simple, this landing-gear of Farman's proved most efficient.

The control of the Farman biplane was simple. The pilot had a foot-bar upon which he rested his feet, and a lever which he held in his right hand. When moved to and fro, the hand lever operated the elevating-plane. Swung from side to side, it put into action the ailerons or balancers. The foot-bar operated the rudder of the machine.

The speed of this Farman biplane, under favourable conditions, was about forty miles an hour.

IX

The next—and last—machine that I shall describe in this section is the Curtiss biplane. This machine, designed and flown at Rheims in 1909, by Mr Glenn H. Curtiss, the American airman, won the Gordon-Bennett speed race —as I have already mentioned—attaining a pace of forty-seven miles an hour.

The Curtiss biplane was, indeed, a remarkably fast and lightly-built machine. The span of its main-planes was only twenty-eight feet nine inches. That is to say, it was no wider from one wing tip to the other than the Bleriot monoplane—which was in itself a very small machine. It possessed 270 square feet of lifting surface. The weight of the biplane, with its pilot on board, was only 710 pounds. This, it will be noted, was approximately the same weight as that of the Bleriot. The planes of the Curtiss were so loaded that they carried 2·63 pounds per square foot.

The engine driving the machine was one

designed and built by Mr Curtiss. It had eight cylinders and developed fifty horse-power. It drove a single propeller, which was approximately five feet in diameter. The biplane ran on a very light chassis, comprising three bicycle wheels. Every part of it, indeed, was built for lightness and speed. It had twin elevating-planes, like those of the Wright biplane, placed in front of the main-planes. At the rear of the main-planes was a fixed horizontal tail-plane, with the rudder arranged in two sections, and fitted above and below this horizontal plane. The pilot of the Curtiss was seated a little in front of the main-planes and slightly above the level of the lower plane.

The control of the machine was interesting. In front of the airman, as he flew, was a wheel. This, as in the case of other machines, was moved to and fro in order to work the elevating-planes, while a twisting movement operated the rear rudders. In connection with the lateral stability of the machine, however, Mr Curtiss introduced a novelty in controlling mechanism. The sideway balance of the biplane was effected by means of ailerons. These, instead of being fixed as flaps at the extremities of the planes, were placed in between them, at each end of the machine. For putting the ailerons into action Mr Curtiss did not employ a hand lever or any foot method of control. Instead, he placed an upright bar behind the pilot, with a horizontal rod and two shoulder-pieces at the top of it. The shoulders of the pilot fitted this horizontal rod, with the result that, if he swung his body from side to side, the mechanism moved also, and so operated the ailerons of the machine. This method of control had the advantage of being an instinctive one. For instance, if one side of the machine dipped down lower than the other, the pilot would instinctively lean his body away from the side of the machine which was drooping. In doing so he automatically put into operation the balancing planes.

This method of working the lateral stability, although ingenious, has not gained favour with constructors or aviators. The most general system is to effect the operation of elevating-planes and ailerons by the dual action of one hand lever.

FOURTH SECTION

HOW TO BECOME AN AIRMAN

I

When for the first time, after centuries of unavailing effort, men began to fly, it was generally thought that, in order to be able to pilot an aeroplane, one must have superhuman qualities. It was said, for instance, that the Wrights possessed an altogether abnormal quickness of movement, that they were not ordinary men at all. It was quite as frcely asserted that they would never be able to teach other men how to fly. They were, as a matter of fact, considered aerial acrobats and nothing more.

But the Wrights were soon able to prove that such ideas were altogether wrong. Their first pupils not only learned to fly without any very long period of tuition, but also without accident. Following upon their success in mastering the art of flight, many other men came forward to learn how to control an aeroplane. Indeed, soon after the Wrights and Henry Farman and the first few pioneers had flown, fully a dozen other men were able to pilot a flying craft. Then the number of competent pilots grew quickly from a dozen to fifty. From fifty the total rose soon until there were at least a hundred pilots. And after this the development was so rapid that the hundred soon became a thousand. To-day a very conservative estimate places the number of airmen at rather more than 2000. And still the flying schools are turning out pilots in large numbers.

Now it is obvious that all these men who have learned to fly cannot be specially endowed by Nature—in a word, they cannot all be men with any specially rare gift which enables them to navigate the air. As a matter of fact, flying is not to be described as difficult. When a pupil is properly taught, he finds that the piloting of an aeroplane, under favourable conditions, is surprisingly easy. All a man needs to have, if he wishes to learn to fly, is what one might call an ordinary amount of activity and generally sound nerves. I should also mention that it would be unwise for any man to take up aviation if he has anything in the nature of an organic weakness—such, for instance, as any heart affection. But one may say, with all confidence, that an ordinary, everyday type of man, provided of course that he is genuinely keen and careful in his early attempts, can make a satisfactory pilot of an aeroplane.

All the mystery which clung to the flying of an aeroplane in the early days of aviation has already been brushed away. It is now recognised quite well that, under good weather conditions, a properly-built machine requires very little control when it is in flight. What it almost does, so to speak, is to fly itself. But, although one should recognise that there are no extraordinary difficulties in learning to fly, it is quite necessary to bear in mind that no liberties can be taken with the air. All the time a man is flying he needs to exercise proper caution and use considerable judgment. The great masters of flight, such as Farman and Bleriot, have always a great respect for the air.

What the airman must always remember when he is in flight is that he cannot afford to make mistakes. Momentary forgetfulness, or some carelessness, may easily spell disaster when you are at the levers of an aeroplane. A pilot, in fact, always needs to keep his wits about him.

When flying, also, it is very unwise—

unless the airman possesses quite exceptional skill—to attempt any tricks, or indulge in what one may call 'circus' performances with a machine. Another excellent rule is to study the prevailing weather conditions before you attempt to make a flight. Still another excellent point to remember is that a machine must always be kept in first-class flying trim. What the pilot should do, before each flight, is just to run his eye over all the controlling mechanism and other vital parts of his machine, so that he may be personally assured that everything is all right.

It has always been my contention that, provided one flies with judgment and does not attempt difficult or dangerous feats, piloting a modern-type aeroplane presents no more danger than driving a motor-car. But the dangers of flying are very real ones when a pilot loses his judgment and attempts all sorts of reckless and ill-advised flights.

II

Now one can come to a would-be pupil's first stage. What he has to do, as a preliminary step, is to make up his mind about joining some flying-school; and in choosing any particular school, there are several points which he needs to consider. For instance, the school he selects should be one possessing a good aerodrome. It is essential that there should be plenty of room on the flying-ground for manœuvring machines. It is necessary also that the aerodrome should have a fairly smooth surface, so that machines can run about all over it without any danger of mishap. In this connection it must be remembered that, although an aeroplane is naturally designed for flying, it does a lot of running about on the ground when in the hands of men who are learning to fly.

Another point concerning a flying-ground, from the pupil's point of view, is that it should not be situated in a position where gusts or eddies of wind are likely to arise. Such troublesome gusts and eddies are sometimes experienced when there are hills or woods in the vicinity. A pupil should also make sure that the school he is joining has plenty of aeroplanes. If it has not, a few mishaps may place all the available machines out of action, and so delay the work of tuition. It is essential that a flying-school should be provided with thoroughly good instructors. A lot depends upon the man who teaches you to fly. He must be genuinely fond of the business, and must, in addition, be keen upon imparting his knowledge to other people. It is essential, too, that he should be a careful man, and one always ready for the work in hand. He must have good judgment as well, and be always capable of deciding whether climatic conditions are favourable for flying.

Then the question arises as to what type of machine a pupil will learn to fly. It is a point upon which, in my opinion, it is difficult to lay down any hard and fast rule. There are many schools nowadays; and many types of machine are used with quite successful results. But, speaking in a general way, I think it is a good idea to learn to fly, at any rate as a first stage, upon some sound, successful type of biplane. Afterwards, of course, a man can learn to handle a monoplane if he cares to do so.

There are now in existence many flying-schools where monoplane flying and nothing else is taught to the pupils, and such schools are doing very good work. What is more to the point, there are very few accidents in connection with them. But a monoplane is a quick machine in its action and control. A biplane is slower, and gives a beginner what one may, perhaps, describe as a greater latitude in regard to the making of any trifling error in manipulation—a distinctly important point for the novice.

In discussing this matter I often find it useful to take, as an instance, the question of a man who is going to learn to ride a horse. For a beginner, undoubtedly the ideal mount is some quiet, steady-going cob. It would not be wise to put a novice on a racehorse and send him out for his first ride. As regards learning to fly, one might take it that the flying-school biplane represents the quiet cob, while the racehorse is represented by the monoplane. The experienced airman, as is only natural, is fond of monoplane flying—the speed and the quickness of control of this machine appeals to him. But the pupil has a different point of view. Taking all things into consideration, it is, in my opinion, a sensible idea to learn to fly first of all upon a biplane.

III

Nowadays, at the best schools, there is a special type of machine used for instructional purposes. It is a steady, slow-flying type of biplane, usually with a specially strengthened form of landing-gear; and it is fitted, as a rule, with a system of dual control. This means that it has two complete sets of controlling levers. One of these is placed before the pilot and the other is in front of the pupil. By this system it is possible, when flying, for the pilot to relinquish his control over the machine, and allow the pupil to take charge of it, for a minute or so, when conditions are favourable. But, should the pupil make any sign of a false movement, the pilot can, in an instant, regain his control over the machine. This dual control system is an excellent one, and greatly facilitates the routine of school work.

Now, having chosen his school, and having decided what type of machine he is going to learn to fly, the pupil comes to the first practical stage in his course of training. In this respect many schools have instituted what is really an excellent idea. This is to give the pupil a short but thoroughly practical course of instruction regarding the mechanism of the aeroplane he is to learn to control. Also, it is the plan to explain to each novice the internal working and the method of control, of some of the best-known flying-machine motors.

A properly conducted school, as a rule, has a good machine-shop, and plenty of aeroplanes being built or repaired; and there are, as well, a number of motors being taken to pieces and overhauled. The pupil, therefore, has an excellent opportunity of acquiring some really useful first-hand information which will stand him in good stead when he actually begins to fly. This instructional work in the machine-shops often fills up, in a very useful way, a blank day, such as is frequently caused by the springing up of a high wind.

Without doubt it is very valuable for a pilot to learn all he can about the construction of his machine, and particularly about the working of the motor which keeps him in the air. If a man understands his motor, he can often extricate himself from an awkward predicament, when compelled to descend, through engine trouble, some distance away from the aerodrome, or where the rescuing mechanics cannot find him.

Now one can turn to the pupil's first flights. In these he will do nothing at all himself, but will simply sit in the passenger-seat of the machine and watch what his instructor is doing. By making a few such flights he accustoms himself to being in the air, and he sees also the movements of the instructor as he flies the machine. This paves the way for the stage when the pupil takes over the control of the machine when in flight, with the instructor's watchful eye upon him. At first he is allowed to fly the machine only when it is passing along straight through the air; but soon, if he shows fair promise, he is allowed to make half turns in the air.

Afterwards he has to learn the trick of making a good landing. In doing this a certain amount of skill is required. The procedure is to make what is known as a *vol plané*. The pupil switches off his engine at a fair height from the ground, and then alters the angle of his elevating-plane, so that the machine begins to glide down, without power, towards the ground. Gauging his distance correctly, the pupil checks the descent of the biplane just before it touches the ground, and makes it skim along a few feet above the surface of the aerodrome, before it settles lightly down and comes to a standstill.

IV

There is no special difficulty in learning to make a *vol plané*. All that is necessary is for the pupil to keep his head and judge the right moment when to check the biplane's glide, and to bring it into a horizontal position preparatory to the actual landing. If he does not check the glide properly, the machine will hit the ground at too great a speed, with the result that some part of the under-carriage may be broken. On the other hand, if the pupil checks the descent of his machine too soon, he may make what is called a 'pancake' landing.

How this occurs I can explain as follows: by tilting up his elevating-plane to stop his glide when he is too high off the ground for landing, the novice brings the biplane to a virtual halt in the air. One must remember, in this connection, that the machine when making a *vol plané* is not being driven by its engine, but relies for its speed entirely upon its downward glide. Therefore, if the pupil throws up his elevating-plane when he is still too high in the air, the effect is to bring the biplane to a standstill, the result being that, there being no sustaining force under its planes, the machine drops.

It does not, however, fall like a stone. Its planes, although they are no longer exercising enough lift to keep it in the air, are able to prevent it from falling rapidly. What it does, really, is to make a sort of parachute descent, the wings acting as the parachute. However, although it is not a sheer drop, such a descent is not good for the aeroplane. Instead of touching the ground lightly, and then running forward on its wheels until it comes to a standstill, it drops flat upon its landing-carriage with appreciable force, the result very often being that the landing-gear suffers sadly. Frequently, in fact, it is completely broken up. In such a case the propeller generally suffers also. But this, as a rule, is the extent of the damage. Injury to the pilot in such an awkward descent is practically unknown.

It is curious to note that even the most experienced airman sometimes makes this error in the manipulation of his machine, and effects a 'pancake' landing. It is just the question of a trifling error of judgment at the last moment. However, the trick is to be learned after a little steady practice. There is nothing particularly difficult about it; it is just one of those things that a pupil needs to learn thoroughly, so that he is able to make the necessary movements without having to think what he is doing.

Naturally, when a number of pupils are learning to perform such aerial evolutions as these, some amusing incidents are to be recorded. One quaint and quite typical instance of a pupil's difficulties occurs to me. In this case, the novice had made very good progress, and had reached the stage when he was making flights by himself. When he was making a *vol plané*, those who were watching him from the aerodrome were surprised to see that he did not switch off his engine.

Instead, he came swooping down at a very high rate, with his motor going at full speed. Everybody—except the pilot—could tell that there was going to be a smash; and so there was. The pilot hit the ground very hard indeed, and completely broke up all the lower part of his machine. When he extricated himself from the wreck, quite unhurt, he wore a very astonished expression. It appears that, in the excitement of the flight, he had quite forgotten to switch off his motor. His mind had been so full of what it was necessary to do in the manipulation of the elevating-plane that this very important point, concerning the stopping of the engine, had quite escaped him.

In such cases, of course, it is very largely a question of the temperament of the individual. Some men get very flurried, while others remain abnormally cool. In regard to the latter type, some rather astonishing things occasionally happen at a flying-school. Here, for example, is a story about a remarkably cool and collected pupil.

On the very first occasion when he was permitted to make a flight by himself, this man flew right away from the aerodrome, and was next seen passing very low over the top of a tram-car, which happened to be moving along a main road not far from the aerodrome. Then, taking a turn, he steered back towards the flying ground again. His horrified instructor saw him making directly for a clump of trees, and at so low an elevation that he would not be able to clear them. It looked, indeed, as though a bad smash was unavoidable. However, this enterprising pupil was quite equal to the emergency. He steered his machine between two trees, with only a foot or two of clearance for his wingtips, and then landed safely in the aerodrome without having turned a hair. When remonstrated with, he did not seem to think that he had done anything at all out of the way.

As a contrast to so abnormally self-possessed a pupil, one sometimes finds a man who loses his head completely when he finds himself, for the first time, in sole charge of an aeroplane. In one such case that came to my notice, the novice rushed right across an aerodrome without his aeroplane leaving the ground, and charged a high fence, with disastrous consequences for the front of his machine. He had entirely lost his head. Although he could easily have prevented the accident by turning his machine round with an application of the rudder, or could have stopped it by switching off his engine, he did neither. Instead, he drove on as though in a trance, and dashed into the fence at full speed.

