THE BOYS' BOOK OF AIRSHIPS

HARRY DELACOMBE

HEIGHTS ATTAINED BY VARIOUS AEROPLANES AT THE TIME OF GOING TO PRESS AS COMPARED WITH THE HEIGHT OF ST. PAUL'S CATHEDRAL, LONDON.

SINCE THIS ILLUSTRATION WAS ENGRAVED, COUNT DE LAMBERT HAS ATTAINED A HEIGHT OF 1300 FEET.

THE BOYS' [illegible]
AIRSH[illegible]

H. DELACOMBE

[illegible]

[illegible]

THE BOYS' BOOK OF AIRSHIPS

BY

H. DELACOMBE

WITH NINETY-THREE ILLUSTRATIONS

NEW YORK
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Paul Edw. Garber

Dedicated

To My Friend

Colonel James B. Templer

who devoted over thirty years of his life

to

Aeronautics

for the benefit of his country,

and through whose conversation I was

first interested in the subject.

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AIRSHIPS

By Harry H. Kemp

(Reprinted from The American Magazine, December, 1908, by permission)

Brave captains of the ocean of the air,
Agile the buffets of the winds to dare,
To dartle upward on a track oblique
As eagles fade from peak to mist-wrapt peak;
Forerunners of the mighty time to be
When men will sail the air as now the sea
And flocks of ships like migrant birds will go,
Their shadows speeding under them below,
And take the buffets of celestial gales
In cloudy tier on tier of bulging sails—
All hail! Columbuses of realms unwon
And windy champaigns germane to the sun.

Neglected as of yore will be the Deep
Ere timid Commerce on its edge did creep,
Abandoned to the pale and lonely moon
And to the awful flails of the Typhoon;
And the brown savage, vivid with tattoo,
Gliding from isle to isle in swift canoe
And clumsy junks manned by the Chinese crew,
And fishing smacks dim-seen through slant gray rain
Alone will tempt the bosom of the Main;
And Liners useless at the docks will stand
Like dead Leviathans washed up to land,
While steamship companies through bribèd law
Will seek the wingèd fleets to overawe.
Yea! Gradual, by ones, and twos, and threes,
The daring mariners will tempt the breeze:
At first for pleasure only will they sail
And chart the sightless currents of the gale,

But next increasing cargoes will be laid
In holds, and over continents conveyed,
And, automobiles, antiquated quite,
Flying machines will throng the upper night—
With flashing headlights high expresses shine
Like meteors dropping in a golden line.
Inventors on invention will refine
Until machines, the children of their skill,
Will move obedient to the infant's will. . . .
Yet here and there when flying ships appear
The superstitious swain will flee for fear,
Until the Marvellous dons Use's face
And miracles become the commonplace.

And then, should murderous War with passion mar,
Terrific fleets would gather from afar;
Nor would banked coast defense and barricade
And the long line of soldiers on parade
Avail against the death which, everywhere,
Would shriek and flame adown the gulfs of air—
But yet, methinks, ere that time war will cease
And in one symphony divine of peace
The world will work and trade and build, and plan
Not profit, but the betterment of man,
Mountains and lines no more will states divide
And all the world become one countryside.
Hail, brave adventurers who soar, and dare
To climb the unscaled ramparts of the air!
The spirit pushes ever on and on
Toward some great end and toward some greater dawn.
Oh, it is hardly daylight yet—'tis gray
First light before the sunrise of the day.
If man has but upon his course begun,
How great will be the world ere God is done!

The Boys' Book of Airships

PART I—BALLOONS

I—Some Early History

Long before George Stephenson designed the first steam locomotive, before the days of steamships, and when Horatio Nelson, England's most famous admiral, was only 25 years of age, two brothers named Joseph and Etienne Montgolfier, who lived at Annonay, about 36 miles from Lyons, in France, invited all their neighbours and sundry public officials of the district to witness an experiment they were about to make with an aerostatical globe of their invention.

These brothers, by making tests with small globes, had discovered that a vessel of this shape, if filled with hot vapour, would rise in the air, the hot vapour being lighter than air itself, and possessing sufficient buoyancy to cause the light hollow ball to float gradually upwards.

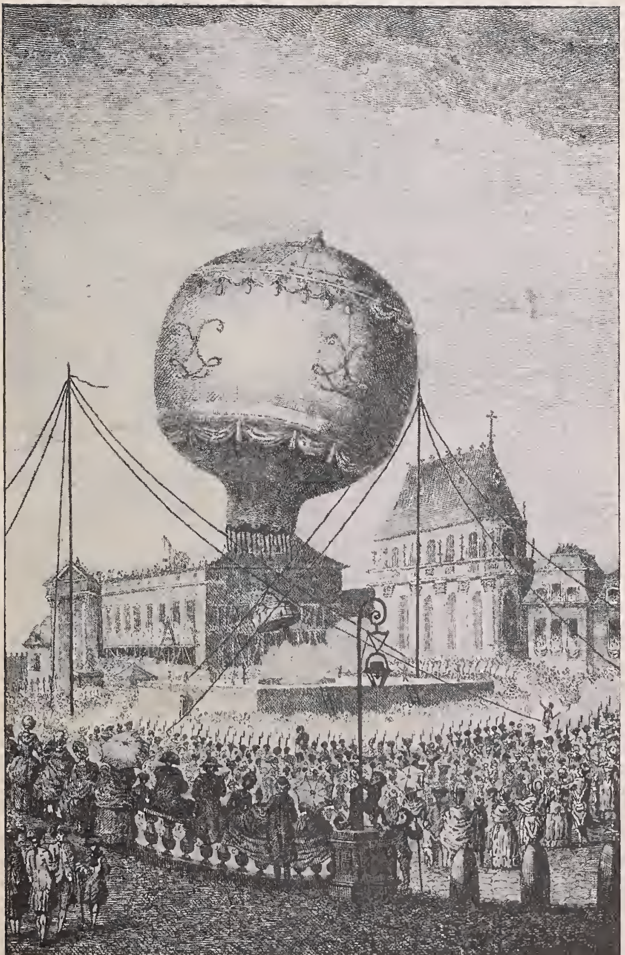
Strange as it may seem to us at the present time, this idea was entirely novel in the year 1783, to which I am now referring, and the spectators who assembled in the public square of Annonay on the 5th of June of this year, were immensely surprised at seeing a huge ball, about 110 feet in circumference, or 35 feet in diameter, attached at its base to a wooden frame or platform, and even more astonished when the inventors announced that, as soon as it was filled with hot air, it would rise of itself into the clouds.

How the brothers proceeded to make such vapour and inflate this globular ball made of varnished silk until it was well filled, how, when it was let loose it rose in a few minutes to a height of more than a mile, and then drifted a mile and a half horizontally with the wind ere it gradually deflated and sank gently to the ground, may be read at length in "Astra Castra" and other works which deal at length with these early days of ballooning.* It is enough here to say that the performance aroused a vast amount of curiosity and interest, not only in France where the experiment was made, but also in England and other civilised parts of the world. The citizens of Paris, who were eager to see an ascent, promptly started a public subscription to defray the expense of making a very light inflammable gas, which we know as hydrogen, to be used instead of hot air for the purpose of filling the Montgolfier balloon. The brothers accordingly took their machine to the French capital, where it was filled with this gas and sent up from the Champ de Mars on the 27th August, in the presence of an enormous crowd.

When it had risen to a height of some 3000 feet from the ground it disappeared in the clouds, eventually coming down in a field near Gonesse, a village 15 miles from the starting point.

As an example of the superstition, not to mention the complete ignorance on such subjects, prevailing at this period, it is amusing to note that when the peasants saw this harmless object descending in their village they were at first completely panic-stricken, believing it to be either some monstrous bird or an unwelcome visitor from another world! At last some who were a little

* Turnor's "Astra Castra," Hildebrandt's "Airships, Past and Present." Wise's "History of Aerostation."



Montgolfier Experiment at Versailles, 1783.

Face page 2.

pluckier than others drew near to the gas-bag, which was, of course, heaving about on the ground with every gentle puff of wind that blew against it. Pitchforks, scythes, and any other agricultural tools that came in handy were used as weapons, and the unfortunate balloon was viciously attacked. At last, when nearly all the gas had escaped through the rents and holes thus made in it, the supposed monster was tied to a horse, which galloped off with it across country.

The unawakened intellect of the time is further illustrated by a public notice which the French government deemed it necessary to publish, and of which the following is a fairly accurate translation:

Notice to the Public! Paris, 27th August, 1783.

On the ascent of balloons or globes in the air. The one in question has been raised in Paris this day, 27th August, 1783, at 5 P. M., in the Champ de Mars.

A discovery has been made which the Government deems it right to make known, so that alarm be not occasioned to the people.

On calculating the different weights of hot air, hydrogen gas, and common air, it has been found that a balloon filled with either of the two former will rise towards heaven till it is in equilibrium with the surrounding air, which may not happen till it has attained a great height.

The first experiment was made at Annonay, in Vivarais, by MM. Montgolfier, the inventors; a globe formed of canvas and paper, 105 feet in circumference, filled with heated air, reached an uncalculated height.

The same experiment has just been renewed at Paris before a great crowd. A globe of taffetas or light canvas covered by elastic gum and filled with inflammable air, has risen from the Champ de Mars, and been lost to view in the clouds, being borne in a northwesterly direction. One cannot foresee where it will descend.

It is proposed to repeat these experiments on a larger scale. Anyone who shall see in the sky such a globe (which resembles "la lune obscurcie") should be aware that, far from being an alarming phenomenon, it is only a machine that cannot possibly cause any harm, and which will some day prove serviceable to the wants of society.

(Signed) DE SAUVIGNY.
LENOIR.

The immediate result of these preliminary experiments was that all over the place small toy balloons were made out of paper, gold-beaters' skin, and any other light material found suitable for the purpose. The next real step towards practical ballooning was effected at Versailles, before the King and Queen of France and a vast crowd of people of every rank and class. On this occasion Montgolfier attached to his balloon a wicker cage in which were put a sheep, a cock and a duck. A fire was lit and the balloon was filled with heated air, as in the first experiment at Annonay. It was liberated, ascended to a height of some 1500 feet, and was carried away by the wind until, gradually losing its buoyancy, it slowly fell in a wood about 2 miles from Versailles, having been in the air for only eight minutes.

The loss of buoyancy was of course due to the cooling of the air with which it was inflated.

Two gamekeepers, who happened to be in the wood at the time, saw the descent of this curious machine with its strange, living freight, who seemed so little disturbed by their experience that the sheep was stated to be placidly feeding!

This experiment was undoubtedly only a prelude to the more ambitious trial of a human ascent, and was taken as a proof that little or no danger was to be apprehended for any man who might make a similar attempt. Despite this idea, King Louis XVI, realising the possible difficulties if not absolute dangers to be encountered, gave an order that two men who were under sentence of death at the time should be untilised on the first occasion, presumably because it would not matter if they were killed.

A gallant gentleman named Pilâtre de Rozier protested indignantly against this course being adopted, asking if two vile criminals were to enjoy the honour and glory of being the first aeronauts in the world, and entreated that this privilege should be accorded to him. Backed up by the Marquis d'Arlandes, who wished to accompany him, M. de Rozier gained his point, and on the 15th October, 1783, he won the undying distinction of being the first man to go up in a balloon.

The machine was constructed by the Montgolfiers, being oval in shape, with a diameter of about 48 feet and a height of about 74. Suspended from the gas-bag was a circular wicker gallery about 3 feet wide, with a balustrade three feet high both on the inside and outside. The inner diameter of this gallery and the aperture which it formed was roughly 16 feet, the neck of the balloon hanging exactly in the centre. Immediately under this neck an iron grate or brazier was supported by chains. The total weight of this machine was over 1600 lbs.

To carry out the experiment, a fire was lit on the grate in order to keep the air with which the balloon was inflated, hot; M. de Rozier got into the gallery, and after a few trials to ascertain that he had sufficient lifting power, the machine was allowed to ascend about 84 feet from the ground, where it was held captive by ropes attached to the gallery. For four and a half minutes the plucky experimenter, by throwing straw and wood on the fire, managed to keep the air in the balloon sufficiently warm to retain its buoyancy, and then, quite gently, it returned to the ground.

This maiden voyage was followed by others, when ascents to a greater height were accomplished, and after a few days M. de Rozier took with him M. Girond de Villette. With both of these gentlemen on board, the machine rose captive to a height of about 330 feet, where it remained perfectly steady for nearly 10 minutes, M. de Rozier maintaining buoyancy meanwhile by constantly replenishing the fire. After the machine made a safe and gentle descent, the Marquis d'Arlandes took M. Villette's place, and another ascent was made with equal success.

Having thus satisfactorily paved the way, these intrepid pioneers determined to attempt a free ascent, that is to say to be completely liberated from any ropes or other controlling forces, and allow themselves to drift in whatever direction the wind would take them, after the manner of the sheep and its two feathery companions previously described. Accordingly on November 21st, 1783, a start was made from the grounds of La Mouette, a Royal palace in the Bois de Boulogne. M. de Rozier and the Marquis d'Arlandes took their places on opposite sides of the gallery so as to keep a good balance. The fire was lit on the grate, the air in the balloon thereby heated as usual, and, after Montgolfier, who was in charge, had ascertained that the machine possessed plenty of lifting power for itself and the two aeronauts, it was liberated and allowed to commence its journey.

Full and authentic accounts of this adventurous expedition can be read in many works,* and any of my young readers who are interested in the veritable beginning of the practice of aeronautics will therein find ample matter on the subject to digest.

As I only intend to touch lightly on the most important events in early aeronautic history, and to deal more particularly with the subject as it is to-day, it will suffice to say that these two French gentlemen, after rising to a considerable height, descended in a field about 5 miles distant from the Palace of La Mouette, the journey occupying less than 25 minutes.

It is well to note that all these earliest human ascents were made in balloons whose buoyancy was obtained by inflation with hot air, a process obviously needing a fire below the opening in the neck of the balloon to obtain the necessary heat, and it is equally clear that such a method must be attended with very considerable risk, however carefully managed.

These facts were so palpable that the idea of attempting a voyage in a balloon filled with inflammable air (hydrogen gas) soon suggested itself. Greater buoyancy, increased safety without a fire, and almost every consideration except the expense of making this inflammable air seemed to give it the preference for use in balloons.

Two brothers named Robert, described as being highly skilled and intelligent mechanics, aided by a M. Charles, designed and constructed a spherical balloon, measuring some 28 feet in diameter, made of gores of

* Cavallo's "History of Aerostation," "Astra Castra," etc.

silk covered with a varnish which is supposed to have been a solution of elastic gum. A network covered the upper half of the sphere, and was fastened to a hoop which surrounded the middle of the balloon. To this hoop was suspended by ropes a sort of boat, which swung a few feet below the balloon; it was approximately 8 feet long, 4 feet wide, and 3½ feet deep, and it weighed 130 lbs. The gas-bag was fitted with a long pipe through which it was filled with gas, and, in order to obviate the chance of it bursting by any expansion of the gas, a safety-valve was made in the top of the sphere which could be opened by pulling a string.

On the 1st December, 1783, in the Garden of the Tuileries at Paris, this balloon was inflated with hydrogen gas, the cost of which had been defrayed by public subscription. M. Charles and one of the Roberts took their places in the boat or car, carrying with them provisions, clothing, ballast in the shape of bags of sand, a barometer to indicate their altitude, and a thermometer so that they could note the variations in temperature.

Subsequent chapters of this book dealing with the present method of making balloons, the instruments used, and the contrivances for inflation and deflation, will show the reader that these Frenchmen, in the very earliest days of ballooning, possessed sufficient foresight and intelligence to anticipate the necessary apparatus and general principles of construction which have remained practically unaltered up to the present day, and to which but few slight additions and improvements have been made.

The first ascent in a balloon inflated with gas lasted about an hour and a half, a descent being effected near Nesle, nearly 30 miles distant from Paris. As the balloon still contained a considerable quantity of gas, M.

Charles determined to ascend again, but this time alone, so that the weight to be lifted was reduced by about 130 pounds in the absence of M. Robert. Being unable to find any convenient receptacle for carrying some earth or stones as ballast to make up this deficiency in weight, M. Charles decided to start without doing so, and, directly the peasants who had been holding the car down released it, the balloon rose very rapidly to a height which was estimated by the aeronaut at about 9000 feet. M. Charles proceeded to take sundry observations, noting the height of his barometer and thermometer, and eventually made a safe descent by using his valve to allow the gas to escape, and by throwing out small quantities of ballast as he neared the ground in order to land gently, thus carrying out the procedure generally approved and followed by aeronauts to-day, as explained in a later chapter dealing with the practice of ballooning.

Before referring to one or two more of the very early balloon ascents, I wish to lay stress on the names of Montgolfier, Pilâtre de Rozier, Robert, and Charles, who, without doubt, will be handed down to posterity as the initiators and absolute pioneers of aeronautics. Within a very few months after the experiments and ascents I have referred to, the example of these few men was followed in almost every part of the civilised world by others proceeding on precisely similar lines, and though ballooning, like other things, is quite simple when you understand it, one should always do honour to and remember those who, having evolved a principle and put it into practical operation, thus laid the foundation of what is daily becoming a most important science.

The first aerostatic experiment made in England is attributed by historians to an Italian, Count Zambeccari, who was living in London. Impressed by the accounts of the experiments conducted at Annonay by the Montgolfiers in the preceding June, he made a balloon of oil silk, spherical in shape, 10 feet in diameter, and weighing 11 lbs. It was gilded on the outside partly to make it look beautiful, and probably more by reason of the idea of making it more gas-tight. It was eventually filled with hydrogen, and on the 25th November, 1783, was liberated from the ground of the Honourable Artillery Company in the City, in the presence of thousands of spectators. Two and a half hours later it came down near Petworth in Sussex, some 48 miles from London, so that it travelled at the rate of nearly 20 miles an hour.