V

In handling the controlling levers of an aeroplane, the novice finds that he has a good deal to learn. He is usually surprised to discover what a very slight movement of the levers is necessary to produce any desired result. Instead of moving a lever perhaps a matter of nearly a foot—as he may have imagined would be necessary—he finds a machine can be controlled perfectly by shifting the lever for a few inches only in any required direction. This delicacy of control of an aeroplane makes it very valuable for a man who is going to fly to possess what is known as good 'hands.' The same characteristic is spoken of in regard to jockeys, the very finest riders being those who are credited with this lightness of control. So it is with airmen. The greatest of our pilots all have this manual delicacy.

In regard to this facility or otherwise in handling an aeroplane, the pupils at a flying-school show marked differences when compared with one another. Some are, even when carefully taught, apt to be a little heavy and clumsy in their control of a machine; others seem to get just the right touch almost by instinct; and it is these latter men who have in them the makings of first-class flyers.

It is, generally speaking, the tendency of a novice to overdo considerably all the controlling movements of an aeroplane. For instance, when he comes to leave the ground on starting a flight, he very often draws back the elevating lever much too far, with the result that the machine slants off up into the air at too steep an angle. Realising that he is rising far too steeply, the flurried pilot will sometimes make a very abrupt reverse movement with his lever, the result being that he dips the front of the machine acutely down, and performs a sort of switchback movement. If he hits the ground while thus diving down, he probably damages his landing-gear; but usually he corrects the dive in time, and flies on all right after a few more nervous ups and downs.

In the early days of the flying schools, when men were learning to pilot the original type of Wright biplane, some amusing incidents happened in connection with the launching of pupils from the starting-rail. The idea was that, when you reached the end of the rail, you raised your elevating-planes just a trifle, and skimmed off into the air. But the pupils—tilting up their elevating-planes at far too big an angle—sometimes got themselves into great trouble. For instance, upon leaving the rail, a machine would sometimes rear itself up into the air like a frightened horse, and then, after hanging poised for a moment or so, would slide backwards through the air, and land ingloriously upon its tail. In such an accident the pilot was rarely hurt, but the damage to the aeroplane as the result of such an awkward fall was often serious.

There is always danger in rising off the ground at too steep an angle. If the elevating movement of the planes is much overdone the aeroplane may have its forward speed checked, with the result that it will slip back, tail first, in the way I have described. However, all these things are merely a question of careful teaching on the part of the instructor, and steady practice on the part of the pupil. To any one who watches the work at a flying-school, it is astonishing how quickly the merest novice will learn to handle a suitable machine.

VI

It is certainly unwise to try to learn flying in a hurry. No pupil should endeavour to 'rush things' with regard to his tuition, and no instructor should make it his aim to turn out large batches of pupils in the shortest possible space of time. In learning to fly, more than in anything else, a man needs to proceed deliberately from stage to stage. If he tries to hurry through his course of tuition, he may get his certificate of proficiency very quickly, but this will not mean, necessarily, that he is a competent airman.

It is a true saying that flying is easy when things are going all right. When circumstances are favourable, a machine almost flies itself. The pupil who hurries through his course of training with the idea of obtaining his certificate in record time, may be all very well as a fair-weather flyer; but he will not be a good man, in nine cases out of ten, when it comes to an emergency. And it is emergencies we have to be ready for when flying. A sudden gust of wind, for instance, may strike a machine. Then it is that the pilot must know what to do, and how to do it; he must not hesitate or think what he has to do. It is in an emergency that a solid grounding of instruction stands a pupil in good stead.

As a rule, when a pupil is first given control of a machine, he is instructed to drive it up and down the aerodrome on the ground, so as to gain a good working knowledge of the control of the engine and the manipulation of the levers. This practice on the ground is called 'rolling.' It forms an excellent prelude to the short, straight flights, or 'hops' off the ground, which are the pupil's next stage. Then he gets to be able to make a turn in the air, and proceeds to the effecting of a *vol plané*. Then he is ready to call out the necessary official observers, and make the attempt to gain his certificate of proficiency.

It is difficult to say how long it should take a pupil to reach this stage of his tuition. It depends very much on the man, and also on the weather. When a pupil is learning in the winter he may encounter many days when it is impossible to do any flying at all. Thus, a spell of bad weather may very greatly retard his progress. However, I think one might say that two or three weeks should, ordinarily, be set aside as a safe time allowance in which to learn to handle a machine properly, and obtain one's certificate of proficiency. Of course, there are many men who go through their training in less time than this, and who learn all there is to learn thoroughly; and, on the other hand, of course, there are pupils who take much longer before they are able to obtain their 'tickets,' as the taking of the certificate is called. However, I think that, for the average man, two or three weeks should be the time allowed.

I have not hitherto referred to the question of the cost of learning to fly, but I will now do so. A would-be pupil, nowadays, can obtain a complete course of tuition, which does not terminate until he has obtained his certificate, for an inclusive fee of £75. For the payment of this amount the flying-school takes upon its own shoulders the risks of a pupil breaking up a machine, and also guarantees him against any third-party claims for damages. By such a system the pupil knows exactly what learning to fly will cost him; and it is greatly preferable, from his point of view, to the early plan of payment, whereby a man was asked for a certain fee for his tuition, and had also to settle all bills for breakages during the course of his schooling. Nowadays, however, the teaching of pupils to fly has become much more of a business than it was a year or so ago; and, the result is that, with a regular supply of pupils coming along, the schools can specify a fixed fee such as I have mentioned.

VII

One can now turn to a description of the actual flights necessary in order to secure a certificate of proficiency. It should be understood, to begin with, that such certificates in this country are only granted by the Royal Aero Club of the United Kingdom. This is the body representing the International Aeronautical Federation, and it controls the sporting aspects of aviation in this country. When he is ready to make the necessary tests, the pupil gives notice to the secretary of the Royal Aero Club, and this official arranges for observers to be present on the aerodrome and watch the novice's flights.

The tests imposed, before a certificate is given, fall under three headings. The pupil has to show that he can control his machine in the air, that he can ascend to a specified altitude, and also that he can descend with his machine under proper control.

The chief test comprises two flights, each of five kilometres (or three miles 185 yards) in length. The course over which the pupil has to make these flights is marked out by two posts, which must be situated not more than 500 metres (547 yards) apart. After each turn round one of the posts the pupil must change his direction when going round the next post.

This means that he will need to fly round the two posts in a series of figures of eight. This turning test is instituted, of course, to show that the pupil can manœuvre his machine with facility.

The next is the altitude test. In making this, the pupil can undertake a separate flight, or can rise to the required height while effecting one of his two distance flights. The altitude he needs to obtain is fifty metres, or 164 feet. Then there is the alighting test. Here the ruling of the Aero Club committee is that the pupil shall alight after each of his flights with his motor stopped at or before the moment of touching the ground, and that his aeroplane must come to a standstill within a distance of 164 feet from a point previously specified.

When he has made these specified flights, the observers send in to the committee of the Royal Aero Club the necessary documentary evidence that the rules have been complied with, and, if everything is in order, the committee grants the pupil his certificate, which is in the form of a little ticket or booklet, and contains a photograph of the aviator possessing it.

When he has gained his certificate, the pupil's course of training comes to an end, and he is regarded by the Royal Aero Club as a competent airman. The certificate he has gained permits him to take part in any flying races or other contests which are organised under the rules of the Club. Pilots who do not hold the necessary certificate cannot compete in any such events.

And now, perhaps, as a final note to this section, I may give a few words of general advice to the would-be aviator. Certainly, the first and most important thing to remember is to be cautious in one's early attempts at flying. Safety lies in forethought—in thinking things over, in not being happy-go-lucky or slap-dash. This is the form of caution I mean : to try to understand all you can about an aeroplane and the conditions governing its flight, and to learn all that is possible about the motor that drives the machine. Then, before attempting a flight, however unambitious, one needs to consider just what the weather conditions are at the moment, and what effect they are likely to have on the machine when one is in the air.

All this may sound very simple—even, perhaps, unnecessary. But it was his faithful attention to small details which made 'Beaumont' the winner of the great flying contests of 1911. He had studied everything; he left nothing to chance.

We are all of us novices still in regard to the conquest of the air. But it is the man who has gone right through the mill who makes the successful flyer. The happy-go-lucky man may make a brilliant flight, it is true, but he is not the reliable, everyday type of pilot that aviation so sadly needs. What we want to turn out is a man who flies to-day, and to-morrow, and next week, and all the year round, and who does not smash himself up in some spectacular feat. He is the man who is going to carry aviation forward—not the devil-may-care type of airman who gets into his machine without looking to see that everything is all right, who knows nothing about his motor—and does not care to learn—and who simply drives his aircraft anyhow, and trusts to luck. He certainly has any amount of pluck; but he is not an airman of the lasting, successful kind—the type of man I, for one, want to see produced by the flying-schools.

FIFTH SECTION

RISKS OF AVIATION: HOW THEY MAY BE AVOIDED—WITH AN ANALYSIS OF ACCIDENTS

I

Most people start out with the idea that flying is a desperate and deadly sort of business. They picture a man high up in the air in a flimsy contraption, and they shudder when they think of all the dreadful things that may happen to him. Then, of course, they read in their daily papers the heading: 'Another airman killed'; and they tell each other that no human being should be allowed to go in for such a horrible occupation.

Well, this attitude is quite a natural one, I suppose. What of the vast indignation that was aroused when railways were projected? Meetings of protest were held; it was declared to be inhuman that people should be induced to travel in such engines of destruction. And yet the railway train survived the ordeal, and a railway carriage is now one of the safest places in the world.

Motor-cars, too. What about them? The same cry of protest was raised when the pioneers began to drive their first crude machines about our roads. That law-abiding people should allow these horrible inventions to occupy the public highway seemed to a great number of persons the crime of the century. A strenuous effort was made, in fact, to hunt the motor-car off the road. But the new industry struggled valiantly; its introducers refused to be shouted down. And the result do-day—is what? We see a smooth-running, silent, six-cylinder machine gliding along our roads. It is a joy to its occupants, and a nuisance to no one. It is more perfectly under control than any horse vehicle could be.

Such is the development of the motor-car. And yet, in the early days of the movement, the papers were full of such headings as: 'Another motor-car accident.' It seemed then, to many people, to be the height of folly to trust themselves in such a machine; yet, nowadays, we ride in a private car, or a motor-cab, purely as a matter of course, and think as little of it as of walking downstairs. So the world progresses. What seems folly to-day is common sense to-morrow;

and the new machine that is condemned this year is used extensively the next.

I have gone into these points so as to approach the risks of flying from the proper aspect. In the very earliest days of aviation the men who were actually flying could be counted on the fingers of two hands. They were all extremely cautious; they did not fly in high winds. They had the greatest respect for the new element they were invading. Then, very quickly, more and more men began to fly; and it was discovered, as well, that one could fly an aeroplane in quite a high wind if one cared to take the risk of doing so.

Then the flying meetings; aerial displays came into being, and men were paid high fees for giving a demonstration before a crowd. The result was that pilots began to lose their early respect for the air, and took liberties with it. They flew sometimes in dangerous winds, just to avoid disappointing a crowd of people who had paid to see them ascend. They tried all sorts of fancy tricks in the air, too; and, all the time, the number of pilots grew and grew.

I want the reader to appreciate the fact, also, that all this work was being done on a purely experimental type of machine—a machine built very lightly, with wood and wire, and driven by a motor which did not always do its work properly. Further, it must be remembered that these aeroplanes were flying about in an uncharted sea—a sea full of deadly eddies and currents, which no man could see, and which struck a machine entirely unawares.

II

WHEN one bears in mind such facts as these, it is not surprising that aeroplane accidents have happened. It would, indeed, be most remarkable if they had not. Here we have men, after centuries of failure, suddenly provided with a means of flying through the air—high or low, in wind or in calm, each according to his own wish. And we must remember that, to those who treat it carelessly, the air is a treacherous foe. It is full of death-traps in the form of sudden gusts and eddies. The wind-gusts, indeed, seem to lie in wait for the pilot who is not cautious, and sooner or later they catch him unawares.

As soon as a fair number of men began to fly, their different temperaments—as revealed in the amount of risk that they were prepared to run—began to show themselves. Some, for instance—such men as the Wright brothers and Farman—refused to do anything in a hurry or on the impulse of the moment, and moved methodically from stage to stage. Others, however, were impatient of anything in the nature of delay. They refused to recognise the limitations of the experimental machines they were flying, and attempted all sorts of sensational feats. The result was inevitable. Accidents happened; men were killed. Each fatality—being a new way in which a man might kill himself—was regarded as an event of great interest; and so we read columns about it in the papers. Then, as more men took up flying, more men were killed.

Another fact, too, soon began to have an adverse effect upon aviation. After the first wonder at man's being able to fly had died down, reports of each individual flight that was made ceased to be published. The result was that people could not judge of the amount of steady, regular flying that was being done. But they still read, without fail, of each accident that took place. And so, by degrees, the public began to entertain quite a false view concerning aviation and the risks the airmen run. They knew nothing of the hundreds of miles that were flown without accident; all they heard about was that So-and-so had been killed. In this way the idea grew in the public mind that there was a terrible risk in the piloting of an aeroplane, and that three out of every six flights made were bound to end in disaster.

'If these chaps go on flying much longer, there won't be any of them left.' This became quite a common observation. As a matter of fact, the idea underlying it was completely wrong. Day by day, week by week, and month by month, the army of airmen grows. Naturally—seeing that the number of pilots has increased so greatly—the list of deaths has grown also. But to hold the view that the risks of flying are as great now as they were when aeroplanes were first built, is to entertain a notion that is quite wrong. Every day the dangers of flying are being lessened, through improvements in the construction of machines, and the general growth of knowledge regarding the conditions that govern flight.

The grateful thanks of the flying world are due to the Aero Club of France for some statistics it has taken the trouble to compile with the express purpose of combating the prevailing impression as to the perils of aerial navigation. Getting figures together with great care, the Club arrives at a reliable estimate as to the actual number of miles that have been flown by aeroplane in France during a series of seasons. Then they compare this total with the list of fatal accidents for the same period. The result is a surprising one—particularly to those people who have held the opinion that there is the gravest risk for a pilot every time an aeroplane leaves the ground. What the statistics of the Aero Club of France show is this—that for every 92,000 miles actually flown by aeroplane, during the year 1912, only one fatal accident had occurred.

Comment is needless in regard to such figures as these. They show, in an undeniable fashion, that thousands of miles may be flown by aeroplane without the slightest risk of accident. They indicate, too, with absolute clearness, what a vast amount of regular flying is done—flying that nobody hears anything about, and which is now undertaken with no more fuss than would be caused by taking out a motor-car for a spin.

III

In the early days of flying, when little was known about the construction of machines, men ran this very definite risk—a machine might suddenly collapse in the air. Some did, in fact, and an analysis I made concerning thirty of the early fatalities showed me very clearly that the breakage of a machine while in flight was the most fruitful cause of accident. Nowadays, however, we are able to reduce this risk practically to vanishing point. On a well-designed machine, which is properly built and adequately overhauled, a man is practically as safe to-day from any unexpected breakage of his mechanism as he would be in a first-class motor-car.

But the early builders of aeroplanes had many lessons to learn, and some of these lessons were only learned at the expense of airmen's lives. Some men might hold that such a loss of life was inevitable; but, to those who study the history of the aeroplane very closely, it seems that a reasonable proportion of these early fatalities could have been avoided if the victims had only been content with the slow progress and patient noting of all phenomena encountered, such as characterised the work of the brothers Wright. However, the enthusiast is often an impatient man; and so, in the early days of the aeroplane, a tendency was shown to jump too hastily from one point of progress to another.

One can take, for instance, the question of increasing the speed of aeroplanes. The first machines flew at from thirty-five to forty miles an hour. But this was too slow a pace to satisfy the more impatient pilots. They wanted to fly much faster than this, and so be able to win valuable prizes that were on offer. Consequently they appealed to aeroplane builders and engine makers to provide them with fast, light machines which would rival the speed of express trains. Such machines were built; the demand usually creates the supply. But some of these machines were not built with due deliberation, and after a proper and adequate test of the stresses and strains imposed on an aeroplane passing at high speed through the air. What was the result? It may be imagined. Some of the machines were too weak to withstand the strains put upon them; a wing, or some equally important part of their mechanism, gave way while they were in the air and they crashed to the ground. If their pilot was a very lucky man he escaped with serious injury; if not, he was killed.

Then enthusiasts sprang up who had no proper knowledge of the technicalities of aviation. Such men were often a peril to themselves if they flew their own machines, or to any unfortunate airman they might induce to act as their pilot. Machines were occasionally built by such enthusiasts which did not comply with even the rudiments of safe construction. Some of them—fortunately for all concerned—broke themselves up before they had even left the ground. Others flew; and they had not been flown long, as a rule, before something gave way, and they crumpled up in the air. Here, again, was a way in which men might lose their lives; and it is a fact that a fair proportion of bad smashes in the early days of flying was due to sheer structural weakness on the part of machines.

Of course, it was no easy matter for the first builders of aeroplanes to estimate just what strains would be imposed on their machines when they were in flight. It was easy to say an aeroplane would fly at such-and-such a speed and carry such-and-such a weight, and that, therefore, if it were built to such-and-such a ratio of strength all would be well. This, however, was estimating that everything happened in the air just as the constructor expected. But often it did not. Machines, when flying, encountered sudden lulls in wind pressure which caused them to drop many feet through the air. Others were hit by vicious wind-gusts of altogether abnormal strength. Others again, were mishandled by over-bold pilots, who jerked and twisted them about in the air, and who planed down from great heights at excessively steep angles.

It is not surprising, therefore, to find that manufacturers had to modify many of their views as to what constituted a safe aeroplane. Wings and tails broke; sometimes an entire machine collapsed. Bitter lessons were learned; but the industry profited by them. The margin of safety of machines was increased, not according to theory—which has sometimes proved a dangerous thing in connection with flying—but in accordance with the lessons learned in the actual navigation of the air.

IV

I have briefly mentioned before the risks of suddenly increasing the speed of machines· and these risks were certainly very grave ones for the men who flew early-type monoplanes fitted with very high-powered engines. In some cases these big engines were installed in machines which had not been specially strengthened in order to receive them. Here lay a very definite danger. Not only was there a risk that a machine might collapse through the strain of being forced through the air at high speed, but there was the additional risk of the shock to the planes of encountering a sudden wind-gust, or of the machine being dropped through the air with a jerk in meeting a lessening of pressure—or what is more familiarly known as an 'air pocket.'

To the collapse of lightly-built, high-speed machines more than one bad accident has been due. Nowadays, one should note, a great deal of attention is paid to the construction of the fast-flying monoplane. Its framework is a marvel of lightness and strength; and the system of straining-wires which supports its wings against the shocks encountered in flight, is of a strength sufficient to allow of an ample margin of safety for all contingencies. An important point, in such a connection, is this: the makers of aeroplanes have not only learned to strengthen their machines generally, but have learned in what specific parts of their craft a particular risk of breakage may lie. Therefore, the pilot of a modern type aeroplane, when he takes the air, is protected by the lessons learned in many hundreds of previous flights.

I have spoken before of the wind as being the airman's foe. That it was so, was clearly proved when pilots began to make cross-country flights and to brave stiff breezes, instead of contenting themselves with ascents only in calm weather. The breakage of some part of a machine while in flight, was, as I have said, the most general cause of accident in the first stages of aviation; but, rivalling it as a cause of disaster, came the action of the wind.

It was not the steady, regular wind the airman feared. In such, he could well control his machine. It was the vicious gusts, striking him unexpectedly, and with great force, he had cause to dread. In a rough sea, a man in a boat can, at least, see the approach of a big wave that threatens to engulf him. But the first men who navigated the aerial sea could not observe the approach of the treacherous wind-gusts that struck their machines upon one side or the other, and strove to upset their equilibrium and send them crashing to the ground.

This was the peril: no man knew, when he ascended on a windy day, what would be the maximum force of any one gust that might strike his machine. Nor could he prepare himself for the moment when it bore down upon him. Thus, he might be in the act of turning when a gust struck his planes, with the result that the sideway tilt of his machine would be suddenly increased to a perilous angle, and he might be sent 'side-slipping' to destruction. But the dangers of wind-flying did not daunt those of the early flyers who were too adventurous in spirit to rest contented with ordinary, jog-trot progress. They persisted in flying in higher and higher winds, and, as was only natural, some of them came very sadly to grief. But the aeroplane cannot be altogether blamed for the deaths of those men who went out to fly when weather conditions were obviously dangerous.

With one frail glider, and in tests carried out when they were the veriest novices, the Wright brothers managed to make nearly 1000 flights. Not once, through all these experiments, was this particular machine damaged. This is an indication of the safety of aerial test work, provided only that proper caution is displayed. It is a melancholy reflection, when one is going through the lists of aeroplane fatalities, to think how many might have been avoided. Really, the crux of the situation in this connection, as it appears to me, is this: the first men who flew, having had all the drudgery and danger of pioneer work, were extremely careful in all they did; and this fact accounts for the comparatively large proportion of these very first airmen who have survived.

But the men who came next in the path of progress, having a machine ready-made, so to speak, and having nothing to do but to get into it and fly, did not, in many cases, exercise this saving grace of caution. And that—at least, in my view—is why a good many of what one may call the second flight of pilots came to grief.

V

When one analyses the fatal accidents that have occurred, two prime causes for such disasters are found. One is the weakness of a machine, leading to some part breaking in the air; the other is the accident caused by a man's flying in too high a wind, and losing control of his machine in a sudden gust. Of thirty fatalities which I analysed as carefully as possible, I found practically half due to one or other of these causes.

This is a definite result at which to arrive when one is seeking to apportion the risks of flying. It means that if one could build thoroughly 'airworthy' craft, and if our pilots—by dint of constant flying, and also by studying carefully the problems that arise—become safer and steadier in the manipulation of their machines, we shall be able to eliminate the two chief dangers of aerial navigation. As regards the first need for greater safety—the airworthy machine—we certainly cannot say, as yet, that anything approaching perfection has been attained. But the present types of aeroplanes, from the knowledge which their builders have obtained as to methods of construction, and also because of the remarkable improvement of flying-machine engines, are infinitely superior to those which were built, say, only a couple of years ago; and every day the manufacturers are learning lessons which increase the margin of safety. So the prospect is extremely hopeful from this point of view.

Then, as to the growing skill and discretion of airmen, I do not think we need entertain any doubts on this score. If the breakage of aeroplanes taught the builders lessons, it is equally certain that the pilots of aeroplanes learned lessons they were not likely to forget from the fatal mistakes of over-daring *confrères.* For instance, knowledge about the real risks of flying in winds has accumulated to such an extent that the man who learns to fly to-day has, at his disposal, such a practical list of 'don'ts' as help him very materially in avoiding accident. Besides, men know better every day just what a machine will do, and will not do, when it is flown under unfavourable conditions. In my own case, for instance—although I do not like intruding the personal note—I have found that some little lesson may be learned from practically every flight one undertakes; and after a few seasons' flying it is surprising what a lot of important information a pilot acquires. He learns to keep himself and his machine in hand, and he becomes cunning and wary in fighting his arch-enemy, the wind.

So far, therefore, so good; but there are, of course, other causes for aeroplane disasters than those I have specified. Take for instance the sheer error of judgment on the part of an airman which has brought about many bad smashes. Here the machine may have been all right, and the weather conditions not unfavourable; and yet an accident has happened through the human machinery having failed. How is this to be avoided? Well, I think I have already answered this question—at any rate, in part. I have said that men are, undoubtedly, becoming better flyers every day; and so one may say, with complete certainty, that bad errors of judgment when a man is in the air will automatically grow less and less. Let me illustrate my argument. Serious accidents, through some mistake on the part of a pilot when landing after a flight, were—in the early days of flying—frequently recorded; but, nowadays, a smash from such a cause is comparatively rare—despite the fact that vastly more cross-country flying is now undertaken. This simply means that, in the general handling of his aeroplane and confidence in his own ability, the present-day airman is very greatly ahead of his predecessors.

Of course, there is always the human element to consider in flying, as there is in everything else. Despite the perfection of its organisation, the modern railway has still to trust the lives of a train-load of passengers to the skill of one man—the engine-driver. So, in an aeroplane as in a motor-car, there is always the factor of 'the man at the wheel' to be considered. But when that man is a thoroughly experienced craftsman, and perfectly familiar with the element in which he is manœuvring, his chances of making a mistake are infinitely fewer than they were when he had no experience to fall back upon and was invading an unknown sea.

It is certain that we shall never evolve a 'fool-proof' aeroplane. But neither is there a 'fool-proof' motor-car; yet there is now available a motor-car which the man of average mental equipment can drive with safety. And the aeroplane makers will not rest content until they have produced an aircraft which the ordinary man can fly without unreasonable risk.

VI

'But what about the stoppage of your engine when you are in the air?'

In setting out this question, I am merely anticipating the query that is so often put to me. Many people—in fact a surprisingly large number—still cherish the notion that the pilot of an aeroplane can only maintain himself in the air through the power of his engine, and that directly this much-abused piece of mechanism fails, he has to come tumbling down and break his neck. The gliding powers of a machine, when deprived of its motive power, are very little appreciated, even to-day. Many people, for instance, picture the terrible risks that a man would run if he dared to pass over London in an aeroplane. Such a flight, by the way, is against the rules of the Royal Aero Club, which does not permit indiscriminate navigation over crowded centres; so I am considering the case purely in theory. I really mention London so as to obtain a sufficiently striking example of what I mean.

Now, suppose a man started to fly over London, and suppose also that his motor failed him when he was right over the heart of the city. What would happen? He would, in the opinion of many, inevitably be dashed to destruction. But, as a matter of fact, provided he uses only ordinary common sense, he need have nothing to fear at all. To begin with, he would not be flying—at the moment his engine stopped—just over the chimney-tops. On the contrary, he would have obtained a wise altitude before attempting to pass over the city. That is to say, he would be flying probably at 5000 feet high, or at an even greater altitude than this. The question of a sufficient altitude is an important one, as I shall show.

And now let us see what the airman would actually do when his motor suddenly failed. His actions would be quite simple. Immediately his engine stopped he would alter the angle of his elevating plane so that his machine began a forward and downward glide. In fact, his mechanical propelling agent failing him, he would begin to use the force of gravity as his motor. But his descent would not be a fall; far from it. He would have to glide down, it is true, but only at a gentle, curving slope, and with his machine under perfect control all the time. Being, let us say, 5000 feet high when he began his glide, he would have London spread out below him as a clear panorama. Looking down from this commanding height, he would be able to note one or other of the many parks or open spaces which are dotted about the great city; and he would also be able to direct his machine accurately so as to reach it and land in it without accident.

In gliding with his engine stopped, the airman has to descend, as I have said, but he is not compelled to glide down straight ahead; he is free to steer to the right or left. He can, indeed, if he chooses, wheel right round in the air, and glide back the way he came. He need be in no great hurry, either, about picking his landing-place. His glide to the ground from a height, say, of 5000 feet, will be a very long one. Even if he is a considerable distance from the nearest park or open space, he will have plenty of time in which to reach it. It is wonderful, to those who have not realised the point before, what a long, slightly sloping glide an aeroplane will make when it descends with its engine stopped.

VII

In the military aeroplane trials which were held on Salisbury Plain during last August, there was a test in which the distance a machine could glide was accurately noted, and the results were remarkable. It will be appropriate for me to mention them here, as they will prove conclusively that an airman is by no means helpless when his motor stops in mid-air.

A great many aeroplanes were tested in these trials, and various results were obtained; but, glancing through the judges' report, I see that Mr Cody's biplane started from a height of a little less than 1000 feet, with the motor stopped, and then glided through the air for a distance of 6000 feet before it touched the ground. The Hanriot monoplane started from a height of about 1300 feet and was able to glide 8000 feet before it touched ground. So it can be seen from this that an airman—when at a height of 5000 feet above London—would not have any difficulty, when his engine failed, of steering a course that would land him comfortably in whatever open space he decided would suit his purpose.

In going through the lists of aeroplane

fatalities, one is struck by the fact that few bad accidents can be attributed to engine failure. There are cases, of course, in which the stopping of the engine, at some particularly inconvenient moment, has brought a pilot to disaster. But an accident which happens from this cause is often due to an airman having made the fundamental error of flying too low. In several cases of bad accidents, for instance, a pilot has fallen into a wood through engine failure; but investigation usually shows, in a case like this, that the victim of the smash was passing over rather dangerous country at an insufficient height. When I was flying in America, in 1910, my engine stopped—through the breaking of a petrol pipe—when I was over the city of Washington. Fortunately, however, my altitude was sufficient for me to glide back safely to the flying-ground from which I had begun my flight.

Naturally, the worse the country below him is for landing purposes, the higher the airman flies. In their race round England for the *Daily Mail* second £10,000 prize, Beaumont and Vedrines averaged a height of about 3000 feet. In future, I think, the tendency will be to fly higher still. In making one of his numerous cross-Channel flights, Mr Hamel attained an altitude of 9000 feet. It is interesting to estimate even roughly, how far a gliding descent would have carried him, had his engine failed while he was over the water. One may take it, I think that he would have been able to cover a distance of appreciably more than five miles before alighting. This shows one the value of high flying in minimising the risks of aviation.

Another very definite reason for flying high is that the wind is usually steadier at a good altitude than it is near the ground, being free from land eddies. When we come to the days of the large, passenger-carrying aeroplanes, I shall not be surprised to find them flying at fully 10,000 feet high or even higher.

To continue a little further the subject of the risks of flying through engine failure, I should mention that several interesting tests have already been made with aeroplanes equipped with a dual motive plant. The lightness of the flying-machine engine makes it quite feasible to fit a machine with two motors. In the case of a two-engine biplane built by Mr Horace Short, of Messrs Short Brothers, aeronautical engineers of the Royal

Aero Club, the motive power is supplied by a couple of fifty horse-power Gnome engines. These two motors are so arranged that they drive three propellers, two in front of the main-planes, and one at the rear. When both engines are running simultaneously the biplane attains a speed of nearly sixty miles an hour. When one is stopped—either accidentally or by design—the remaining motor will keep the machine passing through the air at a speed of a little less than forty miles an hour.

A practical test of this biplane was made at the Naval Flying School at Eastchurch. The machine was piloted first with both engines running; then one of them was stopped altogether. The machine flew on for nine miles with the power of the other engine, and then only landed because the pilot considered the test sufficient. This was a convincing exposition of the value of such a dual engine plant.