In the United States of America experiments had been made at Philadelphia for the adoption of gas in balloons almost simultaneously with those in France, and, on the arrival of the news that M. de Rozier and the Marquis d'Arlandes had made a successful free ascent, two members of the Philosophical Academy, Messrs. Rittenhouse and Hopkins, constructed a machine consisting of 47 small hydrogen balloons attached to a wicker car or cage. After some preliminary trials in which animals were used as passengers, followed by a captive ascent by a man, a free ascent was undertaken by a carpenter named James Wilcox, on the 28th December, 1783.

The wind took him rapidly towards the river, and wishing to avoid the risk of falling in the water, he descended very quickly before reaching the banks. The method adopted for bringing this curious machine down was to cut slits in the balloons, one or two at a time, thus gradually reducing the buoyancy or lifting power. Wilcox cut three of the balloons, but, finding

This is incorrect. There was no such ascent.

this had no effect, he cut three more, and then another five almost simultaneously. The apparatus then fell so fast that the aeronaut evidently made an uncomfortable and somewhat perilous landing, which resulted in a dislocated wrist. So ended the first human ascent in the New World.

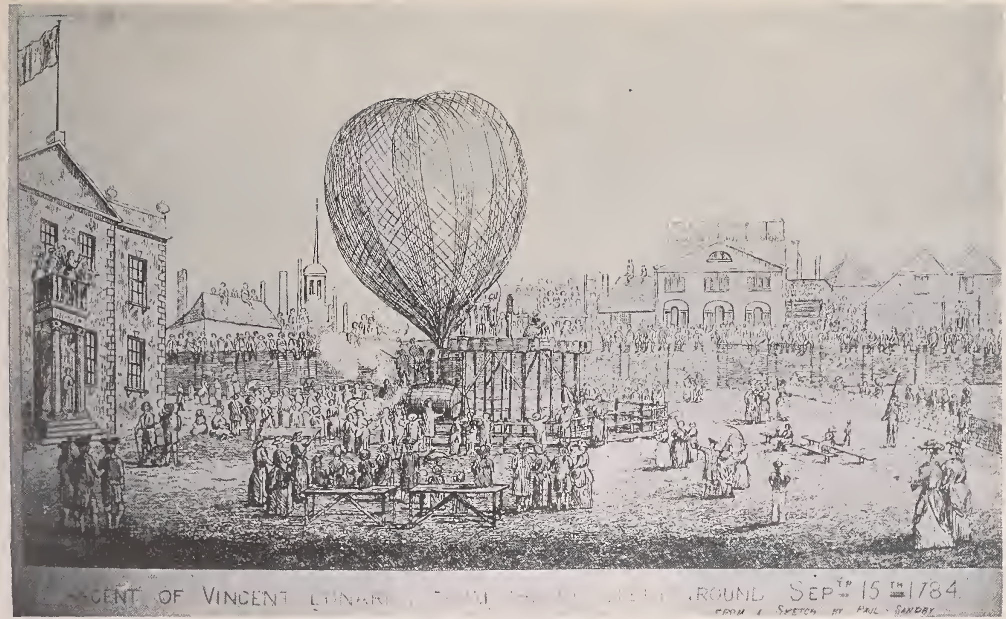
Captive ascents in balloons of all sizes now became quite the vogue, and many ladies as well as gentlemen thus early in the history of ballooning are recorded as having enjoyed the sensation of rising from the ground and floating in the atmosphere.

The next free ascent of note was made by a Frenchman, M. Jean Pierre Blanchard, who, for several years before the Montgolfier discovery, had attempted to fly by mechanical means. As soon, however, as the principle of the balloon was evolved and proved to be practical, M. Blanchard determined to use one for his lifting power, adding the wings devised for his former scheme to aid in ascending and descending, and if possible in steering a course through the air. He constructed a spherical balloon 27 feet in diameter attached to which was a boat made and suspended much in the same manner as that used by M. Charles, with the addition of two flapping wings and a rudder. He also fitted a kind of large open umbrella, which he considered would check the rapidity of a fall in the event of his balloon bursting. The principle of the parachute was thus early introduced in conjunction with balloons.

On the 2nd March, 1784, M. Blanchard made his first ascent from the Champ de Mars, where as usual an immense crowd of spectators had assembled. The balloon being filled with hydrogen, M. Blanchard first attempted to start accompanied by a companion; their combined weight, however, was found too heavy for the lifting power of the balloon, so he eventually ascended by himself. The wings and rudder were operated by the aeronaut, but had no visible effect, the balloon drifting with the wind across the river Seine and over Passy. Then for about a quarter of an hour it remained almost stationary in a calm, until the wind springing up in an opposite direction brought it back across the river, when it again was becalmed for some minutes. Blanchard threw out some ballast and rose into another air-current which carried him a third time across the river. After a trip lasting an hour and a quarter, he descended safely in the plain of Billancourt, near Sevres, which place is now well known as the headquarters of the famous Etablissements Robert-Esnault-Pelterie, the great aeronautical factory where M. Pelterie makes motors, aeroplanes, etc., and conducts his own personal experiments with flying machines, all of which are described in another part of this book.

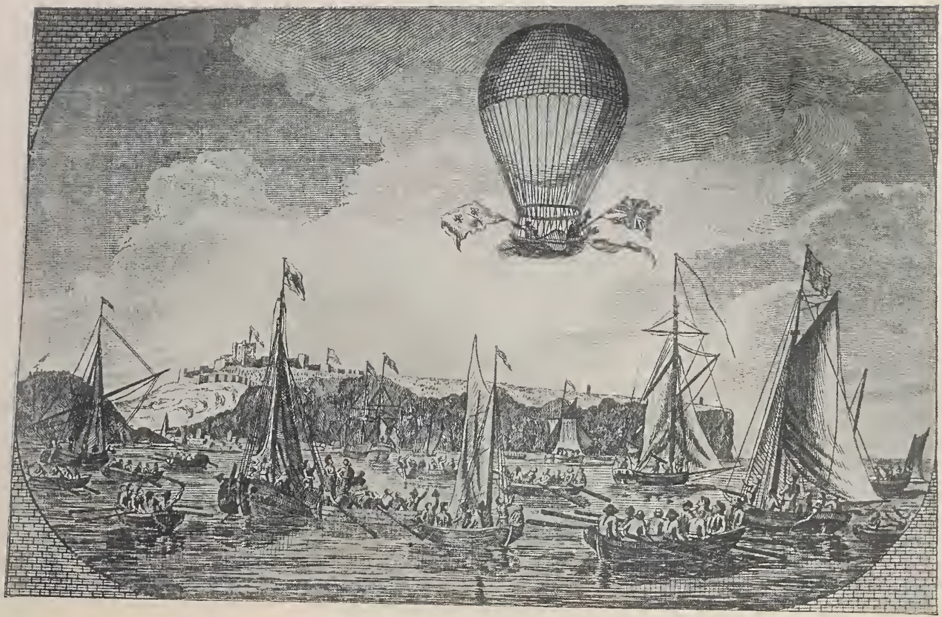
Although ballooning from this time onwards up to the present has been practised by thousands of persons on almost identical lines with those of its originators, and volumes might be filled with really interesting accounts and anecdotes of innumerable ascents, to recount them here would occupy far too much time and space. I must, however, refer to the first free ascent ever carried out in England, made by a Mr. Vincent Lunardi, who at this time was Secretary to the Neapolitan Ambassador in London.

Lunardi built a balloon and car, the latter fitted with a pair of oars, which was exhibited for many days in the old Lyceum in the Strand, which occupied the site of the present famous Lyceum Theatre, and was then a large room used for the exhibition of pictures.



ASCENT OF VINCENT LUNARDI, 1784. THE FIRST BALLOON ASCENT IN ENGLAND.

Face page **12.**



THE FIRST CROSS-CHANNEL TRIP.

Face page 13.

He obtained the patronage of King George III, and permission from Sir George Howard, who was then the Governor, to make an ascent from the grounds of the Pensioners' Hospital at Chelsea.

Owing, however, to the failure of a Frenchman named Moret, who had advertised that he would undertake a similar ascent at an earlier date, and the consequent rage of the crowd who, having paid for admission, smashed up Moret's machine and regarded him as an impostor when he could not rise from the ground, this permission was withdrawn, and Lunardi was for a time unable to secure a suitable starting-place.

Eventually, however, through the agency of several friends who interested themselves on his behalf, the parade ground of the Honourable Artillery Company was placed at his disposal, and on the 15th September, 1784, in the presence of the Prince of Wales, and a crowd estimated at nearly a quarter of a million of people, Mr. Lunardi commenced his ascent accompanied by a dog and a cat.

When it was seen that the plucky foreigner, instead of being an impostor and a failure like Moret, was in reality soaring in mid-air and being carried off by the wind in a northerly direction, the multitude of people were as loud in their praises and exclamations of surprise and delight as they had previously been in their execrations and jeers.

After a run of about an hour and a half Lunardi made a temporary descent in a cornfield at South Mimms, in Hertfordshire, where he landed the cat, which was apparently affected by the cold. Not yet satisfied with what he had accomplished, he threw out ballast and again rose in the air. During the first ascent he had tested the use of his oars, one of which broke off and fell to the ground. With the remaining one, however, he stated that by hard work he brought the balloon to the ground without discharging any gas. (In all probability this idea was entirely fallacious, for the oar could have had little or no effect. Most likely some of the gas was constantly escaping through leaks in the balloon.) He wrote two or three very short letters, which he threw overboard, describing his sensations and experiences, and during the second ascent he carefully watched his barometer and thermometer, noting the changes of temperature at different altitudes, and again threw out despatches. His second descent was effected in a meadow near Ware. Some labourers who were at work would not come near him when asked to render assistance, until at last a young woman who was also in the field was braver than the men and caught hold of the cord which Lunardi had thrown out. The men then plucked up courage and gathering round the car held it down while the aeronaut got out. A crowd quickly assembled and General Smith, with some others who had followed the balloon on horseback from the time it left London, soon arrived on the scene. The gas was allowed to escape by making a cut in the balloon.

Needless to say, Lunardi was quite the hero of the day in London, all incredulity vanished, and when he wished to make other ascents, friends offered him pecuniary assistance, and everything was done to facilitate his experiments.

The first voyage across the English Channel in a balloon was made by M. Blanchard, accompanied by Dr. Jeffries. They left Dover at 10 A. M. on the morning of 7th January, 1785, were carried by a light breeze over the water passing between Cape Gris Nez and Calais at 3 P. M., and landed in the Forest of Guines shortly afterwards. A monument was subsequently erected on this spot, bearing the following inscription:

SOUS LE RÉGNE DE LOUIS XVI,

M DCC LXXXV,

Jean-Pierre Blanchard des Andelys en Normandie,
Accompangné de Jean Jefferies, Anglais,
Partit du château de Douvres
Dans un aérostat,
Le sept janvier à une heures un quart;
Traversa le premier les airs
Au-dessus du Pas-de-Calais,
Et descendit à trois heures trois quarts
Dans le lieu même où les habitants de Guines
Ont élevé cette colonne
À la gloire des deux voyageurs.

I cannot close this brief account of the earliest recorded ascents without mentioning the sad end of Pilâtre de Rozier, the first of all aeronauts.

In an attempt to emulate the performance of Blanchard in crossing the Channel, and also in the hope of proving the efficiency of a balloon filled partly with hydrogen and partly with hot air, he started from the French coast accompanied by Mr. Romaine, on the 15th June, 1785, with a favourable breeze.

Before the balloon had cleared the land, however, the crowds below were horrified to see it suddenly burst into flames, and rapidly fall. Needless to say it was entirely destroyed, and the two plucky occupants were killed. This incident cast a gloom over everyone, and for some time created a bad impression in the public mind as to the wisdom of pursuing the study and sport of ballooning. By degrees, however, it was realised that though an accident might occasionally occur, there was good reason to continue experimenting, and shortly after this time balloons were utilised in warfare, a description of which will be found in the chapters dealing with military ballooning.

With these words I must leave ancient history to be studied in other books, and come to the realities of to-day, and some more practical description of the various kinds of aerostats now in existence and use.

II

Names and Uses of the Various Parts of a Balloon

A balloon is a vessel generally made of light cotton, or silk material, strips of which are sewn together and varnished, whilst others are made of a stronger and heavier material known as rubber fabric, and others again of gold-beaters' skin, several thicknesses of which are frequently joined together by an ingenious process whereby the whole balloon is made in one part.

The usual shape of a balloon is spherical, but this form is sometimes slightly altered, and for certain purposes a pear-shape is adopted. A balloon is usually inflated with ordinary coal gas, and rises because, inclusive of its own weight and its load (whatever that may be composed of), it is lighter than air. A balloon floats in the air, and moves in the same direction and at the exact speed of any air-current in which it is for the time being, located.

This gas-holding part of the balloon is called the "envelope."

The Valve is a wooden or metal device at the top of the envelope with doors opening inwards which, when pulled by a cord known as the valve line, open and allow the gas to escape. These doors are closed by means of springs when the valve line is released.

The Ripping-Valve is a long narrow strip of material closing up a corresponding aperture in the envelope, to the inside of which it is sewn. A stout line known as the ripping-cord is attached to its upper end, so that if it is necessary to deflate the balloon, when descending or at any other time, more rapidly than the valve can effect, by pulling down the ripping-cord the strip of material is torn out, a big gash is made in the envelope, and the gas is thus enabled to escape and the balloon becomes deflated in a few seconds.

THE NET is made of stout cord with a large mesh. It covers the envelope from the top about two-thirds of the way down, adding greatly to its strength, and, as it supports the entire weight of whatever the balloon carries, the strain is thus equally divided all over the upper part of the envelope. It terminates in a number of lines called "leading-lines," to which the hoop is attached.

THE HOOP is a circle of strong wood, usually bound with hemp or steel wire, to which the leading-lines from the net are attached, and also the "car-lines," the other ends of which are fastened to the basket or car. Both the leading-lines and the car-lines are attached to the hoop by the method of loops and toggles.

THE MOUTH is a circular opening in the centre of the bottom of the envelope to which is attached a cylindrical tube or appendix which is called THE NECK.

The balloon is inflated by joining a gas pipe from a main supply securely to this neck, and when it is sufficiently filled with gas the mouth is tied up and the supply pipe disconnected. Immediately prior to the balloon leaving the ground to make an ascent, the mouth is opened and the neck becomes an automatic overflow, as I will explain later.

THE TRAIL-ROPE (which was invented by Charles Green in the year 1828) is a stout rope usually about 250 feet long, varying from 20 to 90 lbs. in weight, ac-

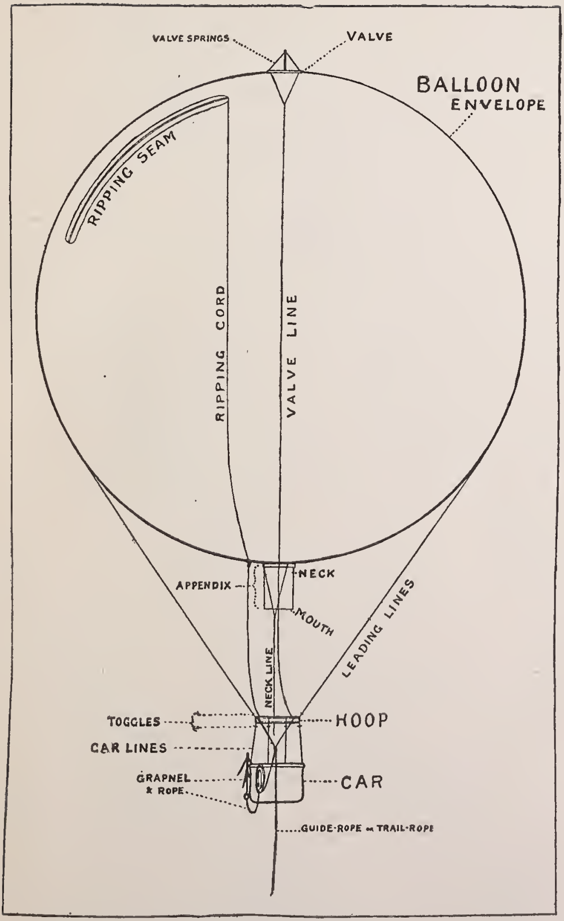


DIAGRAM SHOWING ESSENTIAL PARTS OF A BALLOON.

Face page 18.

cording to the size of the balloon, and is attached to the hoop. It is usually lowered and allowed to hang below the car during an ascent. When descending, as the trail-rope reaches the ground, the balloon is relieved of part of its weight, which enables one to come down more slowly and in greater comfort. It is also used as a brake to check the speed of the balloon when travelling near the ground prior to a descent. Floating near the ground with the trail-rope dragging along in this manner is known as "trailing."

The Grapnel or anchor is attached to the car by a long rope which is kept coiled up and hanging on the outside of the basket. In making a descent the grapnel is used in addition to the trail-rope for checking the speed of the balloon, as when thrown out it will catch in a tree-top, a hedge, or on the surface of the ground itself, and so literally anchor the balloon.

Last but not least is the Car or basket, in which the passengers stand or sit. It is attached to the hoop by the car-lines as stated previously, and varies in size and depth according to the size of the balloon and the number of passengers to be carried.

A glance at the outline diagram will, I think, enable anyone who has not even seen a balloon to understand the names and uses of these various parts as enumerated.

III

Something About Gases—Lifting Power—Variations in Atmospheric Pressure—Effects on a Balloon of (*a*) Increasing Altitudes, (*b*) Sun's Radiation, (*c*) Rain

The theory of ballooning is based entirely upon the principle of Archimedes, which is probably well known to all my readers. This law says that "Every body which is immersed in a fluid loses a part of its weight, or is acted upon by an upward force equal to the weight of the displaced fluid." Hence a body will remain at rest in any position if immersed in a fluid of equal specific gravity; if its specific gravity is greater than that of the fluid, the body will sink; on the other hand if its specific gravity is less, it will float. This law applies to gases in the same way as it does to liquids, consequently a balloon will rise in the air if its total weight is less than the weight of the air which it displaces.