With the building of larger aeroplanes I think we shall arrive, quite inevitably, at the fitting of two or perhaps more power-units to a machine. In this case, the question, 'What will the airman do if his engine stops?' will lose its significance. He will merely fly on with the power of his remaining engine, or engines. The fitting of a large number of power-units to a machine is a matter which needs many more experiments before it is perfectly practical; but the principle—in such a test as I have mentioned—has been proved to be sound; and I think that, for naval and military aeroplanes, the use of dual engine plants will be a feature of special value.

VIII

It has not been my intention, in this section, to go closely into detail. I have endeavoured to outline the main causes of aeroplane accidents, and to show how they may be avoided. I have, so far, dealt with the risks arising from (1) breakages of machines; (2) flying in treacherous winds; (3) errors on the part of pilots; and (4) the dangers arising from engine failure. There are, besides these, a number of less important causes of accident, but into these I shall not enter.

The point of supreme importance is not so much the accidents themselves as the means we may employ to prevent them in the future, and these I have, I think, foreshadowed pretty clearly. Summarising the points, I can now set them out as follows:—

(1) Machines are being better built every day, thereby minimising one of the greatest risks.

(2) Airmen are gaining in skill and discretion, so that risks from the introduction of the 'human element' are lessened.

(3) Aeroplane engines are becoming as reliable as those in motor-cars; and there is now the opportunity of fitting machines with two or more engines, thereby minimising any risks from engine failure while in flight.

I have always contested the argument that flying is essentially dangerous. The sea was regarded as being full of deadly perils when men first went out on it in tiny rowing-boats. Now the great liners cross the ocean with a wonderful degree of safety, and people think nothing at all of the sea journey from England to America. The present-type aeroplane may be compared with the first crude boats in which men ventured out upon the sea. We are fighting the wind at present with frail craft. But the big, metal-built machine, with very powerful engines, is already in definite prospect; and when it comes into regular use, the navigation of the air will—at any rate in my opinion—become as systematised and safe as that of the sea.

SIXTH SECTION

THE WAR AEROPLANE: ITS USES, AND THE PROBLEMS IT PRESENTS

I

A FEW years ago the use of aeroplanes, for purposes of war, was very little considered, and the world's War Departments were experimenting with a few crudely-built machines. Nowadays, the aerial equipment of a modern army is receiving the closest attention; and an elaborate organisation has already been built up so that the 'war-plane' may be used to the fullest advantage.

France—the country which has encouraged flying so enthusiastically from the first—leads the way in the matter of aerial armament. Both in the expenditure of time and of money, she has given the rest of the world an object-lesson of her faith in this new weapon of war. Her War Department now aims to possess 1000 war-planes by the year 1914. The organisation necessary in order to take full advantage of such an air-fleet can perhaps be imagined. To begin with, there are the pilots and the military observers for the machines

—the last-named being the men who ascend in a scouting aircraft and make notes of what they see. Each man must be a highly-trained specialist, who is only produced after at least a year's careful training. He is also, so to speak, a perishable unit; that is to say, apart from any risks of accident during the course of the arduous work he is called upon to do, he cannot be expected to stand the strain of military aeroplaning for more than a limited number of years. Therefore, a fresh stream of airmen and observers must always be poured into the aeroplane corps.

Apart from those who fly the machines, and the men who ascend in them with maps and notebooks and spy out the enemy's dispositions, a very complete organisation is necessary for the upkeep of the aircraft. The modern aeroplane needs much attention; and, in its uses for purposes of war, a machine receives a good deal of rough handling. Therefore every facility must be at hand for keeping machines in proper trim.

The French air service, in the important matter of organisation, is ahead of all other nations. Every detail has received the most careful attention. To begin with, I may take the question of the transport of aeroplanes from point to point. For such work the machines are partially dismantled, and placed in light travelling cases, which are towed by special motor-cars. Then there is the the problem of providing proper garage accommodation for the aeroplanes when they are in camp. To meet this difficulty, the French authorities provide ingenious portable sheds, which can be quickly erected, and which travel from point to point in special motor-lorries. Another very important point is the rapid repairing of machines on the field, should they sustain any damage. To cope with this emergency, the French air corps is provided with a series of travelling workshops. These are big motor-vans containing a complete equipment for dealing with engine breakdown and other troubles; and with each van travels a staff of highly-skilled mechanics.

All this organisation has been most carefully studied; and, in the last autumn manœuvres in France, the employment of some fifty aeroplanes upon scouting work proved that the time and trouble of the authorities had not been expended in vain. The aeroplane service acquitted itself admirably, and showed that aerial reconnaissance must play a vitally important part in future wars.

II

The crux of the situation, so far as the military use of the aeroplane is concerned, is this: by the judicious use of his air-scouts a commander-in-chief can pierce most effectually what has been aptly described as 'the fog of war.' But I should explain, before going further, just what the position of affairs was before the aeroplane came upon the scene. I should, therefore, like the reader to picture two big armies approaching each other prior to a battle. Both commanders send out in advance, before their main forces, a screen of outposts. These men are a shield behind which the commander marshals his large bodies of troops for the delivery of whatever form of main attack he has decided upon. The enemy's scouts—on horse and on foot—strive to penetrate this screen of outposts, so as to learn something of what is going on behind its shelter. But the difficulties of their task are immense; and all that they are able to bring back, as a rule, is a series of fragmentary reports from which the headquarters' staff has to piece together, as best it can, some vague idea of what the real plans of the enemy are.

To be able to pierce 'the fog of war,' and to know what his opponent is planning, and how he is massing his men, is of absolutely vital importance for a commander in time of action. It is instructive, I think, in this connection, to read what the great Napoleon had to say upon this subject. He wrote:—

> 'Nothing is more contradictory, nothing is more bewildering, than the multitude of reports of spies, or of officers sent out to reconnoitre; some locate army corps where they have seen only detachments; others see only detachments where they ought to have seen army corps. Often they have not themselves seen the facts they report, and they have only gathered the hearsay evidence of alarmed, surprised, or bewildered people. . . . If a former preoccupation exists, if there is a tendency to believe that the enemy will come from one direction rather than from another, the gathered evidence is interpreted in one sense, however little it lends itself to being so interpreted. It is thus that great mistakes are made, which are sometimes the ruin of armies and of Empires.'

Napoleon, of course, had no aeroplane scouts. Had he possessed them his wonderful campaigns might have been still more wonderful. But the extract I have given above indicates clearly how extremely important information about an enemy's movements is, and how difficult this information is to obtain.

The modern type scouting aeroplane is

either a biplane or a monoplane. With the former a speed of approximately sixty miles an hour, or sometimes more, is obtained—even when the machine is loaded with fuel for a flight of, say, several hours, and has on board an observer as well as the pilot. Such a scouting biplane is usually driven by a motor developing 100 horse-power. With its crew of two, it will fly, if necessary, for long distances without descending, and will make very wide surveys of any given track of country.

The scouting monoplane has also, as a rule, accomodation for two men—the pilot and the observer. Its engine-power is generally the same as that of the biplane. In speed, however, it excels the biplane. Even when fully loaded, and with its crew of two on board, it can attain a pace of nearly eighty miles an hour. Thus, it is distinctly faster than the biplane. But, as a rule, the monoplane has one disadvantage as compared with the biplane—and that is in regard to the view of the ground which the observer is able to obtain from it.

Although his seat is placed in the most advantageous position, and the wings of these scouting monoplanes are cut away in places, and otherwise arranged in the best possible way, there is usually a difficulty, in this type of craft, in securing an unobstructed outlook upon the land below.

This point is, as can be imagined, a very important one. It is by no means easy to make accurate observations from an aeroplane in flight; therefore the officer who is entrusted with this work needs every possible facility. The construction of the biplane, and the fact that, in many machines, the pilot and the observer are placed in front of the main-planes, makes this type of machine more adaptable than the monoplane to the purposes of reconnaissance. However, the speed of the latter is a factor much in its favour; and, therefore, we find monoplanes, as well as biplanes, used for scouting work.

III

Now, perhaps, I may describe the actual work of an air-scout. We will imagine that a commander-in-chief desires special and urgent information as to the latest move of an antagonist who is creeping steadily forward with the idea of bringing about a decisive action. In such circumstances, he calls into conference the officer who is in charge of the Aeroplane Corps. This officer, after listening to the commander's wishes, arranges the scouting work of the airmen. Each observer, with maps and notebook to hand, is entrusted with the task of flying over a specified area and noting all that he sees.

In this way, with a squadron of machines, each is made to patrol a certain tract of land; the result being that a series of reports is brought back in an astonishingly short space of time. When he has received each observer's notes of what he has seen of the enemy's movements, the officer in charge of the aeroplanes prepares a comprehensive general report, and presents this to the commander.

In this way the air-scouts can cover, in the course of an hour or so's flying, ground which cavalry scouts would take several days to traverse; and the point must be borne in mind also that, even after their two or three days' work, the land-scouts, in nine cases out of ten, would be unable to produce information so valuable as that brought in by the airmen. Besides, the supreme value of the air-scout's news is that it is absolutely fresh. He reports what the enemy was doing, not yesterday, or the day before, but only an hour or so ago. This freshness of the airman's reports enables a commander to act upon them with confidence and decision.

It should be interesting, I think, if I quoted from an actual report, as presented by a French officer-observer, after making an early morning reconnoitring flight. It will convey to the reader, better than any amount of explanation, just how the observer does his work, and how he jots down in his note-book—as briefly as possible—what he sees as he peers down from his fast-flying craft. In the case I am quoting, the report was one of many handed in by the air-scouts when employed, for the first time, in connection with French manœuvres. The news contained in the report in question is not of any unusual importance, but its general style shows exactly how these aerial spies present the tidings they have gleaned.

6.5 a.m.—At Thieuloy, three squadrons of *chasseurs-à-cheval*, hidden behind the southern edge of the village on the road from Thieuloy to St Maur.

6.30 a.m.—At Feuquières, a brigade of infantry on the march eastward on the road from Feuquières to Brombos. Head of main body just leaving Feuquières. Six batteries of artillery parked south of Feuquières.

6.32 a.m.—At point 1800 metres north of Feuquières, two companies on outpost, one facing

north and the other north-east, astride the Feuquières-Sarcus road. One company has dug rifle pits to the west, and the other company section trenches to the east of the road. A Bleriot monoplane has just landed behind the company west of the road. We followed its flight for three minutes.

6.40 a.m.—Agnères—a company in column of route marching from Agnères towards Mereau-court along the Saint Martin-de-Ponsis ravine.

To appreciate the full value of such news as this, one needs to remember that a number of scouting airmen are usually sent out, and that each of them reports in a similar manner to that quoted above. Then, with a map before them, and these reports to hand, the headquarters' staff can mark down the exact positions of the enemy's forces. How vital this information is I have already indicated; so one cannot very well over-estimate the value of the aeroplane in a campaign. Colonel Seely, our Minister for War, declared, not long ago, that air-scouts would revolutionise modern military operations. In France, Germany, and other countries the same view is entertained.

IV

The value of the aeroplane as a scout in time of war is not a matter of theory. In the autumn of 1910, in the French manœuvres, aeroplanes were used successfully for reconnoitring purposes, and this success was repeated, in an even more convincing way, in more recent operations. It is interesting to note that France was estimated to possess, in October, 1912, about 200 war machines.

In Tripoli, during their campaign, the Italians used aircraft for reconnoitring in the actual work of war; and the Italian Government was so pleased with the results obtained that it has recently placed orders for a large number of the latest-type machines. It is understood that Italy now owns some hundred military aeroplanes.

In Germany the aeroplane has been tested several times in manœuvres, with convincing results; and the German War Department is now striving to overtake France in the matter of equipment and organisation. Germany is believed to possess more than two hundred war aeroplanes.

Russia, also, is busy with the creation of an air-fleet; and it was estimated, in October, 1912, that she had about fifty machines. Other countries, large and small, are buying machines, too, according to their needs and resources.

In Britain the position of affairs was, until recently, very far from satisfactory. Even now we are a long way behind such a go-ahead nation as France in the strength of our air-corps, and also in regard to its organisation. However, a definite start has at last been made. We now have, for instance, well-equipped flying-schools, both for naval and military pilots, and an aircraft factory which has recently produced a scouting-type biplane of quite exceptional merit. Everything has been done that could be done—bearing in mind the fact that the Treasury grants for aviation in Britain have never been adequate.

During the financial year 1912–13, for instance, the money allowed for aerial work was £322,000. This, it is true, was £177,000 more than was granted in the previous year; but it compared very unfavourably with the expenditure of either France or Germany. Altogether, France is spending, during 1912–13, approximately £1,000,000 upon the development of her air fleet.

One cannot make bricks without straw,

and the lack of sufficient funds has been a serious handicap to the work of our Flying Corps. How we stand in the matter of machines and men was explained by Colonel Seely, in the House of Commons, when introducing the Estimates for 1913-14. His optimistic and ingenious statements, when analysed, give no cause for congratulation. We are promised that, this year, five aeroplane squadrons will be brought up to establishment strength—and this is almost the only concrete fact to emerge. It means that, probably by next April, we shall possess an organised force of ninety aeroplanes.

When, in the spring of 1912, the scheme for the Royal Flying Corps was propounded, it was understood that, as an effort to make up leeway, the seven aeroplane squadrons, specified in its constitution, would be created without delay. But now we find we must wait until the end of this year, or the beginning of next, before five of them are at proper strength; while, as to the formation of the other two, no statement is made.

The sum to be devoted to aviation by our Navy and Army, for the year 1913-14, is approximately £850,000. In England, more aeroplanes need to be bought, and what is even more important than this—a great many more pilots and observers need to be trained in their difficult work. This has always been my contention—we can buy aeroplanes at a crisis, but we cannot buy the highly-skilled men who are necessary to handle them. The great strength of France lies in her growing corps of absolutely competent military airmen. We have only a handful of these invaluable men compared with her hundreds. Therefore, it is our clear duty to expand the work of our training schools, and to increase the strength of our corps as quickly as we possibly can.

Fortunately, in this connection, I think it is an undoubted fact that public opinion is now much more alive than it was to the importance of military aviation. One striking test after another has been carried out abroad, and much more flying has been seen recently in all parts of England. At the London Aerodrome, Hendon, we have, I think, been able to do work of some service in this respect. The result is that people begin to appreciate what the aerial conquest really means from the national point of view. This is of considerable importance. With public apathy prevailing, there would be no strong pressure brought to bear upon our authorities to compel a more adequate financial grant for the air service. But now that the public is becoming aroused, I think we shall find the Treasury obliged to come forward with far more handsome provisions. If this is so, much anxiety will be removed from the minds of those who foresee the vital importance of the aeroplane in future military operations.

If the money is only forthcoming, we need not fear as to the men. Already, despite the fact that gallant fellows have been killed in this new air service abroad—and also, unfortunately, at home—there is a growing stream of candidates for admission to the Flying Corps. It has already been proved, too, that our military airmen—when they have a chance—are capable of the very finest work. But, with insufficient training, and old-fashioned machines, they cannot be expected to do much.

V

So far, I have endeavoured to show the scouting advantages of the aeroplane. But, in modern war, the rule is to seek to nullify the work of any new weapon immediately it is discovered. So, in regard to the coming of the aeroplane, the military experts quickly sought means to checkmate its successful spying. How could this be done? The problem was a pretty formidable one. It is not easy, on the face of it, to stop the scouting work of a machine which passes over the land 3000 feet or more high, and at the rate of from sixty to eighty miles an hour.

Naturally, the first thought was that gunfire would have to be employed to bring down these air-scouts. Here, however, the opinion of experts is much divided. Tests have been made to show what the vulnerability of an aeroplane would be when exposed to gunfire from below. Kites and balloons have been employed in these experiments—the results obtained, generally speaking, being inconclusive.

Special high-angle guns have been built to throw a shell almost vertically into the air to an immense height; and artillery experts predict that, in any great war, the scouting aeroplanes will be brought down in large numbers by this means of attack. For the air-scouts, however, it is argued that a pilot will—by flying very high and pursuing an erratic course through the air—be able to avoid being hit in the great majority of cases.

In the Tripoli campaign, the Italian airmen, in flying over the enemy's positions, were frequently fired at; their machines were struck once or twice, and a couple of the pilots were reported to have been wounded. But, in the majority of the flights made, the fire of the enemy below was quite harmless. However, as the Italian airmen were not opposed by anything in the nature of high-angle guns, this test cannot be said to have proved much.

This problem, it can be seen, is an awkward one. What effect upon scouting machines will high-angle gunnery have? As a matter of fact, we shall have to wait until actual experience teaches us its lesson. Peace tests, in such a case, are almost certain to be unsatisfactory. However, each expert has his own opinion. Speaking generally, I think that a certain number of scouting aeroplanes are bound to be 'winged' by well-directed artillery fire; but I certainly do not consider that any large proportion of machines will be put out of action in this way. By this I mean that the use of high-angle guns will not affect at all seriously the reconnoitring work a squadron of machines will be able to carry out. In fact, the percentage of machines hit should be quite small, provided that the pilots keep a good altitude, and use discretion in approaching an enemy's position. With this view, I may mention, many thoroughly competent military experts are in agreement; they do not believe that high-angle guns will prove very formidable, when used against aeroplanes in actual war.

Were gun-fire from below the only peril the scouting airman had to face, he would not, indeed, feel unduly perturbed. But there is another, and a far greater, danger awaiting him when he comes to fly in war-time. This risk lies in the attack that may be delivered upon him by a hostile aeroplane. In future campaigns, in fact, we are likely to see warfare waged in the sky itself. Far-seeing War Departments, feeling none too sure as to the efficacy of gun-fire from the ground, are now making plans to send aloft armed aeroplanes, and so give battle to an enemy's air-scouts in their own element. This possibility of aerial fighting introduces a puzzling factor into a consideration of the use of aircraft in actual war. Such questions as these arise: 'How will aeroplanes fight?' and 'What will be the result of this aerial fighting?'

So far as the first question is concerned, it is now possible to give a fairly definite answer. The fighting aeroplane will carry a gun—a specially light, quick-firing weapon, which will be handled by a gunner flying as a passenger in the machine. Tests have already been made, in fact, with aeroplanes so armed. Our own Government aircraft factory, for example, has fitted a powerful biplane with a quick-firing gun; and, so armed, the machine has flown quite successfully. The experiment of aiming and firing the gun has also been carried out; and, although it is naturally difficult to obtain good practice at first from so novel a gun-platform, it is clear there will be no insurmountable difficulty in arming aircraft with such weapons, and using them effectually in time of war.

VI

This, as can be imagined, introduces some pretty problems in military tactics. Given a squadron of aeroplanes armed with guns, how is a commander-in-chief to use them? The answer to this question may be provided without much difficulty. He will endeavour, so far as is possible, to cripple and handicap the aerial scouting of his opponent. His chief aim will be to destroy his enemy's air-fleet, and so rob him of the advantage of his aerial reports. If one commander can actually gain supremacy in the air, this victory will, indeed, mean a great deal to him. He will still have the all-seeing eye of the aeroplane at his disposal, while his opponent will only be able to secure the information gained by cavalry and foot-scouts. Illustrating this position of affairs in a phrase, one may say that the commander-in-chief who has lost the services of his aircraft will be like a blind-folded man endeavouring to fight against one who can see.

The utmost importance, therefore, will be attached to this question of aerial fighting. It is obvious that any army when going into battle must be provided with an effective force of armed aeroplanes. What is really projected is the creation of a fleet of what one may style aerial 'destroyers.' These fighting aircraft can, indeed, be very closely compared with the swift torpedo boat destroyers used on the sea. They promise to be powerful, speedy machines, probably carrying a crew of three men—a pilot, an engineer, and the man who works the gun. Capable of flying long distances, and also of battling against high winds, these destroyers will make it their business to seek out, and fire upon, the enemy's air-scouts. Of course, they will not have it all their own way. The enemy will be similarly armed with fighting craft. Therefore we have all the material for such a combat in the sky as we have read about—but never believed would come to pass—in the pages of imaginative fiction.

Since the fighting aeroplane is at present in an entirely experimental stage, one cannot do more than forecast what is likely to happen in the actual operation of such craft. But it is generally considered, among military experts, that several types of aeroplane will be used in war. There will be, for instance, a purely scouting machine, constructed so as to provide the observer or observers with the best possible view of the land below, and probably fitted with an installation of wireless telegraphy for reporting quickly what is seen. Such a machine will carry fuel for very long flights, and will be built for reliability as well as speed.

Then there will be the fighting machine, armed with a special gun, and probably carrying, as well, apparatus for releasing bombs. Such a craft will be the fighting unit pure and simple. It is generally considered that a certain number of these destroyers will be told off to accompany the air-scouts, and so guard them from the attacks of the enemy's machines. For instance, it is thought that, when going out upon some urgent reconnoitring flight, the scouting aircraft should be accompanied by, say, a couple of 'destroyers,' to protect it against the isolated attacks of any hostile air patrols which might be circling above the enemy's lines.

But, as I have said, the precise use of armed machines is very much a matter of speculation. All we know is that they will be available, and that they will have to be used to the best possible advantage. This much is certain: the aim of one commander-in-chief will be to endeavour to glean news by the aid of his aeroplanes of all that his opponent is doing; and it will be equally the aim of his antagonist to prevent him from carrying out this purpose. If the time should come when two thoroughly well-equipped air-fleets are opposed to each other in actual war, then some remarkably useful lessons will be learned. Until that time comes, we must content ourselves with being, to a greater or lesser extent, theorists.

It is, of course, clear that the human element will play a very large part in the success or failure of an attack by aeroplane. The way a machine is handled and brought into range, and the skill and nerve of the gunner, will be all-important factors in the short, quickly-fought engagement that is likely to take place. The manœuvring of a sixty or seventy mile-an-hour aerial destroyer will be work requiring surpassing nerve and judgment; and the penalty for failure will be disastrous.

VII

So far as the vulnerability of an aircraft is concerned, the planes may be pierced many times without affecting its equilibrium. But the propeller, or propellers, are vital points; and when they are struck and broken the machine is hopelessly crippled, and must glide away to earth. The engine, too, and the fuel tanks, are vulnerable; but there is no reason why vital parts should not be armoured, at any rate lightly. This might protect them from a certain amount of injury. But it is not likely that any aircraft we have to-day would withstand the well-directed fire of a machine-gun; therefore, it will be of the utmost importance, in this aerial fighting, to get in the first blow—or rather, the first shot. The winning crew—so far as one can see—will be that which handles its machine most smartly and has the best gunner on board.

Speed, of course, will be a consideration of the utmost importance in this question of war in the air. When two machines find themselves pitted against each other in actual fighting, the one which can fly a little faster than its antagonist will have a very considerable advantage. This point is always before the eyes of the constructors of such war machines. The slow-flying aeroplane will be generally at the mercy of the high-speed craft; this much seems certain. Therefore, every reasonable sacrifice must be made in the interests of speed.

The same remark applies to the work of the air-scout. Speed will be of the utmost value to him, as well as to the fighting craft. It will enable him to return quickly with any information he has obtained; and this rapidity in gleaning news will, as I have said, be of the greatest importance. Furthermore, speed may help the scouting airman to extricate himself from awkward situations. It may, for example, be of value to him in dodging gun-fire from below; and it may equally well help him in running the gauntlet of the enemy's aerial destroyers, and in escaping destruction purely by the speed of his dash from the danger zone.

It should be interesting, in this connection, to make another reference to the judges' report dealing with the trial of aeroplanes carried out by our military authorities on Salisbury Plain in August, 1912. In the course of their comments on the performances of the machines, the judges set out the order of the points upon which they awarded marks to the competing aeroplanes; and this arrangement of military requirements is instructive, because it shows just what the military aeroplane is expected to be able to do.

First upon the list comes the need for speed; and this follows up the argument I have just been using, to the effect that fast-flying will be exceedingly valuable to the airman in actual war. The principal prizes in this military competition were won by Mr Cody; and the interesting point, while on the subject of speed, is that his big biplane managed to attain a pace of seventy-two miles an hour, even with a full load of petrol, and carrying a passenger as well as the observer. Apart from the constructional excellences of the machine, this result was largely obtained by fitting the biplane with a big engine developing 120 horse-power.

With regard to the question of speed, the judges also placed, as a point of importance, the need for being able to vary the pace of a machine through the air. In the early days of flying, any idea of controlling the speed of an aeroplane would have been regarded as impossible. But now, by having an ample reserve of power in the motor—and also owing to the general efficiency of planes—it is possible to bring about a very distinct difference be-between the high and low speed of any given machine. In the case of Mr Cody's biplane, for example, the airman was able, by driving his engine at its full speed, to attain a rate of seventy-two miles an hour; and then, by throttling down his motor, he caused this speed to drop as low as forty-eight miles an hour. At this slow speed, I should mention, the biplane showed no signs of falling; it flew straight ahead as it had done at its full speed.

The value of flexibility in the matter of speed is easily explained in connection with scouting aeroplanes. Whereas high speed is necessary in going out upon a reconnoitring flight, and also in returning with the information obtained, it is by no means desirable when the observer is actually spying out the land below, and making his notes. What he wants to do, of course, is to carry out his observations with as much detail as possible; and minute observation from a machine flying seventy miles an hour is by no means easy, as may be imagined. But if a machine can be slowed down, when the observer wants to make his notes, to a comparatively reasonable rate, it facilitates his work very much indeed.

In this connection one should, I think, mention the virtue of the airship from the scouting point of view. This type of machine—although it has many disadvantages in other respects—provides quite an ideal platform from which the observer can do his work; the dirigible may, for example, be made to hover for any desired period over a given point, and thus permit of leisurely, perfectly accurate notes being taken. However, with an ability to vary the speed of aeroplanes in the way I have described, one great difficulty is removed from the path of the observing officer. Reconnoitring at forty-eight miles an hour is a different thing from carrying out the same work at a speed of seventy-two miles an hour.

VIII

After speed, the judges in the military trials considered the rate at which a machine could ascend from the ground to be next in order of importance. The value of this point, in time of war, would lie in the air-scout's ability to attain a sufficient altitude for satisfactory reconnoitring after a minimum amount of time actually spent in soaring to the height desired. Also, the ability to rise quickly might stand a pilot in very good stead should he fly, unawares, within the range of a battery of land guns.

In regard to this need for quick rising, the Cody biplane—which won the chief prizes upon general points—was able to ascend from the ground at a 'climbing' speed of 285 feet per minute. This means that, at the end of only one minute's flying, the biplane was nearly 300 feet above the ground. Other machines managed even to excel this; the Deperdussin monoplane, for instance, rose at the rate of 333 feet per minute, while the

Hanriot monoplane succeeded in 'climbing' at a speed of 363 feet per minute. This ability to rise quickly means general efficiency in the machine, ample engine-power, and also a good deal of skill and judgment on the part of the pilot.

Next in importance to rapid rising, the judges put the ability of a machine to make a long glide to the ground without engine-power. What can be done with a modern machine in this respect, I have already indicated; so all I need say is that, in actual military work, a pilot might find this power of making a long glide of the utmost importance to him. If his engine failed over bad country, a good glide might extricate him from a very awkward situation; or, supposing his motor stopped while he was over a hostile position, he might be able to coax his machine back, by means of a judicious glide, into his own lines.

Another important point, in the judges' opinion, lay in the landing-chassis of the aeroplane. A thoroughly efficient chassis is, indeed, a most necessary feature of a military machine. When employed in war, the aeroplane will—of necessity—be subjected to a good deal of rough usage; and it will certainly have to land occasionally upon very awkward ground. If its landing gear is not strong enough, a machine may turn over when alighting, and be completely wrecked. With this point in mind, the judges in the Salisbury Plain tests made each machine alight upon, and rise from, a ploughed field; and it is a tribute to the excellence of the modern type chassis that machine after machine carried out this test, even when loaded with a passenger and pilot and a full supply of fuel.

Other points to which the judges attached importance were the view obtained from a machine when in the air, and the manner in which the engine of the aircraft could be started when setting out for a flight. The first question I have already dealt with; so far as the second is concerned, the authorities wished, if possible, to do away with the need for a mechanic to swing the propeller in order to make the engine start. Such a method of getting away is admittedly clumsy; it presents difficulties, also, when a pilot comes down a long way from his headquarters, and nobody is about to lend him a hand.

What the judges gave special marks for, therefore, was any method by which the pilot or passenger could start up the engine while in the machine, and get away for the flight without any outside assistance. The fitting of starting devices at present, however, offers difficulties to the manufacturers; and thus few machines are so equipped.

Mr Cody, however, was generally able to start his engine in the manner described. It is now possible, also, in connection with some engines, to throttle them down so that the pilot can start his motor himself by a swing of the propeller, and then walk round to the front of the machine and take his seat, without any fear of the engine racing off at high speed, and moving the aeroplane away with a rush. Machines are also being equipped so that the motor may be started from the driving-seat, by the turn of a handle.

IX

I now come to a very important aspect of aeroplaning, and one which is certainly growing in significance every day: this is the use of machines in connection with naval warfare. Here it is certainly gratifying to note that our Admiralty is showing a keen interest in the construction of naval aeroplanes, and has already established depots along the east coast, where specially-built machines are to be employed in long-distance scouting work.

In naval warfare it is of the utmost value to know where an enemy's fleet is, and what it is doing; hence, the aeroplane finds another important duty awaiting it. Whereas on land it supplements the work of the cavalry and foot scout, on the sea it improves vastly upon the reconnoitring which can be done by torpedo boats and torpedo-boat destroyers. So far, however, a great deal of experimental work remains to be done in determining the exact types of aeroplane necessary for naval work. The services required of the machines will be extremely arduous; therefore, nothing but the best possible types will satisfy our naval authorities. However, some extremely workmanlike machines have already been evolved for sea use—both in France and in England.

Primarily, the naval aeroplane—as we know it now—is constructed so that it will rise from, or alight upon, either the land or the water; it is generally fitted with a powerful engine, and has accommodation for a pilot and observer. For landing on terra firma it is fitted with ordinary wheels, while for landing on water it has hollow floats, which are so buoyant that they sustain it on the surface. With regard to the fitting of these floats, and the use of hydro-aeroplanes generally, I shall have something more detailed to say in the next section.

At present the chief use of the naval air-scout is to make experimental flights along the coast and out to sea. So far as our Admiralty is concerned, the idea is to station aeroplanes round our shores, so that, in time of war, we should have a chain of air-scouts ready to patrol the seas, and keep their bases informed of the approach and movements of any hostile fleet.

The rôle of the sea aeroplane, at any rate so far as our special needs are concerned, is largely defensive. Abroad, there are now big and powerful dirigible balloons, which are capable of carrying tons of explosive matter if required, and of flying for several days without making a descent. In time of war these monsters would be an undoubted menace to our shores; and it would be the duty of our defensive aeroplanes to keep on the look-out for the approach of these aerial invaders, and give them battle should they be detected trying to steal upon us.