Before we can form any clear idea of the practice of ballooning and the principles which govern it, we must consider certain facts relating to the properties of air, and of the gases used for filling balloons.

For our purpose the hot air, as used by Montgolfier and others of the early school of aeronauts, may be dismissed with a few words, as its employment has been practically discarded. It consists of a mixture of heated air, the light gaseous products of the fuel, and water vapour. It is best produced from straw amongst which fine wool is scattered, which prevents the development of any smoke. The gas or hot vapour which is thrown off by this brightly burning mixture is considerably lighter than the ordinary atmosphere. Its disadvantages are, however, too numerous to make it of any use for ballooning.

We know that air possesses weight, and also all gases in various proportions. Thus, taking the weight of a cubic foot of air at .08 lbs., it has been ascertained that a cubic foot of ordinary average coal-gas at the same temperature and altitude is approximately .04 lbs., or just one-half the weight of the air. Hydrogen is a very much lighter gas, a cubic foot under the same conditions only weighing .0056 lbs.

Following out the principle of Archimedes that a body immersed in a fluid or gas is acted upon by an upward force equal to the weight of the fluid or gas displaced, one can calculate that a cubic foot of coal-gas is acted upon by an upward force of .04 lbs., and a cubic foot of hydrogen by an upward force of approximately .075 lbs.

The following little table of weights is approximately accurate, and being an easy one to remember may often be useful for making simple calculations of sizes of balloons:

A cubic foot of water weighs............	1000 ozs.
A cubic foot of air weighs..............	1 oz.
A cubic foot of coal-gas weighs.........	½ oz.
A cubic foot of hydrogen weighs.........	1/10 oz.

Hence the weight of coal-gas or hydrogen contained in an envelope of any known cubical capacity may readily be ascertained. How to arrive at the cubical contents of a spherical balloon of known diameter, and *vice versa,* will be found in the chapter dealing with balloon construction.

For the purposes of practical ballooning it is usually assumed that 1000 cubic feet of coal-gas will lift a weight of 40 lbs., and 1000 cubic feet of hydrogen a weight of about 70 lbs.

It is now fairly simple to calculate the size necessary for balloons to carry one, two, or three or more persons, estimating the weight of each person at, say, 150 lbs., and adding the weight of the envelope, net, basket, trail-rope, anchor, and other accessories, whilst a considerable margin of weight must also be allowed for sand ballast, without a plentiful supply of which it is impossible to make a long trip, as I will explain later.

Before quitting the subject of gases, it should be remembered that their expansive qualities are all similar, that is to say, gases of greater or lesser specific gravity expand equally and not according to their different gravities under various pressures.

We read in books of natural philosophy that the pressure of the atmosphere at sea-level is 15 lbs. to the square inch, and this pressure becomes less and less the higher one rises from the earth. All gases by the nature of their composition are elastic, or expansive, so that as a balloon rises higher from the ground the gas which the envelope contains gradually expands as the external pressure of the atmosphere diminishes.

The variations in atmospheric pressure and the degree of expansion of coal-gas and hydrogen at different altitudes need not be entered into here, but tables and calculations dealing with this subject can be found in handbooks and technical works upon ballooning,* a study of which will be most useful to any intending aeronaut.

* Moedebeck's "Pocket Book of Aeronautics" is probably the most comprehensive and useful work yet published in this respect.

As one ascends higher and higher the atmospheric pressure—or the weight of the air—becomes gradually less and less, so that the gas in the envelope expands more and more. Consequently a balloon which leaves the ground with a good margin of lifting power will continue rising until it reaches a height where this upward force ceases to exist, owing to the overflow of expanded gas through the open neck. If the balloon remains at this altitude it is said to be "in equilibrium," and its weight, of course, is then exactly equal to the weight of air it is displacing. If this condition could be obtained, a longer trip would be possible than is practically the case, because the momentum with which the balloon rises takes it beyond this balancing line, until when it eventually stops ascending it weighs more than the atmosphere it is displacing, and consequently begins to sink. Similarly the momentum it gathers in thus sinking generally carries it some distance below the line where it would be in equilibrium.

If left to itself a balloon would continue rising and falling in this way, and at each ascent gas would be lost by escaping through the neck, as the increasing pressure causes it to overflow. By a judicious use of ballast, that is to say, by throwing out very small quantities of sand directly you find the balloon is beginning to descend, this see-saw motion may be greatly reduced, and a condition of equilibrium be almost if not absolutely obtained.

All these points, which are rather difficult to explain on paper, are easily understood when you make an ascent, and the aeronaut in charge tells you exactly what is happening, and why different changes are taking place.

Two more things must be mentioned which exert considerable influence on a balloon, namely, the rays of the sun, and rain. The heat of the sun striking on the envelope makes the gas inside get warmer, which causes it to expand. The balloon consequently displaces more air, additional lifting force is created, and up you go.

Although the material of the envelope is of no great strength, the automatic overflow from the neck when it gets quite full, acts as a safety valve, and so the danger of bursting the balloon is averted.

When rain falls on a balloon it not only tends to cool the gas, causing it to contract and so occupy less space in the air, but also adds considerably to the weight, for the net, car, ropes, and the envelope itself naturally absorb a lot of the moisture.

Accordingly the effect of rain is exactly the reverse of sunshine and the balloon rapidly falls lower and lower. To check this descent it is therefore necessary to keep lightening the balloon, and this is done by throwing out ballast.

From the foregoing remarks it is obvious that the larger the envelope, and the more sand ballast one can carry, the longer is it possible to remain in the air.

IV

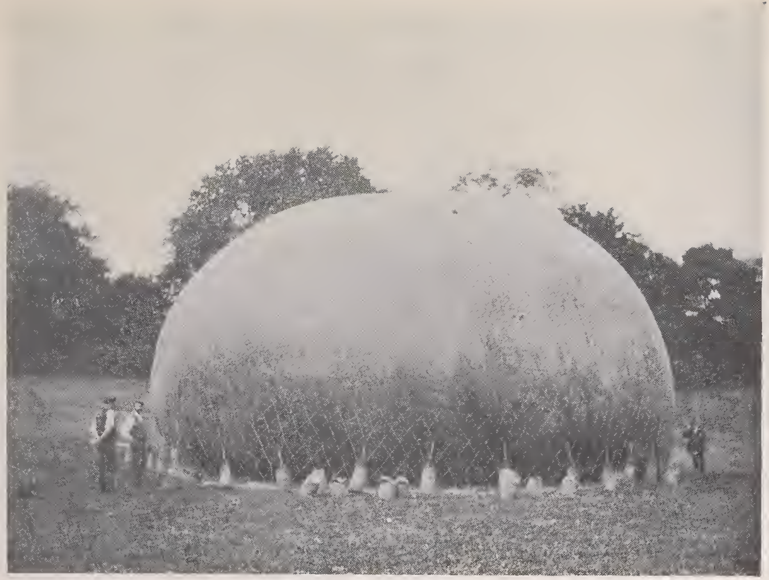
The Practice of Ballooning—Laying Out—Inflating—Weighing and Letting Go—Sensations of Ascent—How to Descend—Landing—Packing up

Laying out a balloon, as the term signifies, is the manner of placing it on the ground and making the necessary connections of its different parts before filling it with gas.

So as to protect the envelope from any dampness or dirt which may be on the ground, it is customary to spread down first a large cloth or sheet of canvas. The envelope is then placed on this sheet with the circular hole to which the valve is fitted exactly over the mouth. The neck is then attached to the mouth and connected to the gas supply pipe. The envelope is spread out radially from the centre, the valve-line connected to the valve, and coiled down, so that it will fall through the mouth as the balloon is inflated; the ripping-cord is attached to the top of the ripping-panel on the inside, passed through its small separate tube at the bottom of the envelope, and coiled down; the valve is then fixed in place, its rim being in two parts between which the round edge of the opening in the envelope is squeezed, being retained in this position by tightening the butterfly screws connecting the two parts of the valve rim.

The net is then placed with its centre exactly over the top of the valve, and is spread out to its fullest extent all round, held by strong bags containing sand (the weight of which is usually 30 lbs.), with large metal hooks attached to their tops, and then hooked onto the net about half way down, and at an exactly equal number of meshes distant from the centre. The supply pipe is now connected to the gas main, the gas turned on, and the inflation commenced. As the envelope begins to fill, the valve and upper part of the envelope are gradually raised from the ground and the balloon commences to assume the shape of a giant mushroom. As the inflation continues the sand-bags are moved downwards one mesh at a time consecutively round the balloon to allow the envelope to rise, care being taken that this is done equally; this process continues until the lowest meshes of the net are occupied, when the balloon will have assumed a spherical form, and the neck be clear of the ground. The leading lines in which the net terminates are then toggled onto the hoop, and the hoop in turn connected to the basket by the car-lines. The gas having been turned off, the supply pipe is disconnected from the neck, the lower end of the valve-line is placed in a white pocket fastened to the hoop; and the neck tied up by a breaking band, to which a green cord is attached. A portion of the stack of the red ripping-cord is drawn through its tube, and placed in a red pocket on the hoop. The trail-rope and anchor-rope are attached to the hoop, and the envelope is allowed to rise higher; the sand bags being removed from the last row of meshes or "doubles" onto the outer ends of the leading-lines, and when all are thus attached they are allowed to slide in towards the hoop. Red bags filled with sand are placed in the car, and as the balloon still rises the other sand bags are detached from the hoop and hooked around the outside of the car. The balloon is now ready for the aeronaut and passengers to get in.

Before starting you must ascertain that the valve-line



A Partly Inflated Balloon.

Face page 26.

Climbing the Net to Make a Repair.

Face page 27.

and ripping-cord are clear, the valve usually being tested to see that it opens and closes properly. You also see that the neck-line is clear, and the trail-rope and anchor-rope coiled on the outside of the basket, all clear for letting go by slipping the thin cords which hold them in position; the different instruments carried are attached in convenient places, and then all is ready.

Trying the lifting power, usually termed "weighing," now takes place. A few people stand round the basket with their hands on it, and the sand bags are taken off one by one, until it is found that the balloon and car will rise. It is desirable to have sufficient lift to ensure the balloon getting away clear of any surrounding buildings, yet only sufficient to rise slowly and not rapidly, the main object in view always being to take as much ballast as possible with you.

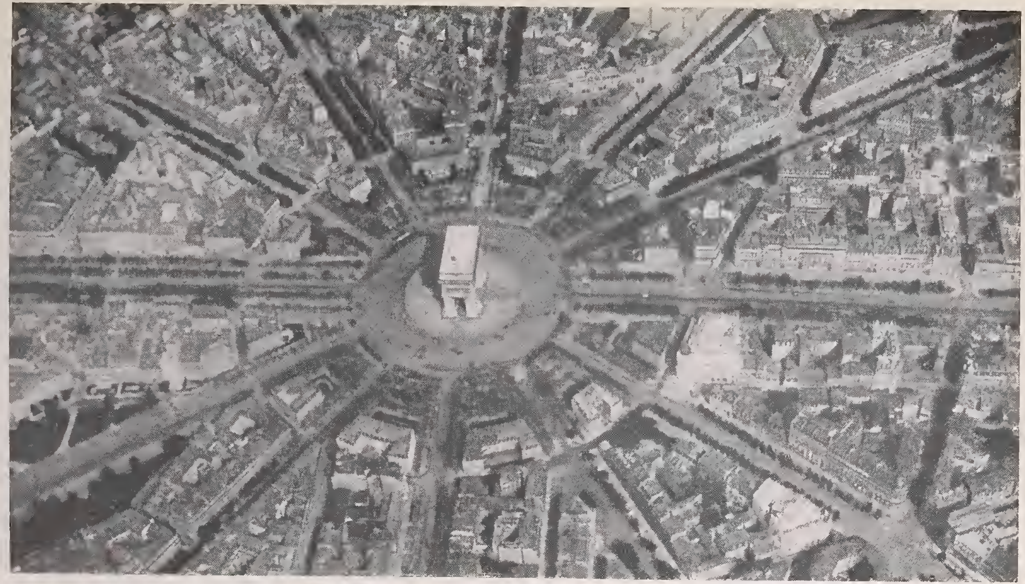
When the balloon has been weighed two or three times in this manner, and the aeronaut in charge is satisfied that all is correct, he pulls the green cord which opens the neck, gives the order "hands off," at which everybody on the ground stands clear, and the balloon commences to ascend.

The sensations of a first ascent are almost invariably most delightful to the passengers. No motion of the balloon is appreciable as it floats steadily in the air, and looking over the side of the car it seems that the earth is gradually receding from one while the balloon is remaining stationary. Giddiness or sickness are rarely if ever experienced during a free ascent, and one feels the delight of being in a perfectly calm and still atmosphere. No wind can be felt, for the balloon is travelling exactly with the wind, and if the eyes are closed it seems that you are in a room well ventilated, but free from all draught.

To anyone who has enjoyed the pleasure of looking down on a city from the summit of a high building, or admired the surrounding landscape from a hill or mountain top, the still more wonderful panorama of the earth below as viewed from a balloon on a clear day at the height of two or three thousand feet can be well imagined. For those who have never tried it, my advice is to be taken up by some reliable aeronaut at the earliest opportunity, and I am convinced that not more than one person out of every fifty (and probably not even that one) will find anything unenjoyable about ballooning in favourable weather. With all novices there must be a feeling not only of curiosity, but of the "shall I like it?" nature, for such an undertaking is sufficiently strange to stir even the strongest mind. After a very few moments of floating in the air a feeling of perfect confidence and exhilaration usually replaces any earlier sensation of misgiving.

At the start of an ascent a bag of sand is always kept in readiness, so that some or all of it may be thrown out in case of a sudden downward draught, or if the balloon does not rise sufficiently to clear any surrounding obstructions. The trail-rope is usually let out on reaching open country.

The novice should remember that, subject to the neck being kept open and clear of any obstruction, it is virtually impossible for the balloon to burst, but should any unforeseen circumstances cause this to occur, and so allow the gas to escape rapidly, it is satisfactory to remember that the balloon will automatically assume the shape of a parachute or open umbrella, and though doubtless this must give rise to anxiety, it has been proved on numerous occasions that it is not attended with any real danger, as the balloon will descend in safety to the ground. The



L'Arc de Triomphe, Paris, from a Balloon.

Face page 28.

The End of a Descent.

Face page 29.

neck-line must, of course, be free, or the balloon could not parachute. Examples of this having happened will be found in a subsequent chapter relating true narratives of what I have either personally witnessed or have heard from the lips of the aeronauts themselves.

We now come to the methods of descent. A balloon, as previously explained, automatically comes down after a certain period owing to loss of gas, but if it is desired to descend earlier the valve-cord is pulled to allow a little gas to escape from the top of the envelope, where, it must be remembered, the gas is always trying to force its way upwards and out. The anchor-rope is then allowed to drop in a loop, so that the anchor itself may be thrown out if required later. The loss of gas and consequent loss of lifting power causes the balloon to come down gradually, and the aëronaut, keeping an eye on the aneroid (which indicates the gradually reducing altitude), regulates the speed of descent by throwing out small quantities of sand if he considers the fall is too rapid.

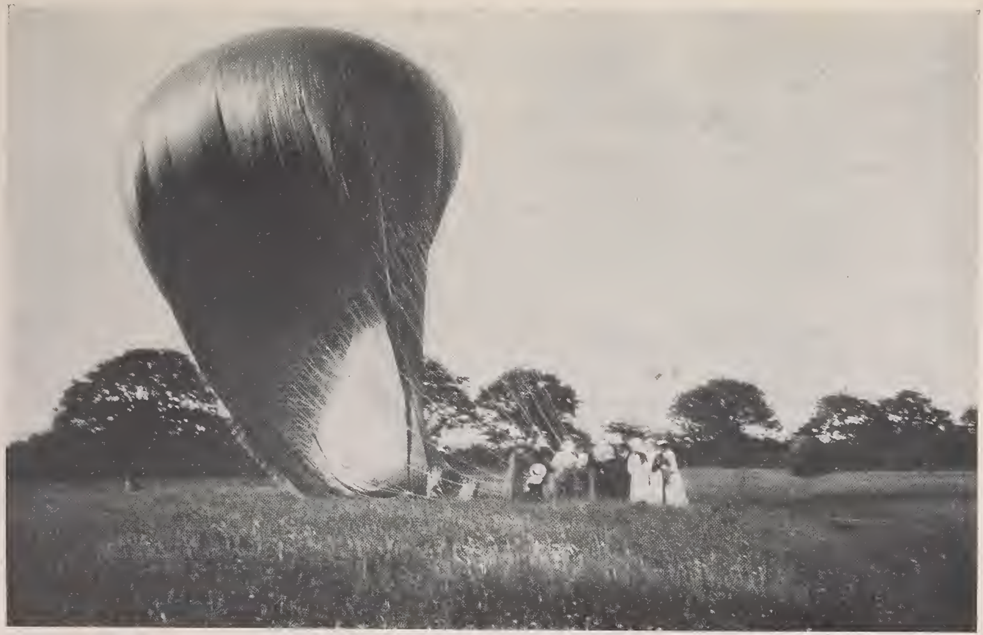
Usually one looks for a large open field or common, free of trees, buildings, or other obstructions likely to damage the balloon or its occupants, and when close to the ground the trail-rope dragging along immediately reduces the load and so aids in checking a rapid descent. In this way you carry on until a suitable spot is arrived at for landing, and then, by again valving, the balloon is brought to the ground. If it is a calm day or only a very slight breeze prevails, the balloon will not drag or bump along the ground, as the trail-rope is sufficient to retain it stationary; if, however, a fresh wind is blowing, the car is often dragged along, brushing through and over hedges, and making it difficult to come to a standstill. In such cases the anchor is let go, and it is customary for the aeronaut to pull down the ripping-cord hand over hand, thus forming a large rent in the upper part of the envelope, out of which the gas will escape in ten or fifteen seconds, the envelope being spread on the ground in the direction it is blown by the wind, while the car with the passengers remains stationary.