What is needed, therefore, is a fast-moving, well-armed aeroplane, capable of flying in the strong winds encountered at sea, and of remaining in the air for long periods without alighting. Such a machine should also be able to descend either upon water or dry ground. One or two air patrols of this type should—in the opinion of many experts—be able to give a good account of any hostile dirigible they might encounter.

With the machines and motors now available, and with the experience already obtained, it should not be difficult for manufacturers to construct a satisfactory aeroplane of this type. When such an aircraft is generally available, it should be acquired in adequate numbers by our Admiralty, and established in well-organised coast depots, so as to form a protective chain along our seaboard.

Apart from the aeroplane to ascend from a shore station and patrol the sea, there is the question of the air-scouts which can accompany a fleet from place to place, and be operated from the deck of a parent ship. Regarding this type of machine, although it is of great importance, but little data has, so far, been obtained. We know that, under favourable conditions, a machine can alight upon and rise from the deck of a ship; but the mere performance of this feat still leaves a great many problems unsolved. A light, portable, very fast-flying form of air-scout seems to be the ideal in this respect—the type of machine which can be taken to pieces and packed away in a small compass in the hold of the parent ship, and which can be assembled quickly when the need arises, and launched into the air. Naval authorities who have devoted attention to the question appear to favour, for this particular service, a high-speed monoplane, powerfully-engined, so as to fly in the high winds it would have to face in work upon the high seas.

For the launching of its aeroplanes, the parent ship would, of course, have a specially cleared deck. As to the actual mechanism employed for despatching the machines into the air, there are many devices now under consideration; most of them are in the nature of launching rails, platforms, or catapult mechanism. It is not a very difficult problem, as I have hinted, to send a machine into the air from a ship's deck, provided the weather is quite favourable and there is no troublesome wind. Under these ideal conditions, also, it is not a very difficult feat for a skilful pilot to alight upon a ship's deck.

But the matter bears quite another aspect when similar feats have to be undertaken in high winds and with a ship rolling about in a big swell. Then the question of getting a machine into the air, and particularly of its return to the ship's deck, is an extremely awkward one. But the problem—difficult though it is—promises to be solved as soon as a series of really practical tests can be made. Already the authorities have been provided with a large number of ingenious suggestions. In one of them provision is made for a large net to be stretched across the deck of the parent ship, into which the aeroplanes would alight—being equipped for the purpose with a special skate or skid form of landing-carriage.

Flying at very high speed, the monoplane sea-scouts would be of the greatest use to the fleets to which they were attached. The distances they could traverse in an hour's flying, and the view over the ocean they would obtain from an altitude of several thousand feet, would render them infinitely superior to a torpedo boat or a destroyer in seeking out the approach of an enemy. It is probable, too, that they would be fitted with wireless telegraphy, so that they could flash back—without an instant's delay—any important news they might be able to obtain.

X

I PROPOSE now to say a final word about the purely destructive possibilities of the war aeroplane. So far we have considered what a scouting machine can do, and we have also dealt with the possibility of fighting in the air between hostile machines. But one must also remember that, armed with guns or bombs, the war aeroplane has the power to attack land forces or positions over which it may be flying.

Hitherto this question of the use of destructive aeroplanes has been treated from the wrong point of view. Critics have said: 'But what damage can a few aeroplanes do? In war-time their handful of bombs would scarcely attract any attention at all.'

This view assumes that, for destructive work, only a few machines would be employed; and, if this were so, the offensive aeroplane would not present a factor of much significance. But, if aircraft are to be used for destructive purposes in war, they will not be employed in twos or threes. If an army despatched, say, half a dozen machines to fly over an enemy's position and do what damage they could, the net result of their bomb-dropping would not be at all serious. But it seems to me that the way to obtain definite results with destructive craft. would be to send them upon an offensive mission in large numbers; and such a view of the case, I know, is held by military authorities who have considered specially this aspect of aerial warfare.

An attack upon the lines of communication of an army—with the object, say, of blowing up bridges and destroying railway junctions—would not be a very serious undertaking if attempted by only a few machines. But let us suppose that an enemy possesses a large squadron of aeroplanes, specially constructed and equipped for this work of destruction, and provided with incendiary and other bombs of high power. Will this alter the situation? I think so. There is, for instance, a distinct difference between the destructive powers of half a dozen or a dozen machines and the organised bombardment of, say, a hundred offensive aircraft—each machine being handled by men who have been specially drilled and prepared for this particular branch of aerial work. In such a case, the use of destructive aeroplanes would prove a very awkward factor in the operations—at any rate, for the army whose lines of communication werc thus assailed.

So far, it is true, the use of destructive aeroplanes has been confined mainly to the pages of adventure books—save that, in the Tripoli campaign, the Italian airmen dropped bombs to the discomfiture of the Arabs in the desert round the Italian headquarters. In the Balkan War, also, a certain amount of destructive work was achieved. In peace manœuvres, too—as at Cambridge in our own operations, when a dirigible balloon dropped bombs during the night—the possibilities of this destructive work have been indicated. But nothing has yet been done on a scale of definite organisation, though both France and Germany realise quite well this dread power of the modern type aeroplane—particularly of the dirigible—and have the construction of special destructive machines in view.

In warfare, as we now know it, there are many new terrors; and the bomb-dropping aeroplane will provide yet another nightmare for the troops engaged. It could, for instance, deliver harassing attacks upon troops when they were on the march or in camp. It could make organised assaults upon an enemy's supply stores, or seek to cripple a foe by destroying his lines of communication; it could attack fortifications. Its wasp-like possibilities of irritation and destruction are very wide indeed.

That the commander-in-chief, in future wars, will need to take very seriously into consideration the destructive work of armed aeroplanes, is certain. It is clear to me, also, that the success attained in this particular branch of aerial warfare will be dependent upon the amount of preparation and organisation devoted to it. Haphazard attacks by aeroplane will be useless; it will be the carefully planned, well-carried-out onslaught of a squadron of armed machines which will tell its tale.

SEVENTH SECTION

MODERN TYPE AEROPLANES: THE DEVELOPMENT OF THE 'WATER-PLANE'

I

In a previous section I described the first practicable aeroplanes as we saw them in flight at the great Rheims meeting in 1909; and now I propose to deal briefly with some of the present-type machines, as they are flown every day across country and at the various aerodromes.

The general principles of the aeroplane—planes, engines, propellers, and controlling gear—have already beeen explained; and these remain virtually the same to-day as in the early days of flying. The aeroplane as we know it now has made no revolutionary progress when compared with the first aeroplanes built by the Wrights and the brothers Voisin. Nevertheless, the improvements effected have been very important. In the matter of the biplane, for instance, these improvements have been marked.

Let me, for instance, take the famous

Farman biplane. This machine, as first flown at the Rheims meeting in 1909, I have already described; and now I will turn to the latest type Farman, as it is used daily at the Hendon aerodrome. One of the first improvements appeal to an ordinary, non-technical person, would be the added comfort provided for the pilot and passengers in the machine. In the early type Farman the airman sat, exposed to the wind, on a little wooden seat at the edge of the main-plane.

If he took up a passenger with him, this unfortunate individual had to crouch behind, him with his legs tucked up at a most awkward angle. Nowadays the pilot and the passenger in the Farman biplane are provided with a neatly covered-in body, set out in advance of the main-planes. They have comfortable seats and plenty of leg-room, and the rush of wind is kept from them. The pilot, too, who sits in advance of the passenger, has a curved wind-screen in front of him, so that he can look out ahead, without the air beating fiercely in his face. These improvements are, I can say from personal experience, very much appreciated by those who fly regularly.

Speaking of comfort in flying, I should not forget to mention an interesting machine built by Messrs A. V. Roe & Co. In this aircraft, which is a biplane, the pilot and his passenger are provided with a completely covered body, which they enter through a small door. This cabin, which has roof, walls, and floor, and is fitted between the main-planes, is equipped with celluloid windows, through which the airman can see to steer his machine. This form of body is still such a novelty that there is a certain amount of prejudice against it, one objection being that the windows may become obscured in flight and so make it difficult to guide the machine.

However, a biplane of this type has been flown successfully; indeed, one competed in the military trials on Salisbury Plain. The comfort of being in such a completely covered-in body, on a long flight, is no small advantage. During the military trials, the late Lieut. Parke flew this type through heavy rainstorms, and came down quite warm and dry.

As to the general design of the Farman biplane, it remains very much the same. But the method of control—while remaining essentially the same—has been refined and improved; and the workmanship and materials in the actual construction of the machine are better than they were in the early days.

The front elevating-plane on the Farman has been abandoned; the elevator is now at the tail, as in the case of a monoplane. But the engine position is the same; and the ingenious Farman landing-chassis remains substantially as it was. The Farman represents, in fact, what one may call a safe, reliable, everyday type of aeroplane. It flies smoothly and well; its control is simple and very efficient; it will keep commendably steady in gusty winds; it is built to withstand hard wear.

For a description of radical changes, however, one would not select the Farman biplane. Henry Farman does not make drastic alterations in his machines; his idea, rather, has been to make headway by moving from one logical step to another. With other machines, however, some striking alterations have been made since the days of the first flights.

Many biplanes, for instance, represent now what is really a blend in design between the features of the biplane and those of the monoplane. For instance, the makers have altered the position of the engine in such biplanes. Formerly, the usual place for the engine was behind the main-planes. Nowadays, many machines are equipped with a long, narrow body, just like that of a monoplane, and have engines fitted in the bow of this body—exactly as in monoplane practice. The two main-planes are placed a little way behind the engine, being arranged one above and one below the tapering body; and, at the extremity of the tail—also as in monoplane building—are the controlling-planes.

One argument used in favour of this type of construction, it is interesting to note, is that—in the event of a smash—the pilot has a better chance of escaping injury than if he were flying a machine with its engine behind the planes. It is held that a danger exists—in the latter type of machine—of the motor being torn from its bed, in a bad accident, and falling forward upon the pilot.

II

A MODERN type biplane is altogether a more solid, strongly-built affair than was its predecessor. Engines are now far more powerful. Those developing 100 horse-power and 120 horse-power are regularly fitted; and in connection with the Paris Aero Exhibition—held in the French capital in November, 1912—motors of even greater power than this were shown. For instance, there was a Gnome engine having fourteen cylinders, and developing 160 horse-power; while a Salmson motor of 300 horse-power was exhibited—the intention being to fit the last-named to a specially-built biplane. Aeroplanes of even greater power are now being designed. For instance, one French maker is to build a biplane having engines of 500 horse-power, and capable of carrying twelve passengers as its regular load.

Being so powerfully engined, the present type of biplane can not only fly fast, but can carry big loads. Military biplanes already built, for instance, can raise as an ordinary load either one, or two, or sometimes three passengers. In the War Office trials, the machines took on board a pilot and passenger, together with petrol and oil sufficient for a continuous flight of four and a half hours, and, thus laden, made non-stop flights over a period of three hours. This provides an idea of the capabilities of existing aeroplanes.

The weight of machines, too, has greatly increased. Mr Cody's big biplane, when empty, weighs 1948 pounds. When loaded ready for a long-distance flight it has a weight of 2658 pounds. All machines are built more strongly nowadays, and with less regard for paring off weight. A two-seated monoplane, for example, weighs as much as 1100 pounds, without pilot, passenger, or fuel, and, when fully loaded, would weigh not far short of 2000 pounds.

One of the principal aims of the biplane constructor, during what one may call recent times, has been to increase the speed of his machine, so that it does not lag so far behind the monoplane in this important respect. For weight-carrying, of course, the biplane is unquestionably superior; and it was recognised that, if its speed could only be increased, it would be a formidable rival to the monoplane. In such increases of speed the latest types of biplanes have achieved remarkable results. From a mere forty miles an hour, their pace has been increased until it is now, on an average, quite sixty miles an hour; while some biplanes, as a maximum, attain more than seventy miles an hour. Of course, the monoplane is still the fastest machine that flies, but the biplane has recovered a great deal of its lost ground.

It is instructive to note that the advent of the successful monoplane was, at first, taken to imply that the biplane, as a distinct type of aircraft, would gradually become extinct. Quite the reverse has been the case. We now have the two types of machine carrying out their individual work. The monoplane is the high-speed craft; the biplane is the weight-carrier and long-distance flyer; and it would appear as though the two types of aircraft will continue to develop along these lines.

It might prove useful to mention—in a non-technical way—some of the improvements in aeroplanes noted in connection with the Paris Aero Show held last November. At this exhibition, seventy-seven aeroplanes were on view, as compared with forty-three at the previous year's exhibition. A point, as illustrating the growing practicability of aeroplane design, is specially worthy of note. One popular type of monoplane had a neat box of tools fitted behind the pilot's seat—just in the same way as a motorist might be equipped with a tool-box. The engine of this particular monoplane was so placed that it could be dismounted in a minute, while about five minutes' work would suffice to fold back the wings and tail-planes of the machine, ready for transport.

Another interesting feature in monoplane design, as seen at this show, was that, instead of using an open skeleton framework of wood, covered with fabric, for the body of the machine, the builders of several of the latest types employed a smooth, papier maché type of tubular body, constructed from paper, cork, and a special fabric. This produces a more workmanlike effect, and allows the body to glide through the air with a minimum of wind resistance.

III

Everything possible is done in the modern type monoplane to lessen the pressure of the air when a machine is flying at high speed. As a rule, in a passenger machine, the two occupants sit one behind the other, and the body is built up until only their heads are visible as they project above it. The bodies are also smoothed away to a fine point at the tail, in order to lessen 'skin friction,' as it is called. In very high-speed flying, as can be imagined, the pressure of the wind is a very important factor. With the intention of reducing friction from wind pressure, the engines of many aeroplanes are covered in by sloping, dome-shaped covers; while the landing-chassis is reduced to its simplest proportions.

Perhaps it would be well if I gave a short list of the most important modern type aeroplanes, with such details as are likely to be instructive. Such a list is here appended :—

Aeroplane	Price	Area of planes	Motor	Speed
Farman bipl.	£1280	645 sq. ft.	75 h.p.	60 m.p.h.
Breguet bipl.	£1560	388 ,,	80 ,,	65 ,,
Bleriot mono.	£1072	215 ,,	70 ,,	70 ,,
Hanriot mono.	£1920	226 ,,	100 ,,	75 ,,

All the above machines are of the passenger-carrying type; but it is interesting to note the features of that very modern product—the racing monoplane. One may take, as an example, the Deperdussin monoplane with which Vedrines won the 1912 Gordon-Bennett race, and which was exhibited at the French Show. This 'freak' machine had planes containing only ninety-seven square feet of lifting surface. The two wings had a span of only twenty-three feet. And yet, to drive this tiny machine, a fourteen-cylinder motor developing 140 horse-power was fitted. Another racing machine, as seen at the show, was the *Nieuport*. This has 140 square feet of surface, and, driven by a fifty horse-power motor, attains a speed of ninety miles an hour.

It is now possible to turn to one of the most interesting of recent developments—the construction of practicable hydro-aeroplanes, or 'water-planes' as they are called. Here you have an aeroplane, usually of fairly ordinary type, but fitted with hollow wooden floats instead of wheels, so that it will rise from, and alight upon, the surface of the water. Apart from its value in naval work, the water-plane possesses many other attractive features. As a sport, for instance, water-planing is quite ideal. There is nothing more exhilarating than a flight in one of these machines—particularly at some pretty seaside resort, and on a fine summer day. The machine makes a smooth, swift rush along the water at the beginning of its flight, leaving a wide track of foam in the wake of its floats. Then, obedient to the movements of the pilot's controlling lever, it gradually draws itself out of the water, and flies through the air.