Nearly everybody has seen a balloon make an ascent, but a very limited number in comparison have seen a landing effected, which is really by far the more interesting and exciting event. It should be remembered that just before the car touches the ground it is advisable to bend the knees, in which way the shock or bump on landing is hardly noticed. It is most important also that everybody should remain in the car until the envelope is deflated, as the balloon, if relieved of the weight of one person, would begin to ascend again.

Generally speaking, one of the party remains near the car to disconnect the hoop from the car-lines and leading lines, to pack up the maps and instruments, and pour out the remaining sand. Another removes the valve and neck. The net is then pulled aside, so as to uncover the envelope, which is then folded in from the sides, rolled up lengthwise, and put into its protective cover, which has formed part of the "splosh," by which name a bundle consisting of the covers for the envelope, net, valve, and car is generally known.

The net and valve are put into their respective bags and placed in the car, together with trail and grapnel ropes and the grapnel, and the car itself is then covered.

With the assistance of helpers, who almost invariably collect after a descent is made, these two packages are placed in the first available cart that can be hired, and driven to the nearest railway station.



Deflating After Descent.

Face page 30.

Packed and Ready to Go to the Station after a Descent in France.

Face page 31.

V

Military Ballooning—First French Balloon Corps—Service in American Civil War—Episodes During Siege of Paris

During the French revolutionary wars in 1794, ten years after the early Montgolfier experiments, balloons were brought into use for military purposes. An Aeronautical School was founded in Paris, and reconnoitring balloons were constructed for each of the republican armies.

Captain Coutelle was in charge of the small body of men attached to General Jourdan's army as a balloon corps, and he was the first to make an ascent. This took place near Mayence, in May, 1794, in a balloon of 30 feet diameter, inflated with hydrogen. This hydrogen was obtained by passing steam through red-hot cylinders charged with scrap iron, the gas so formed being then passed over lime, to free it from the heavy carbonic acid gas. This method was inexpensive but slow, for it took fifty hours to procure sufficient hydrogen to fill the envelope.

When Coutelle made his ascent, the balloon was held captive by two ropes, and he communicated his observations by throwing out weighted letters for the General below. The Austrian enemy strongly objected to this novel method of warfare, and, regarding it as a mean form of spying, opened fire on the balloon with a 17-pr. Howitzer. Several shots were fired without effect, but Coutelle, realising his danger, gave orders for the captive ropes to be eased out, and the balloon ascended to a height of about 1300 feet, which placed it well beyond range.

Two or three weeks later the balloon was moved to Charleroi, and on the 17th June, 1794, it was employed for about eight hours during the battle of Fleurus. Directly the Austrians discerned it in the air they began firing at it, so the aeronauts quickly rose until they were out of range, and were able to keep General Jourdan constantly informed as to the Austrians' movements, thus contributing largely to his success in this battle. The Austrians fully realised this fact, and having no balloon corps of their own, announced that any balloonists who fell into their hands would be treated as spies and shot.

The next battle that the French gained through the assistance of a captive balloon was near Liege, and the Austrian officers afterwards declared that it seemed as if the eyes of the French General were in their camp, for they were attacked at the critical moment of sending off their guns and baggage, the French of course having been kept acquainted with all that was going on by the aeronauts.

Notwithstanding these examples of their utility, it seems that subsequently some of the French generals reported unfavourably on the uses of balloons, and in consequence of this and of the failure of the balloon corps to achieve any success in Egypt, Napoleon early in the present century disbanded the two companies which had been formed, and also closed the aeronautical school.

It is interesting to remember, however, that this first army balloon corps and government training college came into existence no less than a hundred and fifteen years ago, and it is somewhat remarkable that, although balloon corps have been formed from time to time during the intervening period by England, America, and several of the continental powers of Europe, practically nothing has been done in the way of establishing regular government aeronautical departments or training colleges until quite recently.

Balloons were again employed by the French army in the Italian campaign of 1859, when the observation work was carried out by some civilian aeronaut with a large hot-air balloon, and it is not surprising that the results obtained were unimportant. Far more useful work, however, was accomplished by the balloons attached to the Federal army during the American Civil War, in the years 1860-1864. These envelopes were made of the best silk, the upper part containing the valve being of three or four thicknesses to give additional strength where the strain is always greatest. The varnish, on which so much depends for making the balloon gas-tight, was evidently of excellent quality, the envelopes being said to have retained the hydrogen with which they were inflated for upwards of a fortnight at a time. It is, however, probable that this is not strictly accurate; the hydrogen was most likely replenished day by day, in order to keep the envelopes fully inflated.

When the Federal army was preparing to attack the main body of the Confederates the latter occupied one bank of the Chicahominy River, with the town of Richmond lying behind them; the Federal army, about 100,-000 strong, and extended over a front some twelve miles long, held the opposite bank of the river, and balloon ascents were made daily from a central position in their ranks.

The town of Richmond was approximately eight miles distant from where these captive ascents were made, and on clear days, from an altitude of 1000 feet, a good view of the Confederate capital and its surrounding fortifications and roads could be obtained. The country being of a woody character made it somewhat difficult to ascertain the number of troops, but by seeing most of the camps it was possible to form a rough estimate, and also to determine the exact position of various earthworks for a considerable distance.

It is recorded that during the fighting before Richmond a telegraph apparatus was taken up in the balloon car, and, the wire being connected with the telegraph lines at Washington, telegraphic communications were sent direct from the balloon whilst soaring over the battlefield to the Federal Government.

Balloons were again used by the French during the siege of Paris in 1870-71, in spite of the fact that there was no balloon corps in existence at that time in the French army. Valuable services, however, were rendered by free balloons, almost all of which were in charge of sailors and untrained amateur aeronauts. Sixty-six balloons were despatched in this way during the siege, carrying important letters and despatches, and also taking with them carrier-pigeons, which were all trained to act as bearers of return messages.

Captain A. Hildebrandt, Instructor in the Prussian Balloon Corps, relates in his book on ballooning that these sixty-six balloons carried out of Paris 66 aeronauts, 102 passengers, 409 carrier-pigeons, 9 tons of letters and telegrams, as well as six dogs. Five of these dogs were sent as message carriers on the return journey to Paris, but nothing more was ever heard of them. Fifty-seven carrier-pigeons were all that returned to the besieged city, but they carried no less than 100,000 messages. These messages were wonderful bits of work, as many as a thousand different sentences being inscribed in tiny letters on small pieces of paper, which were then attached to the legs of the pigeons. Fifty-nine balloons did their work as arranged, five fell into the hands of the enemy, and two were never heard of after leaving the city, having probably fallen into the sea.

One of the journeys deserving special mention is that of M. Gaston Tissandier, a celebrated French aeronaut, who threw from his car 10,000 copies of a proclamation addressed to the German soldiers. It contained a demand for peace, while stating that the French were prepared to fight on to the bitter end.

Another notorious ascent was that of the great Gambetta, who left Paris with the idea of organizing an army from the provinces which should march to the relief of the besieged city.

After such episodes as these no modern army could be considered as completely equipped without a balloon detachment. Improvements have since been introduced both as regards the construction of balloon envelopes and the method of storing and carrying hydrogen for their inflation, which I will now briefly describe.

VI

MILITARY BALLOONING CONTINUED—THE SCHOOL AT WOOLWICH—TWO IMPORTANT ENGLISH INVENTIONS —A PERILOUS ADVENTURE—CAMPAIGNS IN EGYPT, AFRICA, AND CHINA—AMERICAN AND FRENCH DEVELOPMENT

EIGHT years before the Siege of Paris, when the events occurred which I have just related, experiments with captive balloons were made at Aldershot by an English aeronaut named Coxwell, who was able to demonstrate pretty conclusively that captive balloons would be of considerable value in a war; but the military authorities do not seem to have paid much attention to his success, or to have taken any immediate steps in the matter, for it was not until the year 1878 that the first regular Army Balloon School was started at Woolwich, under Captains Watson and Templer. The following year a company of Royal Engineers was sent to this school for instruction in the necessary field work connected with ballooning. Field work comprises the method of placing a balloon on a wagon, driving to the spot selected for an ascent, laying out, and inflating, all of which, combined with the practice necessary to shift sand bags rapidly and accurately, play an important part in the work of a balloon detachment, quite apart from the duties of the aeronauts themselves.

In the early days of his connection with the Balloon Corps, Captain Templer brought out two inventions of the highest importance, the first of these being a method

Inflating a Service Balloon on the Field.

Face page 36.

Army Balloon Ready to Ascend.

Face page 37.

of storing hydrogen under a heavy pressure in strong steel tubes or bottles. A 10,000 cubic feet service balloon could be inflated from these hydrogen tubes in ten or fifteen minutes on the field, an enormous saving of time by comparison with the method of manufacturing the gas when required for use as previously described, and also a reduction by at least a half of the weight necessary to be carried, when comparing the weight of steel tubes containing sufficient hydrogen to fill a balloon with the weight of the material and apparatus requisite to make the same quantity.

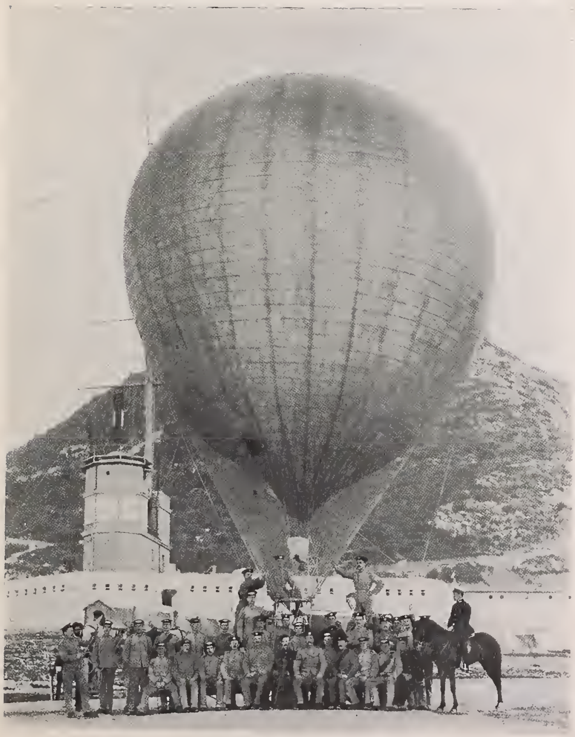
The other invention was perhaps even more important, for it was the discovery of a means whereby small skins, commonly known as gold-beaters' skins, could be joined together (just as you can graft a branch of one tree to the branch of another) and formed into balloon envelopes of any size and of as many thicknesses as desired. The great advantage of envelopes made by this process lies in the fact that they are virtually hydrogen-tight.

As we know, hydrogen is a gas of extremely low density, and it can escape through materials quite capable of containing ordinary coal-gas without allowing any to leak away. Envelopes of silk and cotton fabric are made fairly gas-tight by the use of special varnish, but even coal-gas can gradually filter its way through, and hydrogen would do so much more rapidly. This method of Captain Templer's for growing together skins which are practically hydrogen-tight provided a long-felt want in the manufacture of balloon envelopes, the greater lifting power of hydrogen enabling much smaller balloons to be used than is possible if coal gas is employed to obtain the buoyancy.

The process of making good skin envelopes has remained for many years an English secret, and all attempts at imitation in other countries have only produced poor results. The method of compressing hydrogen in steel cylinders has, however, been generally adopted by all military balloon corps, its advantages being apparent, for it eliminates many if not all of the difficulties previously experienced in transporting material and manufacturing the gas.

Balloon ascents were made almost daily at Woolwich, constant practice being considered essential to gain the experience necessary for ensuring competence either in captive work or free ascents. Going up in all sorts of weather, not always waiting for favourable conditions as would be done by any sensible amateur aeronaut, but determined to train himself and his men for rough service equally as for smooth, it is remarkable that Captain Templer and his companions did not meet with numerous accidents, but fortunately these were of rare occurrence. One free ascent made by Captain Templer and Captain Lee was, however, an exception, and probably constitutes the most extraordinary escape from a fatal disaster ever recorded in the world's history of ballooning. Though Colonel Templer (as he now is) is extremely reticent on the subject himself, I have fortunately obtained sufficient particulars from others to be able to tell you the story of what occurred.

The balloon was filled, as usual, in the middle of a small open space near the gas-works, and as the ground wind was rather boisterous and blowing exactly towards the large gas-holder (frequently though erroneously termed a "gasometer"), the balloon was taken as far as possible in the opposite direction and given what appeared to be a good lift, so that it would have time to rise higher than the top of the gas-holder before reach-



THE BRITISH ARMY BALLOON CORPS AT GIBRALTAR.

Face page 38.

ing this big obstruction to its flight. Notwithstanding these precautions a sudden squall of wind caught the balloon just after the order "hands off" had been given, and though she rose rapidly, it was impossible to clear the frame-work of the gas-holder, against which she dashed with terrific force. One of the uprights struck Templer's face, gashing it open from ear to chin and completely stunning him; brushing along a cross-beam, most of the car-lines were cut through, the basket tilted to one side, and Captain Lee was thrown out, luckily falling on the top of the gas-holder; at the same time several sand bags dropped out of the basket. It all happened so quickly that no one can say exactly what took place, but providentially Templer's legs got entangled either in part of the car or some of the ropes, and he did not fall out, though quite insensible at the time. Relieved of the weight of one man and nearly all its ballast, the balloon shot rapidly upwards, and those below immediately realised that she was carrying off the senseless if not dead body of Templer.

At a height of about 9,000 or 10,000 feet, the coolness of the atmosphere probably helped Templer to regain consciousness, and what his sensations were when he revived I leave you to imagine as best you can. Fancy finding yourself two miles above ground, caught by your legs in a balloon basket, itself only hanging to the hoop by a couple of lines, dizzy and faint from loss of blood, and knowing that unless you managed to handle the balloon by valving and so effect a descent, it would be merely a question of time before it would come down of its own accord, and at a speed which would undoubtedly dash you to pieces on reaching the earth, if you were not choked in mid-air by the rapidity of the descent.

With presence of mind, strength, and extraordinary determination, Templer managed somehow to pull himself up and get above the basket into the hoop, where he first securely tied himself, feeling very faint again after this effort. The balloon was, of course, still rising, but before attempting to check her upward progress he thought it would be better to get the basket into its normal position. One by one he knotted together the severed car-lines, until all were repaired, and the basket safely fixed below him, when he lowered himself down from the hoop into it. Though I fancy he has little or no recollection of accurate details himself, the barograph recorded the altitude during this eventful trip as having reached no less than 18,000 feet, which must have been just at the time when Templer returned to the basket and then, for the first time, gave a pull at his valve-line to commence what he knew must be an awkward descent from this great height, handicapped not only by having no ballast left, but also by the feeling that at any moment he might again swoon off.

His skill as an aeronaut was proved by the fact that while more than half insensible he brought his balloon down without injury either to it or himself, gently descending in a cabbage field. Several men who were working in the field ran to give assistance, only to find the occupant of the car insensible, bleeding, and as far as they could see probably dead. While some did their best to look after the balloon, others carefully lifted Templer into a light cart and drove him back to Woolwich, nearly twenty miles away, where he at last was medically treated in the hospital and the huge gash across his face stitched up. His friends had, of course, long before given up all hope of his escape.

Any reader with a love of adventure will, I think, agree that ballooning under such conditions as these affords as much excitement as one could possibly hope for.

During the Egyptian campaign in 1852 a detachment in charge of three officers with three balloons was sent out from England, but they arrived too late to take an active part in any of the military operations. In 1885 Major Elsdale, from the Balloon School, now located at Chatham, accompanied Sir Charles Warren's expedition to Bechunana-land against the Boers, and another balloon detachment under Major Templer and Lieutenant Mackenzie was sent to the Soudan. The transport division of this detachment consisted of a balloon wagon fitted with a hand-winch, a store wagon, and seventy-five steel cylinders containing compressed gas, with which they were filled at a pressure of 120 atmospheres. A further supply of stores, which comprised various reserve materials and a large number of gas cylinders, remained in the harbour at Suakim, and the hydrogen was forwarded there from Chatham, where it was prepared and compressed.

Ascents were made during the marches toward Tamai, and Sinkat was first espied in the distance from a balloon. The practical application of ballooning for military purposes was fully recognized at this time, and the continued existence of the Army Balloon Department was assured. In 1891 the Balloon Department was again transferred, Aldershot being the site chosen, and where it has since remained.

In November, 1899, a balloon section, under Captain Heath, was ordered to proceed to Natal to take part in the Boer War. Throughout the siege of Ladysmith captive ascents were frequently made and very good work was accomplished by the aeronauts, who determined various Boer positions, earthworks, etc., and the very presence of the balloons tended in some degree to keep the enemy at a good distance from the besieged town.

Captain Phillips was in charge of a balloon division with General Buller's army, and in January, 1900, they attempted to discover the Boer position on the Tugela River at night-time, using searchlights for the purpose. Good work was done by captive balloons during the battles of Vaalkrantz, Spion-Kop, and Springfontein. On the 10th February one balloon was subjected to a heavy Boer fire and eventually shot down, but the occupant of the basket was uninjured.

Another detachment under Major Jones, Lieutenants Grubb and Erle, made daily ascents for about six weeks at the Modder River, where the Boer positions were definitely ascertained, which aided Lord Roberts and Lord Kitchener in no small degree to round up Cronje at Paardeburg.

A third balloon section, under Lieutenant Blakeney, accompanied the Mafeking column and did excellent work at Fourteen Streams, where the balloon was kept constantly inflated for thirteen successive days.

While balloons were thus proving their worth with the English army in South Africa, another detachment was sent to the China War in charge of Colonel Macdonald, R. E., and though it arrived too late to do any work while the fighting was in progress, many useful ascents were made in conjunction with French and German Balloon Corps, who united with the English in carrying out surveying work and constructing maps of the country, which hitherto had not existed.

In the United States of America little or nothing in the way of military ballooning was done subsequent to the events referred to in the last chapter during the Civil

Army Balloon Detachment Outside Ladysmith.

Army Balloon Detachment Advancing on Ladysmith.

Face page 42.

Army Balloon Corps Crossing the Tugela.

Face page 43.

War, and it was not until the year 1892 that a department for balloon stores was formed on the recommendation of General Greely, the Chief of the Signal Corps. Two years later these stores were brought to Fort Logan, a balloon shed was built, a silk balloon constructed, and other materials, such as hydrogen tubes, etc., of the English type, were procured.

During the Spanish-American War, in 1898, a Balloon Division was mobilised, but before this organisation could be completed Major Maxfield was ordered to proceed to Cuba with whatever materials and men he could hastily get hold of. On the 30th of June ascents were made before Santiago de Cuba, and the position of various Spanish fortifications discovered. At the same time certain confirmation was obtained that Admiral Cervera's fleet was lying in the harbour. The next day the Spanish positions on the San Juan Hill were determined from a balloon which ascended near El Paso, and about 650 yards distant from the Spanish trenches. Under the shelter of trees and bushes the enemy's cavalry managed to get within close range of the balloon and shot it down.

The present headquarters of the American Signal and Balloon Corps is at Fort Meyer, and, under the command of General Allen, assisted by numerous officers who are all expert aeronauts, rapid progress is being made, and the United States may be confidently expected to hold a foremost place with regard to military aeronautics and aerial navigation generally.

After the Siege of Paris in 1870 we find that little or nothing was done in France for the maintenance of military balloons, but in 1874 a commission was appointed to give instruction on the subject. In 1877 a balloon department was established at Chalais-Meudon under the command of Captain Renard, well known as one of the greatest French authorities on ballooning, who devised an ingenious method for suspending the car of a captive balloon. This department has made steady and satisfactory progress ever since. In 1891 it was decided to introduce and use steel cylinders for holding compressed gas on the lines invented and perfected by Colonel Templer. Reference must be made to the unfortunate death of Lieutenant Baudic, Director of the Naval Aeronautic Department of Lagoubran, who was drowned by descending in the sea in 1902. This department was disbanded two years later, and in 1905 a great loss was sustained by the death of Colonel Charles Renard.

Balloonists were employed by the French army during the wars in Madagascar in 1895, and at Taku in 1900. Despite the recent progress which has been made in construction of dirigibles, it is unlikely that France will do away with ordinary spherical balloons for either free or captive work with her army, as these more old-fashioned vessels could still perform much useful work on active service, besides which they undoubtedly provide the very best means of training men in the air, even if their work is to be ultimately carried out on dirigible balloons or aeroplanes.

It would occupy too much time and space, besides probably boring many readers, if I entered into details of the gradual growth and progress of military ballooning in all the countries which have taken it up. Those who desire to study such matters and follow this branch of balloon history closely can, however, find much interesting information in Moedebeck's "Pocket Book of Aeronautics," Hildebrandt's "Airships, Past and Present," and other works.

VII

Ballooning as a Sport—Formation of Aero Clubs —Gordon Bennett Races—Other Competitions

Although balloons have been used for military purposes in war for the past hundred and fifteen years, and many ascents have been made from time to time by persons scientifically interested for the purpose of taking observations in the higher atmospheres, it is only of quite recent date that clubs have been formed all the world over for the purpose of ballooning as a sport.

Ascents by professional aeronauts on fête days and holidays have often formed an item on the programme of amusements at public pleasure grounds, but it was not until the last decade that amateurs began to indulge in ballooning to any extent, making trips by day and night, attempting to cross the Channel from England to France, and *vice versa,* and trying to make longer journeys than any previously recorded.

On September 4th, 1901, the Aero Club of the United Kingdom was formed, the story of its origin being of considerable interest. I am indebted to Mr. Frank H. Butler for the following account:

"In September, 1901, my daughter and I decided to make a balloon ascent. A large number of friends came to see us off from the grounds of the Crystal Palace, and the aerial party consisted of my daughter, Miss Vera Butler (now Mrs. Ilted Nicholl), Hon. C. S. Rolls, the late Mr. Stanley Spencer (in his professional capacity as aeronaut in charge), and myself.

"It was a very calm day, and the 'City of York' balloon, 42,000 cubic feet capacity, rose almost straight in the air and remained over the Palace at a height of about 5000 feet for nearly two hours. After discussing all the surroundings we thought out the idea of an Aero Club, and decided to set about its formation as soon as possible.

"A few days later the name of the Aero Club of the United Kingdom was registered at Somerset House, through the secretary of the Automobile Club, the committee of which institution looked to our Aero Club to control the science and sport of balloons, airships and aeroplanes in Great Britain."

The following is a list of the principal Aero Clubs which have been formed in each of the undermentioned countries:

Austria, Wiener Aero Club.
Belgium, Aero Club de Belgique.
France, Aero Club de France.
Germany, Deutscher Luftschiffer Verband.
Great Britain, Aero Club of the United Kingdom.
Italy, Societa Aeronautico Italiana.
Spain, Real Aero Club de Espana.
Sweden, Svenska Aeronautiska Sallskapet.
Switzerland, Aero Club Suisse.
United States, Aero Club of America.

Innumerable other Aero Clubs, which are affiliated to their respective senior national clubs, have also come into existence.

On the 14th October, 1905, the International Aeronautical Federation was formed in Paris as the governing body for the above-mentioned Aero Clubs, delegates from each club being appointed as members of the Federation. This body is regarded by amateur aeronauts in the same light as the committee of the M. C. C. is regarded in the cricket world, that is to say, as the maker of rules for all races and other sporting events, and as the controlling authority in all matters connected with the administration of its affiliated clubs.

During the year 1906 Mr. Gordon Bennett, a well-known American sportsman, offered an International Challenge Cup and money prize to be competed for annually by balloons representing each of the countries mentioned above as affiliated to the International Federation. The conditions governing this Aerial Derby, as it might be termed, were briefly as follows:

The first race should start from Paris under the auspices of the Aerô Club de France, and in subsequent years should start from the country of the winner of the preceding year's race. The winner to be the balloon making the longest trip from the point of ascent to the point of descent measured on the arc of a great circle. Not more than three balloons should be allowed to represent each country.

The first contest for this cup was held on September 30th, 1906, when sixteen balloons, representing seven different nations, started from the Tuileries Gardens in Paris. The result was a win for Lieutenant Frank P. Lahm (America), who landed at Flying Dales, in Yorkshire, a distance of 401 miles from Paris. Signor Vonwiller (Italy), who landed at New Holland, in Yorkshire, distance 367 miles, was second, and the Hon. C. S. Rolls (Great Britian), who landed at Sherborne, in Norfolk, distance 286 miles, third. The latter was nearly approached by Count Henri de la Vaulx, one of the most noted French aerouauts, who landed at Great Walsingham, in Norfolk, having covered a distance of 284 miles. Three other balloons reached England, and the remaining nine descended at various points between Paris and the French coast.

In accordance with the rules of the competition, the Gordon Bennett race of 1907 was held in America, and on October 21st of that year, nine balloons, representing America, England, France and Germany, ascended from Forest Park, St. Louis.

A westerly wind prevailed and the competitors were taken towards the Atlantic, the winner, Mr. Oscar Erbsloh (Germany), ultimately descending near the coast, 872 miles distant from St. Louis. M. Alfred Le Blanc (France) came down very near the winner, having covered a distance of 867 miles, whilst Captain von Abercorn (Germany) was third, with a distance of 797 miles.

M. Le Blanc was in the air for 44 hours, which constituted a world's record, and for which he received a special medal from the president of the Aero Club of America. It is also worthy of remark that Mr. Erbsloh's distance of 872 miles exceeded by two miles the distance travelled by Mr. John Wise in the year 1859, which had stood for nearly fifty years as the American long distance record.

The third Gordon Bennett race took place on the 11th October, 1908, starting from Berlin. A far larger entry was received for this event than for the two preceding races, twenty-three balloons taking part in the contest as representatives of the following countries: Belgium, France, Germany, Great Britain, Italy, Spain, Switzerland, and the United States.

Colonel Schaeck, in the Swiss balloon "Helvetia," was picked up by a fishing vessel some miles out at sea near Ersholm, in Norway, and, though the rules seemed to imply that any descent in the sea would entail dis-

The First Gordon Bennett Balloon Race, Paris.

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BALLOONS STARTING FOR THE GORDON BENNETT BALLOON RACE, OCTOBER, 1908, FROM SCHWARZENDORF.

Face page 49.

qualification, a special meeting of the International Federation decided that such rule could not be enforced until the following year, and the race was awarded to this competitor. Mr. John Dunville, in the English balloon "Banshee," which descended near Hvidding on the German-Danish frontier, was placed second, and Mr. Geerts, who landed near Emden in the Belgian balloon "Belgica," was third.

This race was far more remarkable than the two previous ones, by reason of the numerous exciting incidents and mishaps which befell some of the contestants. Two balloons, doubtless owing to their necks being either too long or getting twisted in such a manner as to prevent the expanded gas from freely overflowing, burst in the air. One of these, the American "Conqueror," after reaching a height of about 4000 feet, was clearly seen by thousands of spectators on the balloon ground to split from the bottom and commence rapidly falling. The upper part of the envelope assumed a parachute form, thus checking the speed of the descent, and the balloon with its two occupants fell on the roof of a house, whence the aeronauts came safely to ground. The other balloon which burst later in the race was the Spanish "Montanes," and in this case the envelope was split when the balloon was at a height of 6000 feet, but, parachuting like the "Conquerer," it came down without in any way injuring its two passengers. Three other balloons were carried over the North Sea, but in each case their occupants were rescued. Messrs. Arnold and Hewat, who were in the American balloon "St. Louis," jumped from their car into the water and were picked up by a pilot-boat. Their balloon was found several days later and brought ashore at Grimsby by a trawler. The occupants of the German balloon "Bussley" and the Spanish balloon "Castilia" were somewhat similarly picked up by other vessels, and the balloons got on board at the same time.

The third American balloon competing made a rapid descent which terminated in a tree top only a few yards distant from the edge of a cliff, her pilot suddenly seeing water, which he took to be the North Sea, and immediately deciding to come down before he and his companion were blown away from the land.

The distance from Berlin to Ersholm, where the "Helvetia" was brought ashore, is about 752 miles, and though this is not the longest balloon voyage on record as regards distance covered, the time Colonel Schaeck remained in the air, namely, just over seventy-three hours, exceeded by about twenty hours any other aerial trip of which there is authentic information.

Many other forms of balloon contests besides long distance events are of annual occurrence. Point-to-point competitions, where the winner is the balloon descending nearest to a given spot, which is decided upon prior to the start and according to the wind prevailing at the time, have become extremely popular. An International contest on these lines, in which no less than thirty-one balloons took part, was held from the Hurlingham Club, London, on May 30th, 1908.

Hare-and-hounds races, where one balloon acting as hare starts before the others, is another form of sport which tests the skill of aeronauts, the winner in this case being the balloon which lands nearest to the point at which the hare descends. The hare, of course, tries to pick up any air-current which will take him in a somewhat different direction to that in which the majority of his pursuers are being carried, and the hounds immediately try to follow the direction of the hare by either

THE "CONQUEROR" AS SHE FELL ON THE ROOF. (GORDON BENNETT RACE, BERLIN.)

Face page 50.

Night Ascent by Charles J. Glidden.

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rising or descending so as to pick up the most favourable current for pursuit.

Yet another form of competition is that for the aeronaut who best maintains a uniform altitude during an ascent, which is determined by reading the automatic record of the barograph, and is known as a stability test. Events of this description, in addition to night ascents, cross-channel journeys, and ordinary trips without any particular objective, form a sufficiently attractive programme to satisfy any aeronaut with sporting proclivities, and I do not believe that the advent of aeroplanes will, to any extent, lessen the enthusiasm of the more old-fashioned balloonist, or tend in any way to diminish the interest which is taken in ballooning from its sporting side.

VIII

Description of International Point-to-Point Race—How It Was Won—A Clever Descent—An Unexpected Passenger

In the preceding chapter I referred to the International Point-to-Point race which started from the Hurlingham Club, London, on May 30th, 1908, and as several incidents of a somewhat unusual character occurred in connection with it, I think it will be of interest to describe what took place. This cannot be better done than by repeating as nearly as I can, word for word, the account Mr. Griffith Brewer (one of England's most prominent amateurs) kindly gave me of how he managed to win:

"Having raced for three years without a single trophy to my credit, and then to be the winner of the first international race for balloons ever held in Great Britain, I naturally consider a great event in my somewhat prosaic existence," said Mr. Brewer.

"I entered my old balloon 'Lotus' in the race really more from a matter of habit than from any idea that it was possible for her to win the cup, and it was not until near the date of the race that I was reminded of the fact that I had not made up my crew by an enquiry whether I could take Sir Claude De Crespigny as one of my passengers.

"On ascertaining that his weight did not exceed 11 st., I agreed that he should be one of the party, and as soon as I had an hour to spare I looked up Sir Claude's 'Memoirs,' a copy of which I had bought several years ago. In this book the Duke of Beaufort described him as the hardest man he ever knew, with a total disregard for danger or of injury to himself; also that, besides breaking his leg during a balloon ascent from Malden, he on another occasion crossed the North Sea in a balloon of only 37,000 cubic-feet capacity, and at a height at one time of 17,000 feet, under conditions which make one shudder at the risk he must have taken. It also appears that besides being a man of a most masterful nature he was a fighter of determined character. The result of refreshing my memory about this remarkable man led me to the conclusion that I had not secured quite the passive kind of individual one usually desires as a companion in a balloon race.

"A fellow-competitor who knew Sir Claude personally tried to put fear into my soul by relating bloodcurdling tales about his dominant mind, his fearlessness, etc., until I almost felt that my passenger might eventually assume supreme control of the trip and take us on some glorious and record-breaking journey in cloud-land.

"The obvious antidote to such an adventure was palpably, therefore, to take another 'bulldog,' capable of checkmating any mutiny on the party of Sir Claude tending to rob me of my position as pilot in charge, and in the person of Mr. A. C. Hamerton I found the man I needed. Many have reason to remember the sinews of his arm, for, paddling against him for the championship or sailing an outrigged canoe on salt water, his opponents always had their work cut out. His powers of endurance have stood many tests, even to that of being the only saloon passenger saved from a liner which sank in the Channel after a collision, he being eventually picked up after swimming for more than an hour in a cold November sea.

"What do you think of a timid chap like me starting for a balloon race with such a nice couple?" laughingly asked Mr. Brewer. "Well, you will hear by and by how we got on.

"The 'Lotus' was, unfortunately, considerably smaller than the limit allowed by the conditions of the race for a balloon carrying three people, being only 990 cubic metres instead of 1200, so it could have been 210 cubic metres larger without exceeding the limit. If we could carry an auxiliary balloon of something less capacity than this margin, we should be able to rise with more lifting power, and consequently take more ballast. Having obtained the approval and consent of the International Federation, I was able to establish a precedent by carrying a small auxiliary balloon attached to the 'Lotus' for the race in question.

"The day before the race a strong east wind was blowing, in which it would have been impossible to inflate and successfully start thirty balloons—which, by the way, is the largest number that had ever started simultaneously up to this time. That evening, instead of going to bed, I proceeded at 11:30 P. M. to Hurlingham, and took up my quarters for the night in the car of the 'Lotus,' over which I previously spread a tarpaulin to keep out the wind and rain. All night long it rained in torrents and at times blew heavily, but at 6 o'clock in the morning the wind abated, the rain ceased, and the work of inflating the balloons was then commenced.

"Now was my opportunity to study the prevailing wind currents before the formation of the lower clouds would obscure a view of the upper strata. Lying on my back I could see that the clouds up to a height of about 3000 feet were travelling from E. by N., those above them seemed to be moving from E. by S., whilst a third current higher still was carrying some light clouds from due east. I expected that unless any considerable change took place during the day in the lower wind, the direction of which one can, of course, always ascertain, the two upper currents would also remain unchanged, and so I felt sure that if the winning-post was fixed in a westerly direction from Hurlingham I should be able to pick up whichever current was most favourable for carrying the 'Lotus' on the desired course. At last all the balloons were inflated and in the afternoon they were started rapidly one after another till it came to our turn. With our little auxiliary balloon attached to one side, the 'Lotus' was brought to the starting mat, and on weighing up we found we had a good lift with five bags of ballast in the basket, each weighing about 35 pounds. The winning-post had been chosen at Burchett's Green, a small village three miles beyond Maidenhead, and as by now the strength of the wind had considerably diminished it was rather a moot point if these five bags would be sufficient to enable us to cover the necessary thirty miles from Hurlingham.

"About four o'clock we let go, twenty-one balloons having started before us, and proceeded on a course W. S. W., crossing the Thames over Putney Bridge, which was black with people. Continuing over Barnes Common we passed Richmond and again crossed the Thames, where we took our first reading and drew the line of our course on the map, which showed that we were travelling too far to the south, so I knew it was necessary for us to rise into the middle current above 3000 feet which I had noted in the morning. We threw a little ballast and rose slowly, finding as we progressed that our course first became due west and then west by north. It was now necessary to watch our ballast closely, every tendency to descend being checked by throwing a small quantity, though not sufficient to cause us to rise quickly, and in this way we went on gradually working up in the same air current to our maximum height of 5,900 feet, at which altitude the course became due west, showing that we had completely penetrated the middle current and reached the third and highest which I had noted in the morning. We passed over Colnbrook at 5:30 and the race became exciting, for our line of direction was so good that we hoped soon to see Burchett's Green right ahead of us, and if we could work a little more to the north we should be able to utilise the lower current and possibly descend quite near the actual winning-post. We were unable to do this, however, and soon after crossing the Thames at Maidenhead we saw the white cross, which had been laid down in a field to mark our destination, still to the north of us.