There is a distinct aspect of safety in connection with flying over the sea—a point which would-be passengers who are timorous should bear in mind. Several times machines made involuntary descents which would have been serious had they occurred on land, but on the water no ill results were to be noted.

As a sport, water-planing has many possibilities, and we shall undoubtedly hear a great deal more of it in the future. Already there have been a number of interesting contests, chiefly in the south of France, and the flights of the machines have proved a delightful spectacle.

In England, during last summer, ***The Daily Mail*** organised a series of seaside tours for water-planes, and I was able to give a number of demonstration flights at Brighton, Cowes, and other places. Everywhere the performances aroused the keenest interest. During the summer of 1913, I am sure that this form of exhibition flying should be greatly developed. Apart from the amusement provided by the flights of the machines, such a demonstration has this very definite lesson to teach—that Britain cannot afford to neglect the rapid progress that is being made in aviation.

IV

ALTHOUGH the question of the construction of a water-plane sometimes seems a simple one, in reality it is not. 'All you have to do,' I have heard a man say, 'is to stick a pair of floats underneath a machine, instead of wheels, and—well, there you are.'

Unfortunately, the problem is not so simple. Many technical questions affecting weight, design, and equipment must be considered; and it is a problem in itself to plan a system of floats which shall be thoroughly efficient in the water and offer the minimum of resistance in the air. Again, the constructor is confronted with the problem of making his water-plane a sea-worthy craft; he must build a machine which will be able to descend on the sea when the surface is rough, without being damaged in so doing. Such a seagoing machine has not yet been evolved; but there is every promise that a practical craft of this kind will be produced before long. The water-plane is quite in its infancy, but it is already possible to see that it has a most important future.

Sea-flying, indeed, presents many possibilities. One important point is that aerial navigation over water is not so difficult as over land. The winds that blow over the sea are steadier than those over the land, because their flow is not disturbed and broken up by hills, woods, and valleys. The question of starting and alighting, also, is an easier one, in many respects, when water is available, than is the case on land. One of the difficulties in building large-sized aeroplanes concerns their landing-gear. But with the sea-going aeroplane this difficulty is very greatly simplified.

It is probable that, in the not far distant future, we shall find large, passenger-carrying water-planes being built. Already a syndicate is seeking to arrange a regular cross-channel service of aeroplanes between Dover and Calais for next summer. Plans are also being made to construct powerful machines with engine plants of 300 horse-power and more. Such machines, flying at sixty miles an hour, should be able to weather very strong winds, and so be able to fly quite regularly between any two points. Many constructors of aeroplanes regard the commercial future of the water-plane as being a most important one. With the production of more powerful engines, it should soon become possible to manufacture a water-plane to carry a dozen or more passengers from place to place. But, before such machines can be built, the present type water-plane must be improved in many details.

So far, the tendency has been to take an ordinary land aeroplane and equip it with floats. But this policy has drawbacks. The land aeroplane, for one thing, does not possess the strength necessary for really practical sea-work. It is now recognised that something in the nature of a 'flying boat' is wanted —that is to say, a machine that will float quite well even on rough water, and yet fly efficiently when it is required to do so.

Already, some makers are working along these lines—and with definite success. For instance, several machines are now built of which the lower part is a lightly constructed boat, or rather canoe. This is capable of riding well upon the water, and in it are placed the pilot and his passenger. This canoe-shaped body tapers away to a point, at the tail, and here are fitted the controlling-planes. Then, built upon the canoe body, are the main supporting planes. The object of such a machine, of course, is to provide something which will serve equally well in either element—air or water.

But there are difficulties in this form of construction, as in everything else. For instance, it is not considered good practice, in aeroplane building, to place heavy weights low down on a machine; they have a tendency, for one thing, to set up a pendulum movement when flying. However, several manufacturers are attacking such difficulties as these, and already—as in the case of the Curtiss and Donnet-Leveque machines—a practicable form of flying boat has been built.

When such a craft as the flying boat is

really marketable, in a general way, there should be a very wide sale for it. Motor-boating is a popular sport, for instance; and yet the pleasures of hydro-aeroplaning should far exceed those to be derived from the motor-boat. The question of price, of course, enters very largely into these matters. Unless a water-plane can be produced and sold at a reasonable price, the sale for such machines is bound to be restricted. But in this regard, more than one firm is making plans to build a special, small-type water-plane which will sell for £400, or even less.

But the really important future of these air and water craft is in regard to the construction of big, passenger-carrying machines. Of course, we are a long way yet from the production of an 'air-liner,' such as the reader may have become acquainted with in the pages of fiction. The way, however, is now clear for the construction of very much bigger water-planes than those at present available. When good aerial motors of from 300 horse-power to 500 horse-power are ready for the aeroplane makers' use, we should see interesting developments. Without doubt, an extremely promising future lies before the water-plane—for sport, for practical use, and also for naval purposes.

EIGHTH SECTION

COMMERCIAL POSSIBILITIES OF THE AEROPLANE

I

This subject should appeal to everybody just now. The wonder aroused by the conquest of the air has somewhat subsided. People are becoming more accustomed to the aeroplane, and to reading about the long-distance flights airmen are able to make; and so the question naturally arises: 'What is it going to lead to? What good will flying be to the world?'

Well, one must admit that it is early yet for any man, however well informed, to make definite statements as to what the aeroplane will, or will not, do. Almost every day technical experts are astonished at the results achieved; the aeroplane is, in fact, already doing many things that nobody, a year or so ago, would have believed possible. And yet the machine is still in its veriest infancy. Therefore, both the optimist and the pessimist need beware.

When the first crude motor-cars rattled

along our roads, at a snail's pace, there were sceptics who aked: 'What good will these things ever be? They are toys, of course —and silly toys at that!' Well, such sceptics have lived to hide their heads—if an out-and-out sceptic ever betrays any such signs of shame. We have seen the motor-car used for one of the most important and practical purposes to which any vehicle could be put—I mean that motor-vans are now regularly employed in transporting mails by road from one big centre to another. Here is a work requiring the greatest reliability; and it is gratifying to note that these motor mail services are being increased.

Suppose one had told the sceptic, years ago, that those erratic, early-type motor-cars would develop until they were used for carrying such valuable goods as mail bags, he would have laughed with scorn; and yet such has been the progress of the motor-car that commercial vehicles are now employed in many thousands, and promise to be used even more extensively in the future. These points are worth mention, because, in considering the progress of aviation, the wonderful development of the motor-car shows us that it is foolish to declare, in the early days of any new invention, what its limitations are likely to be. Men who take such a task upon themselves very often prove to be utterly wrong.

When an ordinary inquirer asks me such a question as: 'Will aeroplanes take the place of trains?' I have to reply, quite truthfully, 'I am sure I do not know.' In the matter of flying, one can see so far ahead and no farther. So many complexities crop up with regard to construction and the application of power, that it would be presumption for any one to define the exact passenger-carrying future of the aeroplane. What one can say at present is this: it will be possible, quite soon, to build a machine to carry a dozen or more passengers as its ordinary load, and to fly for a good many hours without descending, as well as to combat practically any wind short of a gale.

That does not, of course, get to the stage of abandoning trains; but, it shows that the aeroplane is progressing very definitely along the road to practicability. When these first regular passenger-carrying machines are built, and have been flown for some time under test conditions, then we shall know a great deal more about the future than we do to-day.

In the meantime, one may say that there is no reason at all why the aeroplane should not be used for passenger transport, as the train now is. From the point of view of the danger of passing through the air, I do not think this will be an adverse factor when a commercial type of aeroplane is available. So far, as I have pointed out, men have been using small, flimsy machines, built of wood and wire. For regular passenger work, of course, such craft are not to be considered seriously. Neither must they be taken as fair examples when the danger of aerial travel is under review. In another section of this book I have shown how the breakage of these frail machines has brought about a large proportion of the aeroplane accidents that have already happened. But, when we come to the big, metal-built passenger-carrier of the future, this question of breakage in the air should not be one to enter at all seriously into the question.

The reader will remember that many aeroplane accidents can be traced to a machine being overturned by adverse winds; but, in this connection, improvements in construction are now very largely obviating risk. Aircraft manufacturers are, in fact, pretty confident that they will be able to evolve a machine capable of remaining in the air with safety, in the highest winds that are ordinarily encountered. Of course, when there is a raging gale blowing, the big aeroplane will undoubtedly have to seek shelter as our cross-Channel steamers sometimes have to do.

II

One of the first practical uses of the aeroplane will be as a carrier of mails. Already, in this regard, some interesting tests have been carried out. At the Hendon aerodrome, for example, an experiment was arranged at the end of the flying season of 1911, which was sanctioned and observed by our postal authorities. The aim, in this test, was to carry bags of special letters and post cards between the aerodrome and a landing-ground situated at Windsor. The weather, during the period when the flights were carried out, was extremely bad, with treacherous winds, and a good deal of rain. But almost every day during the tests a machine was able to make the specified flight.

It was not possible, however, to undertake these aerial trips exactly at prearranged times. For instance, a pilot would be ready to start at an early hour in the morning, and would then have to watch the weather conditions very carefully, and dash off directly a favourable opportunity presented itself, quite apart from any consideration of leaving the aerodrome at a specified time.

This, of course, is one of the admitted failings of the present type aeroplane, when we come to examine it from the commercial point of view. If you said to one of the most skilful pilots of the day: 'You must start away upon a certain flight to-morrow afternoon at exactly 3.30 p.m.,' he would not guarantee to carry out your orders. The wind, at the particular time mentioned, might be altogether too rough for flying; therefore, he would have to postpone his start. But if you said to this same aviator: 'I want you to make a flight between two given places to-morrow, and I will let you start at any time between sunrise and sunset that you care to select'—this would be quite a different story.

In such conditions as these, the airman would be ready to start away directly it became light. Perhaps, however, there would be a thick fog then; or a very tricky wind might be blowing. In such a case, he would be content to wait. Then it might happen that the wind would blow gustily all day long.

If this happened, the pilot would still wait near his machine. And then, perhaps, just before dusk, there would fall a dead calm. Instantly profiting by it, the pilot would slip away on his journey, and complete it successfully.

If there is only latitude in this way, regarding the hour of the day on which a start can be made, it is possible—even with present type machines—to make any prearranged flight upon almost every day of the week. What I mean is that it is a very bad day, indeed, upon which there is not a chance, during some hour of the day, for a skilled pilot to make a flight. As a matter of fact, the chances of carrying out a required flight in this way have been reduced to statistics; and it is now estimated that an experienced airman, flying a modern type machine, should be able to ascend upon eighty per cent. of the days of the year. This is a very different state of affairs from that which prevailed in the early days of flying, when no man dared leave the ground unless a calm prevailed.

In the experimental mail-carrying test at Hendon, to which I have just referred, this ability of the airman to snatch a favourable opportunity, and fly quickly from one point to another, was very strikingly demonstrated.

Time after time, after waiting by his machine all day, with mail-bags ready to hoist aboard —but with a treacherous wind blowing—the pilot was able to dart off in an evening lull and finish his flight just before it was dark. The early morning and the evening are generally ideal times for cross-country flights. Frequently, as the reader will have noticed, there is a calm just after dawn which soon gives way to quite a high wind; and then in the evening again, the wind drops away for a spell. This is why, in all big cross-country air races, the competing airmen have been up and waiting for the dawn, in order to get away. A few hours' flying before breakfast are invaluable if long distances are to be covered.

A point to be remembered too, is that it does not take an aeroplane long to get from point to point once it has started away. It is, indeed, amazing with what speed a machine flies from place to place. Not only is it often travelling at a pace faster than that of an express train, but it is going unerringly between its two points exactly as a bird flies.

III

A practical instance of this virtue of the aeroplane in the matter of speed is likely to be more convincing than any amount of argument; and a friend of mine supplies what I think is a striking example. He came to the Hendon aerodrome, very early one morning, to see Vedrines start a flight from London to Paris. After some little delay, owing to fog, the airman got away, steering a course for Dover, upon reaching which he intended to alter his path a little and fly to Dieppe, where he had arranged to make his first landing to take petrol on board. He started a few minutes after six o'clock, and my friend then set out, by means of tram and train, to reach his home on the south-west outskirts of London. In about an hour and a half he duly reached his house, having travelled some twenty miles.

In that same hour and a half, Vedrines had flown down to the coast from London, had passed over Dover 3000 feet high, had crossed the Channel to France, had flown along the French coast, and landed safely at Dieppe. In the time my friend was taking just to reach his suburban home, the airman had flown from

London to a point on the French coast. It is a remarkable illustration of what the aeroplane will do, and a simple one as well.

In regard to our mail-carrying at Hendon, the speed of the aeroplane was very notably demonstrated. Rising in a sixty-five-mile-an-hour monoplane, an airman sped from the aerodrome to Windsor in a few minutes. In fact, hardly had he started—or so it seemed to those on the aerodrome—when a telephone call announced his safe arrival.

Of course, the commercial value of any machine lies in its ability to do a certain thing at a certain time, and to keep on doing it without breaking down or giving trouble. That is what many people thought the motor-car would never be able to do—but it has done it. Similarly, many critics refuse to believe that the aeroplane can ever be brought under this commercial heading; but I, for one, certainly believe that it can. The petrol motor has already shown its reliability when fitted to the motor-car; and there is no reason why the engine in an aeroplane should not run just as reliably. Already, when we have flights of eight, ten, and twelve hours' duration being made with various types of machines, there is proof that the engine of an aeroplane will not only run, but will keep on running.

But the sceptic says: 'It is all very well to make a flight at some time during the day when the wind permits. What is wanted for any commercial undertaking—such as mail-carrying—is an ability to start away at a given hour, to the very minute, and to repeat this performance day after day without accident or breakdown.'

This view of the case is perfectly correct. Before the aeroplane can be used, say, as a regular mail-carrier, it must be able to fly at regular hours for week after week and month after month. That is the problem to be faced, and the new industry recognises it. As regards adverse weather, we can omit this point from the present argument; it is certain that a big, powerful machine, specially built for its particular work, and flying at high speeds, will be able to start at a given time on any day when there is not a tearing gale of wind. Already, in a present type monoplane, a man has flown in a wind of forty-seven miles an hour. The metal-built, commercial type aeroplane should weather a sixty-miles-an-hour wind, should need arise.

Then there comes the question of failure from mechanical breakdown. Here, we enter upon the question of dual power plants. I have already shown that a machine with two engines can be built and flown, and that it can do what it was built to do quite well. It is clear that commercial aeroplanes will have two engines, or very likely more—these power units being arranged so that they will run together or independently. Thus, if an engine gives trouble in flight, it will be cut out from the series, and overhauled in the air while the other engines are carrying the machine on its way. By such an arrangement as this, the chance of a stoppage from engine breakdown should be almost eliminated.

These things sound very easy when one is writing about them. It is a different matter when the manufacturer comes to plan out an actual machine. Then one difficulty after another arises. But I am sure any experienced builder of aeroplanes will agree with me that there is no insuperable difficulty in the way of producing such a multi-engined mail-carrying aeroplane as I have endeavoured to describe. Much money will have to be spent before such a machine is a practical, everyday means of transport;

and a good many experimental machines will be built and broken up; but without doubt the finished, successful machine will come.