"All the balloons which we had sighted during the trip were well away to the south, so, imagining that the race was already in our grasp, I prepared to descend as quickly as possible and commenced to valve, knowing that the longer I took to come down the more we should be carried out of our course. Whether we landed 200 yards or so further from the winning cross did not then seem of any importance, as we appeared to have the race to ourselves, so I did not descend quite as carefully as I should have done had I known that another competitor had previously landed almost below me, and spying the 'Lotus' in the distance, had craftily deflated as quickly as possible so that I could not see his position.

"At 6:56 we came down in a bean field, but not wishing to damage the beans we were immediately carried by many willing helpers into a grass field nearby, where we deflated.

"As a matter of fact it was subsequently ascertained that our point of descent was 1966 yards from the goal, whilst the other balloon, which we had never discerned, landed just 200 yards further distant."

"And what of your fears; did you have a mutiny and general fight in the central blue miles above the clouds?" I asked.

Mr. Brewer laughed. "Rather not," he replied. "Sir Claude was not only one of the pleasantest companions, but was most careful in keeping our course on the map, which was far from easy considering the cloudy state of the atmosphere, and I could not have had a pleasanter party or a crew working in better unison."

Two or three lessons which may be borne in mind by any aeronaut with advantage are taught by this narrative. Firstly, when one is about to take part in a balloon contest no detail is small enough to be overlooked, even if it involves considerable trouble and inconvenience. Mr. Brewer, having carefully thought out the problem of a point-to-point race, was anxious to glean as much information as possible as to the direction of the prevailing air currents, and the night of discomfort he underwent in order to do this as described was rewarded by the result of the race, for undoubtedly his observations gave him an advantage over many other competitors, though he had generously hinted to several of them the gist of the knowledge he had acquired.

Mr. C. F. Pollock, the pilot of the balloon which landed before the "Lotus," showed much acuteness in deflating as quickly as possible, for he rightly anticipated that the occupants of the "Lotus," which he could see was making an excellent course for the winning-post, might descend with less care if they thought no other balloon was near them than if they spotted another competitor so close to the desired landing point.

I cannot leave the story of this race without mentioning the clever performance of a Belgian competitor, Mr. Geerts, who ascended alone, carrying only half a bag of ballast owing to the extreme smallness of his balloon. Before he had covered a third of the distance he found himself without any sand, and in order to maintain an altitude which would keep him in a favourable air-current he threw out every article he could possibly dispense with, including his anchor and anchor-rope. Still some miles from the winning-post he utilised his trail-rope as ballast, cutting pieces off it and throwing them out whenever he found he was descending. Eventually he came down in a field about 5000 yards from Burchett's Green, gaining the third prize, as well as receiving numerous congratulations that evening from other competitors who were full of admiration at the skilful way he had handled his balloon.

Another episode which at first appeared likely to entail a nasty accident ended most curiously and caused considerable amusement. The last balloon to start from Hurlingham was the Belgian "Emulation du Nord," whose three occupants, having risen from the ground with apparently sufficient lift, were all busy waving adieus to their friends below. An eddy of wind carried the balloon slightly downwards, the car crashed through the upper branches of a high tree, was tilted considerably to one side, and a disaster appeared imminent. The balloon, however, tore itself free, breaking off a huge bough which had worked its way through the car-lines, adding, of course, considerably to the weight. Several bags of ballast were promptly thrown out, and the bal-

Belgian Balloon Carrying Away Branch of Tree.

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loon, thus lightened, regained its lifting power and sailed away, bearing with it this large leafy addition, which became an undesired and totally unexpected additional passenger. When it was seen that the danger was past, dismay gave way to amusement, and the crowd of onlookers was free to laugh heartily at the unique sight of a balloon ascending in company with a tree, a small picture of which I am able to reproduce.

It is worthy of note that this balloon travelled for a distance of about fifteen miles, and then made a safe descent still accompanied by the gigantic bough.

IX

Cross-Channel Trips—The First Record—Green's Voyage to Nassau—A Frequent Crosser—Only Just Over—The First Lady to Cross—An Exciting Night Passage

In the first chapter of this book reference is made to M. Blanchard and Dr. Jeffries, who were the first human beings to cross the sea from England to France, or *vice versa,* by aerial and not aqueous means of transit. Their journey from Dover to Calais was performed in the very early days of the science, during the month of January, 1785, in a balloon filled with hydrogen, and was without doubt the indirect cause of the death of Pilâtre de Rozier the following June, for this pioneer-in-chief, determining not to be outdone by any other aeronaut, attempted to cross from France to England in a balloon inflated partly with hot air and partly with hydrogen. The balloon burst in mid-air, both de Rozier and his companion, M. Romaine, losing their lives.

Since that time the number of successful and adventurous balloon crossings which have been carried out are legion, and it would be quite impossible to give a full account of them in these pages. There are a few, however, which stand out prominently and to which I cannot refrain from referring.

From about 1825, two aeronauts did more to make ballooning famous than all others put together at that time. I allude to Mr. Green in England and Mr. Wise in America, their names being now practically house-

Cross-Channel Balloon Trip by Messrs. Spencer and Pollock.
Views of Crystal Palace and Hastings Harbour.

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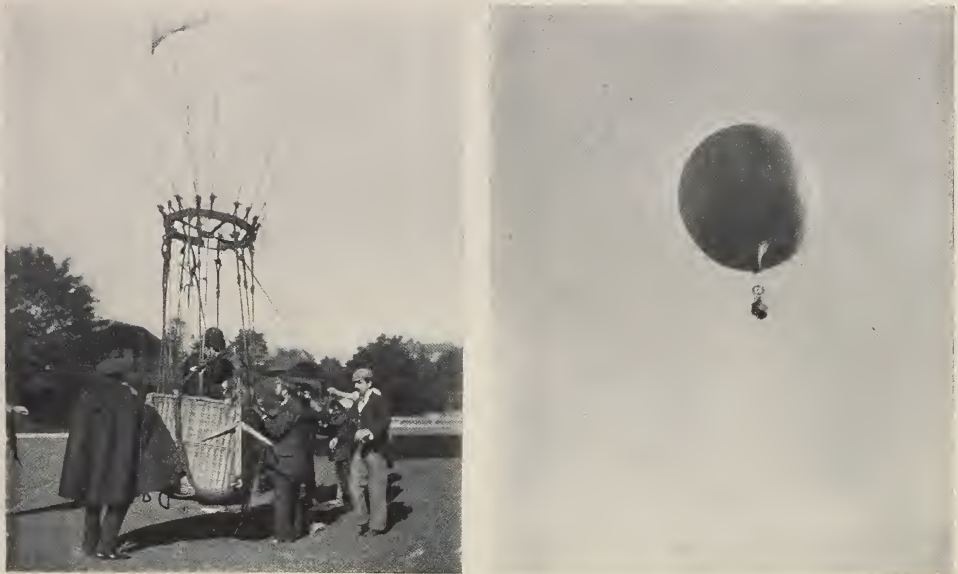

Mr. Pollock's First Cross-Channel Trip from Eastbourne.

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hold words in the aerial world. In November, 1836, Green, accompanied by Monk Mason and Holland, started from London in an 85,000 cubic feet balloon, and, crossing the English coast line at Dover and the French a little west of Calais, kept on in an easterly direction till the following day, when they eventually landed near Weilburg in the Duchy of Nassau, about thirty miles from Frankfort.

The amateur who easily holds the record for crossing the Channel is Mr. C. F. Pollock, who has already accomplished the trip eleven times, and will in every probability do it many times more. I am particularly glad to be able to reproduce pictures of his first start to achieve this trip, taken in Devonshire Park, Eastbourne, whence he ascended alone in a small balloon. He had twice previously been up in the air, and it is significant of the confidence rapidly gained, both in his personal competence and in the safety of a balloon, to think that such a journey should have been undertaken at only his third ascent, and that he should have met with complete success in carrying out his venture.

He told me all about it not long ago, but said that his third crossing, made in July, 1899, with Mr. Percival Spencer, was really far more exciting and worthy of repetition, so I will relate those incidents as accurately as I can from what I learned of them from him and from Mr. Spencer, who kindly allows me to reproduce the splendid photos he took during their trip.

The ascent was made at 2:30 P. M. from the Crystal Palace, and a voyage commenced over Penge, Bromley, Beckenham and other picturesque suburbs, then over agricultural land, with distant views of heaths, villages, and undulating grounds, rendered flat and like a chessboard by the altitude of the observers. Distant gunshots were audible now and then (probably some sportsmen potting rabbits), yet the stillness and tranquillity usual to a balloon trip pervaded all. On looking ahead it was noticed that they were approaching Knockholt Beeches, which forms a good landmark due southeast of the Palace, and therefore on the best and most direct route across the Channel. For an hour they travelled on till reaching Sevenoaks, which with its splendid Knole Park lay spread out 2000 feet below. Riverhead Hill, away to the left, did not present any distinguishing prominence.

On the earth gradients assist in discovering one's whereabouts; not so in a balloon, for at even a thousand feet up everything below appears flat, and other signs have to be utilised for deciding your position. The junction of railway lines at Dunton Green served this purpose for our travellers, and the balloon passed on towards Tunbridge and Tunbridge Wells at a height of about 5000 feet. They had no maps in the car (which now-a-days would be a most unusual omission, for one-half inch to the mile motor maps are invariably taken), but their geographical knowledge of the country was sufficient for them to know their approximate course.

The altitude was maintained for some time, the heat of the sun's rays causing the gas to expand in the envelope, whilst the masses of cloud below kept the air in the lower strata cool, and prevented the balloon descending into them. As the sun shone on these clouds the effects were various, beautiful, weird, and wonderful; perhaps the prettiest sight being when the balloon, rising from the rolling, billowy mass, left a shadow sharply silhouetted on the clouds, surrounded by a ring of rainbow-coloured tints.

Through openings in the clouds rays of sunshine lit up the country below, and such glimpses were never altogether lost, though of course a clear atmosphere would have given a far better visionary command of the course. The coast line was not seen till about 4:30, when the termination of the land appeared through the clouds like a thin white line, at a distance of some 15 miles.

"During the next half hour we had to decide the important question of whether we should descend in England or attempt the crossing," said Mr. Spencer. "The balloon continued to maintain its altitude, and we noted by first fixing our gaze on the earth and then consulting the compass that our direction was due southeast. It could not be better from a theoretical point of view, but we had already used four out of the ten bags of ballast with which we started from the ground, and whether or not what remained was sufficient for our purpose was extremely dubious. However, on nearly reaching the coast and passing between Hastings and St. Leonard's, we decided not to open the valve, but to hold on and attempt to reach the other side somehow!

"At 5:30 P. M. we were passing out to sea; behind us to the right lay the coast line to Dungeness, and, beyond, the white cliffs of Dover. Immediately behind was Hastings, and thence the eye travelled past Bexhill to Eastbourne and Beachey Head—the latter prominent, but the towns almost indistinguishable owing to distance and clouds. By 5:30 the latter completely shut out our view of the English coast, and soon our balloon, after rising to 7000 feet, fell quickly to 2000, which necessitated the expenditure of two-and-a-half of our remaining six jealously guarded bags of ballast to raise us once more into the sunshine. By six o'clock we were up at 8000 feet, and after a consultation we decided not to come down again into the cold lower air lest we exhausted our sand and so became unable to get the balloon to rise once more.

"Peering through the clouds, Mr. Pollock was the first to discern the white line of cliffs which mask the French coast, still far away, but necessary for us to reach before descending, if possible. By dint of careful and constant discharge of ballast in small quantities, we maintained the balloon's equilibrium and increased its altitude to 9000 feet. At this height the vast solitude of the sea was wonderfully impressive. The hum of the waves could no longer be heard, and the water below us seemed dark and untenanted. Previously we had noticed a few ships on the water, and from the direction of the smoke of one of them—a large steamer near Hastings—we saw that the wind on the surface of the water was coming from the west, whilst we above were in a northwesterly current. At 7 P. M. we were at a height of 7000 feet, and though the white line of the French coast was still visible, we had apparently drifted very little nearer to it. Mr. Pollock, with his yachting experience of winds near the coast, suggested that we might be meeting an off-shore wind, and so be unable to make the land even though we got fairly close to it. Such, however, was not my opinion, as I have noticed that the vast bulk of air moves in a constant direction, and a balloon is not governed by the local ground currents which prevail in in-shore and off-shore breezes. Our ballast, though, was fast coming to an end; in fact only one bag of sand remained, and in order to maintain our altitude and equilibrium this was being rapidly parted with also. We gathered together all the empty sand-bags (the ten weighing some pounds), prepared to use them as ballast when our sand supply was exhausted.

At 7.30 P. M. we were at 10,000 feet, being presumably borne slowly towards the shore, yet having no certain means of detecting whether we were moving or not.

"So tranquil, so absolutely calm is a balloon voyage, that it is impossible to notice the slightest motion, even though the balloon be travelling in a gale of wind, unless some object on the earth can be observed and used as a guide. We could not see any ships which would have served us for this purpose, but there was now no doubt about the coast line. It was perfectly clear ahead, and we could even distinguish the mouth of the River Somme, with the low lying coast to the left, and the long white range of cliffs to the east.

"Mr. Pollock recognised the spot, having crossed it during his first voyage from Eastbourne to France in October, 1897.

"Looking down on a view from a height of 11,000 feet one is apt to imagine oneself much nearer to a place than one really is, and twenty miles seems no great distance to the bird's-eye glance of the aeronaut. It was quite a debatable question therefore as to whether we should be able to reach land without touching water. We knew that if we were unable to maintain the altitude of the balloon, and it once sank below the level of the clouds, a rapid descent might commence which, our ballast being expended, we should be powerless to prevent. At 7.35 the last of our sand was thrown out, but we managed to maintain equilibrium by throwing over first the empty sand-bags, and then the linen wrapper, meant to contain the empty envelope when packed up after descending.

"Despite these efforts we were sinking lower at 7.45, and gradually fell to 9000 and then 8000 feet, whilst we were still about 10 miles from the shore. Save for our two selves the basket was literally empty, for I had slung the camera up in the rigging so that it would keep dry if our car touched the water.

"Desperate situations demand drastic measures, so to prevent our balloon from continuing its descent, we decided to unship our anchor and drop it into the sea. The seventy pounds weight of steel bar and prongs was accordingly cast overboard, and fell with lightning-like rapidity, whistling as it whirled through the air, until it reached the deserted sea thousands of feet below us.

"Thus tremendously lightened, the balloon speedily ascended to its maximum height during the whole trip, namely 12,000 feet, where it reassumed perfect equilibrium, but for a few moments only! For as the sun disappeared behind the bank of evening clouds, which formed a dark fringe on the distant horizon, and so deprived us of the benefit of its heat rays, the balloon began to settle slowly yet surely.

"To say the least of it, it now became most interesting to watch the French coast, and to wonder whether or not we should reach it. We now observed some vessels in the sea below us, and by carefully noting our position with theirs, and watching how we progressed, we became convinced that we were still moving towards land, but now—7.50 P. M.—our balloon had dropped to 8000 feet, and was continuing its downward course.

"Fortunately our fears were not realised, as the loss of the sun's warmth did not cause such a rapid drop as we had expected, and at 7.55 we were falling slowly enough to justify our renewed hopes of fetching the coast after all.

"Towns, harbours, country-side, and land laid out in rectangular patches, entirely different from the irregular appearance of English fields—all could now be distinguished. At 8 p. m. the white chalk cliffs appeared almost perpendicular, and we passed away from the sea and came over land still at a height of about 5000 feet. In another five minutes, however, we had come down so low that we were obliged to look out hastily for a suitable landing spot, for we were rapidly approaching the earth, with a large wood looming up right in front of us. We opened our valve to effect a descent before getting among the trees, and by 8.10 our trail-rope touched, a moment or two afterwards our car was bumping, and we came to a standstill about one hundred yards short of the wood.

"The populace, in the shape of capped and bloused agriculturists, arrived in due course, and afforded us an excellent opportunity of practising the French language, for none spoke English, but we soon learned that we were at Woincourt, about one and a half miles inland, somewhere midway between Dieppe and Treport.

"We had accomplished our object, therefore, but had only a few minutes to spare, as a descent seven or eight minutes earlier would have meant a ducking for us, and the failure when so close to shore would have been most galling.

"A vehicle was soon provided, in which our balloon, packed away in its car, and ourselves were conveyed to the nearest station, not, however, before we had accepted hospitality in the shape of food and drink, which was most generously placed before us ere we started off."

Another trip across the Channel which Mr. Spencer will always remember was made on February 20, 1906, for on that day he had the pleasure of taking Mrs. Griffith Brewer and Mr. F. H. Butler from London, to a spot a few miles south of Boulogne, the trip being noteworthy from the fact that this was the first time a lady had ever successfully undertaken the journey in a balloon. As I was fortunate enough to persuade Mrs. Brewer to send me her own version of the run, I can give the account in her own words:

"We ascended from Wandsworth Gasworks at 2.15 P. M. on February 20, 1906, in a balloon of 45,000 cubic feet capacity, my companions being Mr. F. H. Butler and Mr. Percival Spencer, who was in charge. It was bitterly cold, and the wind was blowing from N. W. at about 35 miles an hour. Rising with a good lift, we went up with something of a bound it seemed to me, only to descend rapidly soon afterwards in the unpleasant vicinity of a church steeple.

"I gave half an eye to the somewhat playful methods of Mr. Butler, who was deliberately ladling a few grains of sand over one side of the basket with a highly polished trowel, but kept the rest of my vision for Mr. Spencer's manipulations—having no desire to see the point of that spire suddenly appear through the bottom of the basket!

"The throwing of a whole bag of ballast, and Mr. Spencer's remark, 'that's done it,' somewhat restored my equanimity, and I was prepared to enjoy a trip in more apparent safety.

"We passed over and between the two towers of the Crystal Palace at a good height, and reached the coast at Dungeness about 4 o'clock, all feeling very cold, and with reason, for the sand-bags were frozen! When fairly over the sea Mr. Butler suggested it was time for refreshments; somewhat of a shock to me, for I had never thought of providing anything. Not so Mr. Butler, however, who, if he is nothing else in a balloon, is at least most resourceful!

"A bottle of champagne came to light, a huge cake, and even sausage-rolls. Although deciding to reserve the wine for consumption on terra firma we ate our cake and yet had it, for truly it was of the magnum species!

"After this sumptuous repast we got into some clouds, and for half an hour completely lost sight of land and sea, till the atmosphere cleared again and we could see both France and England distinctly, being rather nearer to the French coast of the two.

"Boulogne Harbour was recognisable in the distance, with the Channel steamer *Onward* making her way towards it. We grew quite excited as to which of the two, balloon or boat, would reach land first, for we had left the English shore at just the same time.

"We were some miles south of Boulogne, however, and in the waning light and at that distance it was rather difficult to decide who really were the winners, but I believe we were just over first.

"We crossed the sand dunes with our trail-rope just touching them, and Mr. Spencer, on seeing that water was no longer below us, but land, raised his cap and shook me vigorously by the hand, Mr. Butler immediately following suit (why, I cannot think!). The balloon went slowly on, the wind having dropped to about 18 miles an hour, and we achieved a good landing with the merest apology for a couple of bumps shortly after 5.30 P. M.

"Several pairs of willing yokel hands held us down while the gas slowly escaped from the valve (our balloon not having any ripping-panel), and as soon as possible I was lifted out, for I was far too cold to have the power of a jump left. I immediately took a sharp constitutional in company with the local curé, who kept up a running fire of questions whilst I attempted to restore some running of the blood through my veins. I was quite incapable of answering, my teeth doing all the chattering for some little time.

"A cart being procured, we, in company with our balloon, were bundled into it and driven at a jog-trot to Samer, some 6 miles away, this being the nearest spot which could boast both an inn and a railway station. An inn—even the most primitive kind—was viewed with keen pleasure by three hungry travellers, one of whom was nearly half frozen, I declare. We were soon cheered by hot soup and other good things, not forgetting the champagne before referred to, but here cruel fate intervened as far as I was concerned! Through extreme anxiety to drink my own health, as the first 'She'-aeronaut to have crossed the Channel, my hand shook to such an extent that it was incapable of holding the glass and—over it went! Do you think my temporary excitement was excusable? Remember, my friend, I'm only a woman after all, and naturally felt a bit pleased with myself."

Of such people, spirits and natures are aeronauts made, or should I say born, for surely some people must be born for aerial travel just as we say some are born for the sea, and others to be soldiers, lawyers, or politicians.

Having referred to Mrs. Brewer being a record breaker as the first lady to cross the Channel, I cannot complete this chapter without mentioning England's keenest lady aeronaut, the Hon. Mrs. Assheton Harbord, who has made over a hundred and fifty ascents, has taken part in several races and competitions, and who has crossed the Channel by balloon no less than five times.

The third occasion on which she performed this journey was the night of 31st January, 1908, when she experienced, I fancy, the most thrilling sensations of all her many trips. I had the pleasure of seeing her the day after she returned to London, and heard the following tale, which she allows me to reproduce, from her own lips:

"Being ambitious of winning the Northcliffe Challenge Cup, which is awarded for the longest balloon trip made by a member of the Aero Club of the United Kingdom during the year, and a favourable wind prevailing on the evening of Friday, January 21st, I left the Battersea Gasworks in my balloon 'Valkyrie,' accompanied by Mr. C. F. Pollock as pilot.

"The night was very dark, there being no moon, and a northwesterly wind blew so strongly that fifteen men experienced considerable difficulty in holding the balloon down. There were doubts, in fact, as to our being able to start at all, but taking advantage of a momentary lull the order was given for 'All hands off' at exactly 9.45 P. M., and we ascended without any difficulty, quickly reaching an altitude of 2000 feet.

"We took with us seventeen 45-lb. bags of ballast, four of which we expended during the first three-quarters of an hour, and provisions in the shape of sandwiches, hot coffee, etc., sufficient for our needs if we succeeded in making a long trip.

"Owing to the intense darkness we were unable to discern the Crystal Palace (usually a good leading mark when trying to cross the Channel starting from London), or in fact any other landmarks, and at 10.30 something most unusual and not altogether pleasant occurred! We seemed suddenly to be struck by a heavy squall which caused the basket to sway to an angle of about 45 degrees—to such an extent indeed that we were obliged to hold on tightly to prevent being thrown out. The real cause was probably that we ran into two different air-currents, which acted in opposite directions on the envelope and the car.

"After about ten minutes of this discomfort, the oscillations ceased, and we commenced falling rapidly, from which time we had to discharge ballast practically continuously during the whole voyage, though generally at nighttime it is unnecessary to do so for hours together.

"We managed to recognise Lydd on our left, and the coastline came into sight immediately after, just one hour and five minutes after our start. We left the English shore to the right of Dungeness at 11.07 P. M., our altitude then being 3700 feet. The French coast was reached at 11.58, only 51 minutes having therefore been occupied in crossing the Channel, which was the most uneventful and peaceful part of our whole trip. When in mid-channel we could see both the English and French lighthouses, the revolving rays from which kept coming over the balloon and lighting everything up.

"Crossing the French coastline we passed over La Touquet, and then proceeded through the inky darkness until 1.30 A. M., when there was a good deal of sheet lightning flashing around us, and we ran into a succession of strong vertical currents, which made the balloon alternately shoot up rapidly and then speedily fall again. The atmospheric conditions at this time were most curious, the car, hoop, neck, and gear of the balloon all seeming to be illuminated by electricity, and when I rubbed any of these parts my glove appeared to be alight.

"At 2 A. M. we encountered a terrific snowstorm which covered us and half filled the basket with snow; hail was also coming down, making a great clatter on the envelope, and the balloon was naturally much affected by the extra weight thus acquired. Very shortly, however, we found ourselves again rising with great rapidity, until an altitude of 8000 feet was attained, when we commenced to fall equally fast. The discharge of five bags of ballast in four minutes failed to check this descent, for our instruments showed that we were falling at the rate of 1000 feet a minute.

"Suddenly, at a height of 1500 feet, the bottom of the car crashed with great violence upon something, and we quickly realised we must have struck a tree on a mountain. Had we dashed on the firm ground at such a pace the result must have been fatal. The long trail-rope began catching in everything it could find, subjecting the car to violent jerks, and we could hear the branches of trees being bent and broken as the rope tore through them. We were dashing along at a terrific speed, the darkness was so intense that I could scarcely distinguish my companion, and it must be admitted that the roaring of the wind, combined with the heavy snowstorm, made us extremely anxious.

"As the last bag of ballast thrown out had not the slightest effect in making the balloon rise, and as only three bags were now left, we decided there was no alternative but to make a descent, chancing where we should land, as we could see nothing.

"Mr. Pollock accordingly opened the valve, and I crouched down, gripping the ropes in the bottom of the car, and feeling a thrill of anticipation as to our next experience.

"Were we to land on a house-top, or should we find ourselves struggling in the chill waters of some river? Anything unexpected might be in store for us, but suddenly down we crashed with great force into some trees once more, many branches breaking off into the car.

"Mr. Pollock 'ripped' at once, but the wind carried us upward again for a moment, and then down we came, this time, however, with the basket overturned, and began dragging through the tree-tops.

"Mr. Pollock shouted 'Are you in,' fearing I might have lost hold and been thrown out, but I called back 'Yes,' clinging on for all I knew; and very hard it was too, to keep in that basket while it received a succession of violent blows from the trees. At last some boughs caught the envelope, causing a large rent, which, together with the ripping-panel, allowed enough gas to escape to bring us to a standstill.

"Having collected our senses and somewhat recovered from this severe shaking, we clambered out and discovered we were in the midst of a dense forest. I was fortunate in striking a path which we followed, and which, after half an hour's walking, brought us to a main road along which we walked for another hour.

"At last we espied a wood-cutter, from whom we learned that we had descended in the Department of the Meuse, near the small village of Houdiemont, and about 25 kilometres from the German frontier.

"This man walked back with us to the balloon, and then promised to return with a cart, which he did in three hours' time. Meanwhile we had been discovered by more wood-cutters, who set to work most willingly to help us, and with their assistance we packed up.

"The envelope, being high up in the trees, was only got down with considerable difficulty, and sad to relate many pieces of the beautiful 'Valkyrie' were left hanging from various branches, on one of which we found the feed-pipe, which had been completely torn off. The

300 feet of trail-rope lay stretched far away on the tree-tops.

"Unluckily we smashed all our instruments, the first crash quite settling the Statoscope, a very sensitive apparatus which indicates the rise and fall of the balloon.

"We took three hours driving the 14 kilometres to Verdun, the horses going at a snail's pace through the bitterly cold N. W. wind. The day, however, was beautifully fine, and could we have weathered the storm and kept up for another two hours, we should without doubt have been able to stand on for a much longer time, and would have accomplished a tremendously long run, probably landing in Switzerland, over 600 miles from London, before mid-day.

"We, however, did travel an actual distance of about 290 miles from our starting-point as the crow flies, making the mean speed for the trip just over 45 miles an hour.

"Under the circumstances we were bound to descend when we did, and much is due to Mr. Pollock for his presence of mind and promptness of action when every moment was of the greatest importance, for considerable nerve is required in making a rapid descent in pitch darkness without the remotest idea of what one will land on.

"This, my third trip across the Channel, was a most thrilling experience throughout, and though the distance accomplished was nothing very great, it was a most sporting run, and one always to be remembered."

X

How Balloons are Built—Calculations of Sizes—Cutting out Material—Tailor Work—Varnishing—The Valve—The Neck—Forbes' Narrative

I have purposely said nothing about balloon construction in earlier chapters, with the idea of first relating what they have done and can do, what affects them in various ways, and what requirements are likely in different kinds of balloons. Now that these points have been in some degree dealt with, it seems to me that a few remarks on the methods of building—without attempting to tackle the subject in every technical detail—may prove interesting, and throw a little light on the general principles adopted by those whose trade, occupation, or pleasure it may be to make balloons.

Whether a small or a large envelope is required, anything from a tiny "pilot" to a huge long-distance aerostat, one must first decide the lifting power desired and the kind of gas to be used for inflation. Then, according to what type of balloon is to be made, one knows if paper, cotton, silk, rubber fabric, or skin is to be the envelope material, and the various weights of these substances per square foot, yard, or metre must be borne in mind, also the widths in which they can be obtained.

The most general shape of the envelope now-a-days is the spherical, and it will be sufficient for our purpose if I stick to that pattern, for the pear-shaped gas-bag usually only differs from the sphere in its lower part, and what applies to the one very nearly does to the other.

The first thing to be considered then is, "What is the balloon to lift?" Let us take an ordinary type which is capable of carrying three or four people, ballast in reasonable quantity, and a suitable car and accessories. Estimate the average weight of passengers, say 450 to 600 lbs., allow 300 lbs. for ballast, another 250 lbs. for car, anchor, trail-rope, etc., etc., and, remembering that a good margin of weight (about another 450 lbs.) is still to be included for the envelope, valve and net, one can assume a total lift of 1600 lbs. is requisite. One knows the lifting power of ordinary coal-gas (viz: 40 lbs. per 1000 cubic feet), and hence the cubical contents of the balloon can be calculated, and it will be found that for one such as described above, the volume required would be 40,000 cubic feet.

Before saying more on this subject we must put down a few figures which are all-important in computing sizes, surfaces and volumes of spheres, and which can easily be remembered.

We most of us know the figure usually represented by the mystic symbol π, viz. 3.14159.

Circumference=diameter x 3.14159
Surface=diameter ^{2} x 3.14159
Volume=radius ^{3} x 4.1809

Hence one can easily calculate the quantity of material required for an envelope of any given volume, and the length of each "gore," as the strips are called which, running from base to summit, when joined together form a perfect sphere.

Cutting the material into gores and joining it up is known as the "tailor" work. There are several different methods of cutting out and I daresay it would puzzle most of my readers to cut paper, linen, silk or what-not into a number of shapes which, when sewn or stuck together, would be of regular spherical shape, so it may be as well to describe the method usually adopted by English balloon builders as perhaps the simplest, if not the best.

Having calculated the cubical contents of your balloon, you next use your tables, to ascertain its circumference. You then notice the exact width in inches of your material and decide on the number of gores you will use, which, joined with an inch lap-over, will equal the circumference of the sphere. As a simple illustration, assuming the circumference to be 132 feet (which is approximately the circumference of a 40,000 cubic foot balloon) and the material to be 2 feet 6 inches in width, it would be safe to decide on 56 gores, which would leave a good margin for over-lapping on each at the widest part.

If you have sufficient floor space you then with a string and piece of chalk draw concentric circles, starting with a radius of 2 feet 6 inches and increasing the radius by that length for each circle until you have drawn fourteen, when the distance from the centre to the outer circle will be 35 feet. Now draw a straight line from the centre to the outer circle and on this outer circle measure 2 feet 6 inches to the right or left of the point where the straight line meets it and draw another straight line from the centre of the circles to this second point. One then obtains a triangular form with two long straight sides and a slightly curved base formed by the segment of the outer circle, with segments of the other circles gradually diminishing in length towards the apex. The length of these segments must then be accurately measured and a straight line 66 feet in length must be drawn on the floor. At the middle of this line, 33 feet from either end, a straight line must be drawn at right angles to it, exactly 2 feet 6 inches in length and crossing it midway. A succession of straight lines similarly sub-divided and drawn at right angles 2 feet 6 inches apart must then be drawn above and below, each successive pair being of the exact length of the measured segments of the circles working from the larger down to the smaller, till the final measurements at the centre of the circle is 0. By joining the extreme ends of the original 66 feet long line with the successive ends of these gradually increasing lines drawn at right angles to it, one obtains the exact model by which each of the 56 gores of the balloon must be made.

Placing a strip of the material over this diagram, the most economical way to cut out would be to use the two waste pieces of triangular shape cut off from the two sides to form the ends, the two pieces being placed back to back and stitched together to form a narrower part at each end of every gore.

Besides being economical another advantage is gained by this method of tailoring, namely, the additional strength caused by the over-lapping joints of the material at the top and bottom of the sphere.

It will be realised that in all probability the bottom of the envelope, when a certain amount of gas has been lost during an ascent, is subjected to the greatest strain, as it will flap about loosely, and by the natural tendency of the gas to rise to the top of the envelope, there is also more strain round about the valve than lower down in the gas-bag.

Anyone who wishes to learn more of balloon manufacture could best do so by going to a friendly builder and watching his methods of laying out a model gore in the manner I have described above, or by some other rule-of-thumb plan, and should there be no builder near at hand, as much information as the majority could wish for is to be found in Colonel Moedebeck's "Pocket Book of Aeronautics." Before leaving the construction of the envelope I wish to mention the ingenious and useful invention of Mr. Patrick Y. Alexander, the well-known English expert, which takes the form of a petticoat made of the envelope material and about 6 inches in depth, sewn by its upper side around the envelope about midway between the equator and the bottom. The object of this rain-guard, as it is called, is to keep the occupants of the car, whether of a spherical or of a dirigible balloon, free from rain-water, which without this protection would run down the sides of the envelope and eventually rush in a regular stream from the neck into the car. The petticoat, which hangs vertically downwards from its point of juncture with the envelope, obviates this nuisance, as the rain running down the sides of the gas-bag meets it and falls vertically from it, thus affording almost perfect shelter for the passengers, like an umbrella.

Although this idea has been adopted only to a very limited extent in England, it is being very generally used in Germany and some of the other European countries.

Cotton and silk materials are coated with varnish of the finest quality to make them as gas-tight as possible, and it is found necessary to give a balloon a fresh coat of varnish probably after every three or four ascents, or even more frequently if ascents of considerable duration have been made, or if the envelope has been exposed to a hot sun.

A very important item in balloon construction is the valve in the centre of the top of the envelope, the most generally adopted form being that known as the "Butterfly." Other types of valves, their manufacture and general working, will be found fully described in one or other of the handbooks to which I have referred in earlier chapters.

As the neck acts in the double capacity of an inlet for inflating the balloon and practically as an automatic overflow for the expanding gas during the ascent, its dimensions are of the utmost importance to the safety of the balloon. Experiment and theory have brought to a nicety the estimate of correct dimensions and lengths for the necks of envelopes of every size, so as to allow a good margin of safety and avoid the risk of the envelope bursting through increase of pressure before sufficient gas has escaped through the open neck.

To quote a recent instance of the serious results which may accrue in the event of these recognised neck dimensions being ignored, I will relate what I saw happen to the American balloon "Conqueror" in the Gordon Bennett race from Berlin in October, 1908.

This craft was in charge of Mr. A. H. Forbes of the New York Aero Club, accompanied by Mr. Post, the Club's Secretary, as his aide. Almost everyone on the balloon ground had commented upon the prodigiously long neck of the "Conqueror," which, instead of terminating some 6 or 7 feet below the envelope, reached right down to the car and was probably 15 or 16 feet long.

Experienced aeronauts expressed their opinion to Mr. Forbes that the material of his envelope which he considered to be of extraordinarily good quality, could not possibly withstand the pressure which would be generated in the balloon by expansion as the ascent was made and before sufficient gas could be driven down so long a neck to reduce it. The pilot, however, thought otherwise, and the balloon was sent on her journey without alteration.

At a distance of about a mile or a mile and a half from the starting-point, the "Conqueror" had attained an altitude of probably 4000 feet, when several of us noticed the bottom of the envelope was flapping ominously, and we quickly realised that an accident had happened. It was only too true, for the envelope had burst and gas was rushing out at a terrific speed. In less time than it takes to tell the thousands upon thousands of spectators congregated on the balloon ground and over the surrounding neighbourhood, saw that the "Conqueror" was falling rapidly towards the earth and cries of apprehension were heard.