IV

The speed of the aeroplane will render it especially valuable for the carrying of urgent mail matter and certain forms of 'express' goods. For such urgent matter special charges will naturally be made. The same remark will apply to passenger traffic—at any rate, in its early stages. In its first application, the commercial aeroplane will have distinctly limited uses. It will not be able to compete with railway goods traffic in the matter of cost, for instance. If people want to send goods by aeroplane, they will have to pay special rates. Therefore the air service will only carry such goods as must reach their destination very quickly. As regards passenger carrying, too, special fares will undoubtedly be charged in connection with aeroplane services. For instance, when the first regular service between London and Paris is instituted, the charges for the journey by aeroplane will be appreciably higher than those made at present for the trip by train and steamer. But then, by the air-mail, the passenger should be whisked from one capital to another without changing his seat, in, say, a little over two hours—instead of having to change from train to boat, and from boat to train, and being some seven hours *en route*. Such high-speed travel will, of course, be worth special fares. Naturally, at first, there will be a prejudice against the new air service; people will speak of its dangers, and may be chary of booking seats in the aeroplanes. But this prejudice will, I am certain, be worn down.

There are, without doubt, many very busy men travelling, say, several times a month between London and Paris, who would be willing to pay special fares in order to make the journey at high speed, and without the trouble and discomfort of the sea-crossing. Here, then, is one definite opportunity for the establishment of an air service. The same remark applies, only in a less urgent way, to the commencement of passenger services between London and Manchester, and other big cities in England.

Abroad, the chances for the air service are most favourable. Paris and Berlin, for instance, should be linked up by means of a service of passenger aeroplanes—Paris and Madrid as well. As a matter of fact, the field for the passenger-carrying aeroplane is a wide one. All that is required is a suitable machine. This will not be evolved quickly. The industry will need to progress logically from one stage to another, as all other great industries have done.

Apart from passenger carrying and the transport of goods, the commercial aeroplane has other opportunities for profitable work. There are, for instance, wide tracts of land in our colonies, and in other places abroad, which need to be surveyed at regular intervals. Here a reliable type of passenger-carrying aeroplane would offer distinct advantages. It would carry a surveyor very quickly from point to point. It would be independent of roads, woods, or mountains, and it would give him a unique opportunity of surveying the land as he passed over it. Already it has been reported that a monoplane was purchased in Paris, some time ago, for carrying out survey work on a Persian oil-field.

In the same way, the aeroplane will have a very definite use in the surveying of the land for the construction of railways and roads in countries which are in process of development. For establishing regular communication between inaccessible stations and frontier posts, and their nearest bases, the aeroplane should find another use. Indeed, a very promising future lies before the commercial aeroplane, as soon as the machine is available for use; and, of course, as it develops and becomes more practicable, so its field of employment will widen.

The criticism has been raised that the working cost of the commercial aeroplane will be very high—so high that it will be unable to compete at all favourably with any present means of transport. Here, however, it is scarcely wise to enter into detailed discussion—so much remains to be demonstrated regarding the actual power required in flying; A man has flown with a nine horse-power engine; and yet, to-day, single-seated monoplanes are fitted with engines of fifty horse-power. The Wrights did with twenty-four horse-power what some other builders required fifty horse-power to accomplish.

The possibility of a soaring flight, like that of the birds, in which—after attaining a requisite altitude—a machine might glide for miles without the expenditure of any power at all, is still waiting to be more thoroughly investigated. That flying will ultimately be possible with very low power —granted that the most efficient form of machine is discovered—many very careful students of aviation firmly believe.

If high-powered engines are always necessary to carry a moderate load by air, no doubt aerial transport will be expensive; but the greatest authorities are of opinion that an efficient, weight-carrying machine may be evolved which will not require any very big engine power. This, however, is a question that one can scarcely go into with any degree of detail at the present time. To begin with, as I have said, I think we shall see commercial aeroplanes carrying mails and express goods, and also being used as high-speed passenger craft. Afterwards—well, no man can predict what the ultimate commercial development of aviation may be.

NINTH SECTION

THE FUTURE OF FLYING, WITH SPECIAL REFERENCE TO THE DEVELOPMENT OF AIRSHIPS.

I

I HAVE dealt, in the previous section, with the purely commercial side of aviation; and here, as a fitting conclusion to the book, I propose to discuss the general future of aerial navigation.

For some time to come the most important progress made will be as regards the use of aeroplanes in war. Great fleets of machines will, without doubt, be created both for scouting and for destructive use. What the ultimate development will be, in this connection, one finds it very hard to say. Many men who have studied the problem carefully do not hesitate to declare that the aeroplane will eventually make war impossible. By this they mean that its powers will become so terrible, in their effect upon combatants and non-combatants alike, that fighting will be too ghastly a business to be undertaken by civilised communities. This, however, is a point of some doubt, and it is difficult to express an opinion upon it. It is certain, however, that for the next few years the development of war-aeroplanes will be rapid and of far-reaching importance.

Generally speaking, I regard the future of flight as being assured. Not for nothing did men strive for centuries to conquer the air. Now, when the conquest has come, I feel certain that flying will play an extraordinarily large part in the growth of the resources of civilisation. The future of the aircraft will lie in the matter of speed. As time goes on, there will be a growing demand for quicker transit between cities, and also between the capitals of great nations.

This brings up the point—can land and sea transit offer anything more in the way of speed than they provide at present? I do not pretend to be an expert upon this subject, but it seems to me that, with trains and permanent ways as we have them to-day, a railway speed limit has almost been reached. It is extremely difficult, as a matter of fact, to speed up an express to the extent of a mere mile or so, even on a long run. This shows how near to the limit the modern express is running. Of course, the present method of working trains is not necessarily the final development. There is, for instance, the possibility of constructing a mono-rail system of railways, with trains driven by electric power. In this system it is considered possible to attain extremely high speeds. But the question of cost is one that needs to be gone into very carefully; and the general practicability of any such system, even when installed, remains to be proved. At any rate, I am dealing at the moment with the present facilities provided; and my point is that, for land travel, the limit of speed has almost been reached.

Then one comes to the question of travel by sea. Here, I think, it is safe to say that higher speeds than are at present attained can only be reached by the expenditure of sums of money out of proportion to the results achieved. Thousands of pounds in money, and thousands of tons of coal, are needed to drive a huge liner a knot or two faster than the leviathan of some competing line. In fact, there is already a tendency upon the part of rival passenger fleets to abandon these ruinous speed combats, and to build big ships which will steam at a good pace, but which will not attempt to break records.

The hustling American business man, who grudges the time it takes him to cross by sea from America to Britain, can scarcely hope for any distinctly quicker passages than he now makes—that is to say, so long as ships are built and engined as they are at present.

And yet, as I have said, the demand is all for greater speed. We have wireless telegraphy sending its messages through the air for a couple of thousand miles in a second or so of time; everywhere there is a desire to speed things up, to save the time which, in business, is becoming more and more precious every day. Can our existing methods of transit respond to this demand? That is the point. If they can, and to the extent that is desired, then the future of the aeroplane is not so important as I like to think it will be. But I do not believe that trains or ships will be able to respond to the demands made upon them. I think myself that the aeroplane has arrived just at a time when mankind most needs it to meet this demand for greater speed in communication.

I believe that the navigation of the

air will provide a means of getting from place to place which will always be faster than any method available on land or sea; and I believe, also, that in this ability to attain huge speeds one of the greatest futures of the aeroplane will lie. Already we know that a racing-type monoplane can exceed 100 miles an hour through the air. But this does not represent a limit by any means. I anticipate that it will be possible to drive a machine through the air at 150 miles an hour—and even at greater speeds than this.

What this will mean in the way of quick communication the reader can imagine. Not only will the machine rush through the air at this tremendous speed, but it will make its way from starting point to destination in a straight line, independent of rivers, seas, mountains, or forests. Here, surely, is where the conquest of the air will be of practical value to the world.

A very important point to be remembered, also, when we are considering this particular aspect of the aeroplane's future, is that the highway of the air needs no special track or permanent way. If a 150-mile-an-hour aeroplane rushes across Europe, linking the large cities one with another, it does not need any costly laying down of a line over which it may pass. All it requires is a starting-ground and various landing-points *en route*; for the rest, it sails freely along the great airway.

II

Speaking of airways reminds me that, as the volume of air traffic grows, special rules will need to be framed for the navigation of the air. In this regard, there have already been several international conferences, at which the problems arising have been carefully discussed. It seems clear that, in flying across Europe from one country to another, aircraft will be required to follow a certain prearranged aerial path or airway. This track will be indicated by special land signs during the day and by lights during the night.

Then, of course, an important point concerns the Customs service. For the administration of the Customs with trains and ships no very great difficulty presents itself. But when we come to consider the air service, with a machine flying several thousand feet high, and passing across the frontier between two countries, there is rather a peculiar situation to be faced. It is probable, however, that it will be met by requiring all aircraft, when they pass from one country to another, to alight at a specified point at the frontier, there to undergo the Customs examination.

It is suggested that all aircraft should be registered and numbered, and that they should carry a suitable identification mark or sign, so that they can be recognised from the ground even when flying at a fair height. The idea is that an aeroplane should give indications, when it is flying, of its nationality, and also of its type—that is to say, whether it is a naval or military craft, a passenger-carrying machine, or a privately-owned vessel. In addition, of course, it would carry a special number which would identify it individually.

The greatest care will have to be taken in tracing the international voyages made by aircraft. For instance, if an aeroplane seeks to start from London to journey to some point in France or Germany, it is held that its owner will have to obtain a special passport setting out the details of its flight, and indicating its landing-points. Such a passport would, of course, have to be shown if required, when the airman descended at any point specified by the Customs authorities.

Considerable argument, and much diversity of opinion, has been aroused by the question: 'Should the navigation of the air be declared entirely free?' So far as the sea is concerned, it will be remembered that it is quite free for navigation, save for the fact that each country which possesses a seaboard has rights over the water for a distance of three miles from the land. As regards the air, however, many people argue that it should be declared free, without any restrictions whatever, for the navigation of aircraft. Others hold that any country should be given power over the air for a certain distance above the ground—the precise distance not yet being specified. Others, again, contend that it is essential for the air *not* to be declared free. They hold, in fact, that every country should have absolute power to control the air traffic that passes above it.

According to old Roman law the air is not free for anybody to fly about in. It is held, under these ancient laws, that a landowner has a right of property in the air above his land to any height. According to these laws, therefore, if he desired to do so, a reactionary landowner might entirely prohibit the passage of aeroplanes over his property. This question of the ownership of the air proves an awkward problem, as the reader can imagine, and it is a problem which has yet to be solved. The most reasonable notion, according to many legal experts, is that individuals and nations should be given a limited form of ownership over the air; that is to say, they should have certain very definite control given them over aerial navigation, but that they should not be able to veto it altogether.

It is quite clear, of course, that control over the passage of aircraft is necessary. The Royal Aero Club has already recognised this. It prohibits, for instance, flying over towns—on account of the danger to the inhabitants should any machine fall suddenly; and it is framing, from time to time, other rules for the good government of flying. We shall find that, as flying progresses, a sensible, workmanlike set of international rules will be prepared. It is obvious, of course, that aeroplanes will not be allowed to fly indiscriminately over fortified positions or points of strategic importance; if such flying were allowed, the air spy would provide a new terror. This point is already under consideration, and it is suggested that certain localities should be declared 'out of bounds,' and that no aircraft should be allowed to fly within more than a certain number of miles of them.

With the laying down of certain definite airways, with the identification of aircraft, and with the prescribing of specified landing-places for machines when on international journeys, to say nothing of the regulation of the height of flying, and the indication of certain localities over which aviation is not allowed, it seems to me that it will not be very difficult for experts of great nations to come together and frame a suitable set of aerial laws. Yet, in the early stages of this new industry, we do not want to be saddled with too many rules and regulations: the wise course will be to frame laws as the need arises, and not anticipate conditions which may never come about.

III

In this section I shall make special reference to the airship and its possibilities. In the very early days of the aerial conquest the dirigible balloon was considered an ideal form of aircraft, and its future seemed assured. Then the aeroplane came along and started upon its successful career. It marched, or rather flew, from one triumph to another; and the airship, making slow progress by dint of many failures, fell a good deal into disrepute. Its disadvantages, in its early stages, were many. It was big and clumsy, and it was extremely costly. It required large and expensive sheds, and trained crews of men needed to be at hand to tow it from its harbour, and house it again after a flight. Further, it was an extremely tricky machine to handle in a wind; and the result of this was that many machines, after costing thousands of pounds, were hopelessly wrecked when starting upon, or landing from, a flight. A difficulty was that its speed through the air was slow; and for this reason it made poor progress against head winds.

These were very definite discouragements, and for some time the dirigible balloon languished. But there were enthusiasts who refused to be discouraged by its apparent limitations. In Germany, particularly, these pioneers worked extremely hard, and in face of many disappointments. But, nowadays, they are meeting with their reward. The airship has, indeed, conquered many of its early imperfections, and has now attained to a practicability which merits its being developed and studied quite as attentively as the aeroplane.

Organisation has played a large part in the recent success of the airship—particularly in Germany. In that country there are now aerial harbours for these big machines, not in one or two places, but at a great many points. This means that, should a high and awkward wind arise, the airship commander can study his map, and make for the most suitable harbour he sees marked upon it. Then the airship crews in Germany have been so well trained that the huge dirigibles are now handled with the greatest skill and ease. This is a very important point.

As regards the machines themselves, they have been improved, constructionally, to a surprising extent. The speed of the rigid airship—the type of craft possessing the rigid form of outer casing, or hull, with the gas-containing ballonets inside it, which has been made famous by Count Zeppelin—has been increased to a very remarkable extent. To attain this result more powerful and efficient engines have been fitted, propellers have been improved, and the general strength of the machine much augmented. The result is that one of the latest type German airships can attain, as her highest speed, a pace of fifty miles an hour, and has a capacity for remaining aloft for a period of four days and nights if the need arises.

Controversy has arisen of late upon the question, 'airship *v.* aeroplane.' Some people appear to imagine that, in the rivalry between heavier and lighter than air machines, one or other must necessarily go to the wall. But I do not think this will happen—not, at any rate, for some time to come. Both types of aircraft appear likely to be very greatly developed. The passenger-carrying possibilities of the airship are important. A practical instance may be instructive in this regard. A Zeppelin airship has acted as a passenger craft over a period of seven months, making during that time 183 aerial excursions, and carrying 3902 people.

The airship, of course, is an extremely expensive machine, not only to build, but to keep in commission; this is one of its drawbacks. But for military use, as a machine for detailed reconnaissance, and also as an instrument of destruction, it is bound to have importance in the future. Any War Department is wise to construct airships at the present time, as well as aeroplanes; both, undoubtedly, will have their uses in war. With ample provision in the way of sheds and landing crews, the airship may also prove a successful passenger machine, when placed upon regular services between fixed points.

. . . . .

And now a final word. The future of flying may, in my opinion, be summarised thus:—

1.—Machines will develop to a much more important extent as instruments of war.

2.—Aeroplaning, and particularly water-planing, will become a popular sport, and aerial tours will be undertaken as motor-car trips now are.

3.—The strongly-built, practicable aeroplane will be used for the transport of mails and express goods.

4.—When more improvements have been effected in the way of reliability, and in making the machines 'airworthy,' regular passenger services by aeroplane will be instituted.

5.—Eventually the air will become the ideal medium for high-speed transit, both for passengers and goods.

More might be said, but I have already said enough. I have expressed what are my honest opinions; and I have endeavoured not to be over-enthusiastic as to the development of the aeroplane. But, when one thinks of the future of flight, the possibilities are so vast that one may surely be forgiven for being a little sanguine.

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