With commendable presence of mind and promptitude Mr. Forbes, who had luckily armed himself with a large bowie knife, cut adrift the 32 bags of ballast suspended around and outside the car, whilst Mr. Post threw out from the inside, all ballast, the anchor, trail-rope, instruments, and every article which did not form part of the balloon itself. Thus quickly relieved of a tremendous amount of weight, the speed of the fall was appreciably diminished when still about 2000 feet from the ground, but by this time the envelope had split a long way up one side, as is clearly shown in the remarkable photograph reproduced on the opposite page. To the great relief of everybody, however, especially those possessing some knowledge of these subjects, the upper part of the gas-bag gradually formed itself into a parachute and when the balloon disappeared from our sight, probably at a height of 400 or 500 feet from the ground,

THE "CONQUEROR" BURSTS IN MID-AIR (GORDON BENNETT RACE, BERLIN).

Face page 82.

INAUGURAL ASCENT OF THE ENGLISH AERO CLUB BALLOON AT STAMFORD BRIDGE.

Face page 83.

she was falling sufficiently slowly to encourage the hope that a fatal calamity would be averted.

Hurrying to a telephone office on the ground, I believe I was the first person to obtain the news, which was sent through within three or four minutes, that the balloon had fallen on the roof of a house and its two occupants were absolutely uninjured, which welcome tidings I was able to convey to Messrs. Arnold and Hewat, who were just waiting to make their ascent in the American balloon "St. Louis," and who were naturally terribly anxious to hear news of their countrymen before starting on their long trip.

Whilst this anecdote points a moral on the rashness of deviating to any great extent from the recognised regulation length of neck, it also serves to illustrate the fact that because a balloon bursts in mid-air the consequences may not prove fatal, as on a few other occasions besides the one I have referred to, similar instances have occurred from one cause or another and the aeronauts have descended in safety, through the envelope of the balloon shaping itself into a parachute against the upper part of the net.

Motoring back to our hotel with Mr. Roger Wallace, Chairman of the English Aero Club, immediately after the last balloon had ascended, I arrived in time to meet Mr. Forbes on his return from the house on which they had fallen, and the following little story is, almost word for word, the description he then and there gave me of his personal impressions. He said:

"About 4,000 feet up, we heard it pop, and knew we were in for a merry few minutes. I luckily carry a bowie knife, and it was just handy for cutting away 32 bags of ballast in quick time, while Post threw out everything possible. She parachuted finely, and my only fear was of killing people below with our sand-bags, but I had to risk it. We held on by the hoop, and at last dashed against the chimney of a four-storey residence, brushing it off and making a splash with the roof tiles, where the car luckily stuck fast, and the envelope fell right over the roof top. Lots of people in the house offered assistance, and we crawled to the top and got down by a trap-door quite comfortably. It just goes to show how safe ballooning really is, and I guess our friends felt more awkward for a bit than we did directly we saw how quietly we were coming down.

XI

Balloon Photography

As the art of photography has gradually developed and improved during the past 50 years, the taking of photographs from balloons has become a matter of frequent occurrence, so that pictures of the clouds taken from above them, bird's-eye views of snow-capped mountain peaks, and panoramic views of towns, the country, and the sea, are becoming familiar to everybody.

So many opportunities occur of obtaining a variety of such views whenever a balloon ascent is made that a suitable camera is now regarded as being an almost indispensable adjunct to the equipment of every aeronaut, but the fact that free ascents necessitate the use of a balloon of considerable size, entailing no small expense to fill it with 30,000 or more cubic feet of gas, places balloon photography beyond the reach of those who are not blessed with considerable means. Furthermore, as a free balloon drifts in whatever direction it may be carried by prevailing air-currents, one can only take such photographs as chance offers, and it is almost impossible to make sure of obtaining a picture of any particular object unless a captive balloon is employed for the purpose. Here again one's field of operation is limited to the neighbourhood surrounding the gas-works where the balloon is filled, and the expense, instead of being lessened, is somewhat increased, as one must pay for an engine to haul the balloon up and down.

Nobody in England has studied the subject of balloon photography under various conditions more thoroughly than Mr. Griffith Brewer, to whom I am indebted for much valuable information on this subject, and through whose kindness I am able to explain a fairly simple method of taking photographs from a small captive balloon of only 500 cubic feet capacity. This immediately reduces the expense of the undertaking to a reasonable figure, and shows a means whereby any of my readers may carry out extremely interesting combined experiments in ballooning and photography at a moderate cost.

As we know, the lifting power of 500 feet of coal gas is approximately 20 pounds, and this is quite sufficient to raise a skin balloon of these dimensions equipped with a light net and hoop, a small camera, and a considerable length of cable strong enough to hold the balloon captive and to haul it down again.

Mr. Brewer purchased a balloon of this description and capacity, which he found could be inflated through an ordinary 16-light gas meter in about two hours. A net provided with the usual leading-lines was employed for covering the envelope and for attaching to the hoop. The camera was of box form, with half-plate dark slides focussed at infinity, and with screw-clamped trunnions at its side, by which it was mounted in triangular side frames so that it could be set at any desired angle. The lens was fitted with a Bausch and Lomb shutter, and though this type may not be recognised as the best or most up-to-date, Mr. Brewer considers it certainly the simplest. The shutter is set and held in position by a hook which can be withdrawn by an electro-magnet, so releasing the shutter and exposing the plate. The captive-line, 500 feet in length, was made up into one cable with two rubber-covered flexible wire conductors, and wound on a reel running on ball bearings, the inner

Shadow of Balloon, Photographed from Its Own Car.

Face page 86.

STRAWBERRY HILL FROM A CAPTIVE BALLOON.

Face page 87.

ends of the two wires being connected with a plug terminal on the reel to enable a battery circuit with electric switch to be connected.

Having detailed the apparatus, it is now necessary to describe how it may be used. When the balloon has been inflated the hoop is attached to the leading-lines, and the swing frame of the camera inserted in the hoop, to which it is firmly connected by means of two long bolts. The captive-line is then attached to a bridle connected to a cross-bar on the hoop, and the ends of the electric wires passed into the front partition of the camera and fastened to the terminal screws of the electro-magnet. The dark slide is now inserted, its front removed, and the shutter set and held ready by the hook.

If a true plan, or absolutely vertical downward view, is desired, the camera is turned on its trunnions with the plate in a horizontal position and the lens pointing downwards; on releasing the reel the captive-rope is let out and the balloon quickly ascends under its own lifting power until checked by applying a brake to the reel. The connection plug is then inserted, and on pressing the button the circuit is completed, and an electric current passing through the wires operates the magnetic release on the hook and so effects an exposure of the plate. By hauling in the line on the reel the balloon can be brought to the ground, the shutter reset, the plate changed, and the balloon is ready to be sent up a second time to take another view.

Whilst balloon photography in an amateur way may thus afford a pleasant occupation, and enable anyone to obtain a collection of extremely interesting pictures, it can be advantageously used for more serious and important work. For instance, if siege operations are being carried out during a war, photographs can be taken from captive balloons which will show the lines and position of the enemy probably to a distance of three miles. During manœuvring operations in times of peace, balloon photographs are useful for showing at a glance the formation and disposition of troops at certain moments, and a bird's-eye view of the field of operations.

The usual height chosen for taking such photographs from a captive balloon is from 800 to 1200 feet; for obtaining good results a clear atmosphere and bright light are essential, whilst the velocity of the wind should not exceed 10 miles per hour. In a stronger wind the exposures become blurred through the movement of the balloon, and if it attains a velocity of 20 miles per hour it is practically useless to make any attempt at getting a picture. Owing to the restraint which the captive-rope exercises on the balloon, there is an incessant swaying motion, and sudden jerks are frequently felt, conditions which are of course unfavourable for getting a good photograph; advantage therefore should always be taken of any momentary lull in the wind.

In a free balloon there is none of the swaying and jerking experienced when captive, and the car is practically steady when the balloon is travelling in any air-current up to a speed of possibly 60 miles per hour. It is consequently far easier to obtain good results from free than from captive balloons, but of course it is not always feasible to make an ascent from a position which will ensure the balloon passing over any particular spot which one wishes to photograph.

If balloons are used in time of war for this purpose, it is naturally desirable to make them as difficult a mark for the enemy's artillery and rifle fire as possible, and this is best accomplished by constantly changing the altitude of the balloon.

XII

Parachutes

The parachute is in reality of much earlier origin than the balloon, for historians have stated that experiments on a small scale were made by the Siamese over four hundred years ago, small and light umbrella-shaped articles being taken to a considerable height from the ground, weights according to their sizes attached to them, and then allowed to drop.

The resistance or grip of the air which is obtained by anything made in the shape of an umbrella is very appreciable, and I expect every one of my readers has experienced the sensation of being almost lifted from the ground when trying to hold up an umbrella with a strong wind blowing.

The first successful experiments on a larger scale which are recorded were those of Le Normand, in the year 1783, when he descended from the branches of a high tree in a parachute he had constructed himself, but subsequently he appears to have only experimented with animals placed in a basket and attached to his parachute.

In 1797 the French aeronaut Garnerin went up in a parachute attached to a balloon, disconnecting the supporting rope at a height placed at between 3000 and 6000 feet by different accounts, and descended in perfect safety to the ground.

In England, Mr. Cocking studied the principle and theory of parachutes, and early in the nineteenth century gave lectures on the subject before several learned societies, the Society of Arts awarding him a medal for his work and discoveries.

In the year 1837 he persuaded the celebrated aeronaut, Mr. Green, to take him up in a balloon with this new form of parachute, the design of which was a somewhat flat inverted cone with a basket suspended from the open apex. His idea was that this inverted surface would offer somewhat less resistance than the ordinary form of convex cone or umbrella-shape, and prevent the oscillation which had been noticed with former parachutes.

Green's great Nassau balloon was used for the purpose, and an ascent was made late in the afternoon from the Public Gardens at Vauxhall. The balloon, with the parachute securely fixed below it, drifted away in the direction of Blackheath, and was soon out of sight of the thousands of spectators who had congregated to watch the experiment, but two or three gentlemen on horseback followed its direction, and one of them, a Mr. Underwood, gave an account of what he saw, which was published the following morning in the daily papers.

It seems that when the balloon was over Lee, in Kent, at a height of about 5000 feet, Cocking, calling out "good-bye" to Green and his companion in the balloon basket, pulled the disconnecting cord. The parachute commenced to fall rapidly, and to oscillate with increasing force, until suddenly it appeared to split up in all directions and drop like a stone to the earth. Mr. Cocking was found in a terrible state, almost broken to pieces, and he expired in a few moments after Mr. Underwood reached his side.

The weight of this parachute and its occupant was about 560 pounds, of which the balloon was of course immediately relieved directly Mr. Cocking severed his connection. Despite the fact that Green opened his top

COCKING'S PARACHUTE.

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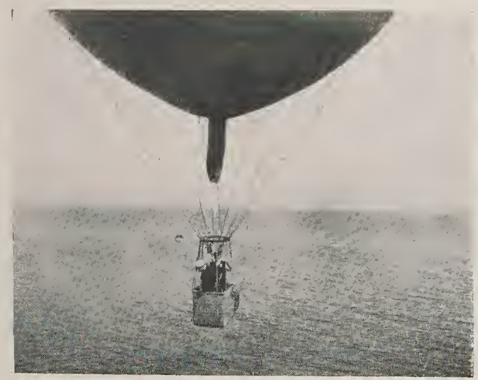
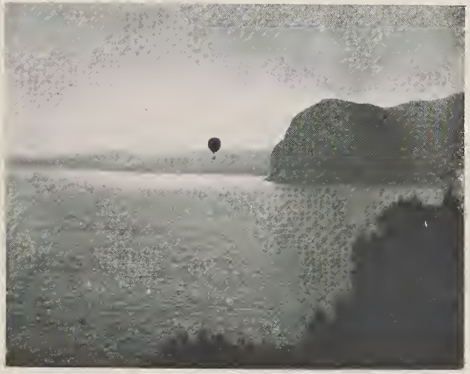


From Monaco to Mentone.
Mr. A. M. Singer and M. Jacques Faure.



Trailing Over Beaulieu Bay.

Face page 91.

valve as wide as possible, the balloon shot upwards with terrible velocity, and the two aeronauts would undoubtedly have been suffocated had they not applied their mouths to two pipes leading into an air bag, which they had taken with them anticipating what was likely to occur, for the gas escaping from the neck of the balloon would probably have rendered them unconscious in a few moments, and, as it was it had the effect of completely blinding them both for some minutes.

With a gradual reduction in the speed of its ascent the balloon gained equilibrium at a height of over 23,000 feet, and of course its occupants had no idea of what had happened to the unfortunate parachutist meanwhile.

In all probability the theory which Mr. Cocking tested so fatally to himself is a correct one, and his failure was due to faulty or weak construction rather than to any error in design. I base this opinion upon the remarks made several years afterwards by that very eminent American aeronaut, Mr. Wise, who referred to Cocking's experiments in the following words:

"Looking at this contrivance with an unprejudiced eye, it struck me as remarkably ingenious, embracing none but true principles, adaptive to the end for which it was intended; and so confirmed was I in this conclusion (and am yet), that I would not have hesitated to repeat the experiment with a similar machine, with no other alteration than a tough wooden hoop in the top of it instead of a tin one, as was in his machine. I ventured this opinion in a Philadelphia newspaper at the time, and promised to demonstrate its truth, before the summer should pass by, by experiment with a true model of this new invention, in letting down, from a great height, a living animal.

"On the 18th September I ascended from Philadelphia with both a Garnerin and Cocking parachute attached. In the former I had placed a dog, and in the latter a cat. The concave parachute was first dropped, which in two seconds afterwards commenced to oscillate with great violence, to which the dog, its occupant, gave the most ample testimony by a yelp, corresponding to each vibration, as far as I could hear him. Seeing it safely in the hands of some individuals below, the convex parachute was next put to the test. I took particular care to watch its whole descent with a spy-glass. When it was dropped it oscillated a little for a few moments and then commenced describing spiral circles of perhaps a 100 feet diameter (this is a mere guess calculation, however), the parachute all the while revolving on its own vertical axis, which motion was in the same direction as its spiral motion; and thus it continued gyrating with a double motion, but apparently very smoothly and gracefully, until it reached the top of a dwelling in Eleventh Street, where it lodged safely, and was taken in from the dormer-window."

There is no real benefit to be derived from the use of parachutes for balloon work, and beyond providing a sensational element at shows or exhibitions they are never likely to play an important part in aeronautics. It was early discovered that a hole in the apex of the cone would greatly minimise—though it could not entirely eliminate—the vibration and oscillation during a parachute descent, and with this addition there is scarcely any difference in the construction of the parachute as used to-day with that used by Garnerin more than a hundred years ago.

Although the first leap into space and the rapid descent prior to the opening of the parachute forms a sensational spectacle, and must require considerable nerve on the part of the parachutist, there is little or no danger in the proceeding, and accidents have been extremely rare. Curiously enough almost every country has produced female parachutists, amongst the most famous of whom may be mentioned Fräu Poiteven, who once, when taken up in a balloon by her husband, descended in her parachute from a height of 6000 feet, occupying 45 minutes to reach the ground. Her husband, having valved and come down with his balloon as quickly as possible, was actually packing up when she came to earth.

Fräulein Käthe Paulus is another noted parachutist, who has used for many of her descents a double parachute invented by Lattemann. These are rolled up one under the other and hang from the balloon. Directly the spring has been made the upper one opens, and the lower one comes into operation and aids in checking the speed of the descent as soon as the motion becomes steady.

In England Miss Spencer has descended scores of times without ever experiencing the slightest discomfort or meeting with any injury whatever; in fact she regards the occupation on a fine day with as little excitement as an ordinary individual would if going for a walk in the garden.

It was at one time thought that parachutes might form a safeguard for balloonists in the event of the envelope bursting in mid-air, when the aeronaut could disconnect his parachute and descend in safety to the ground, but, as a matter of fact, any such precaution has been found totally unnecessary, for, on the rare occasions when a balloon has burst, the envelope itself forms a gigantic parachute in the upper part of the netting. Several cases of this are on record, one or two of which I have referred to in earlier chapters.

While feeling obliged to make some reference to parachutes in these pages, I do not consider them of sufficient importance to enter into any explanation of their dimensions, construction, or the various calculations employed for designing them.

PART II—AIRSHIPS

I

DEVELOPMENT OF THE DIRIGIBLE—DUKE DE CHARTRES' AIRSHIP—MEUSNIER'S DESIGN—GIFFARD'S EXPERIMENT

HAVING attempted in Part I to give some kind of account of ordinary balloons, their origin, history, and uses, I must now proceed a step further in aeronautics, and devote some space and attention to dirigible balloons, or airships,—as they are commonly called,—following their gradual development from the earliest type recorded up to the present time, which finds them arriving in various forms at some degree of practical utility, though still far from perfect, and by no means what they are likely to become ere anything approaching finality is reached in their design, construction, and improvement.

As was only natural, directly the Montgolfiers and other pioneers of ballooning had demonstrated the feasibility of ascending into aerial regions by the aid of the lighter-than-air vessels, there was a pretty general opinion that some means should and could be devised for propelling and steering such craft after the manner adopted with boats and ships floating in the water.

The principle of employing oars or sails in conjunction with a rudder for guiding purposes was, therefore, the first obvious way to try and achieve this object, and, although some attempts were made in this direction with spherical or pear-shaped balloons, their unsuitability was quickly realised, and early in 1784 (the year following the first Montgolfier ascent) various persons commenced building airships, either egg-shaped, or cylindrical with conical or hemispherical ends.

One Brisson, a member of the Academy of Paris, read a paper before his brother members in which he advocated the shape of a cylinder with conical ends as the most steerable in the air; the length, he considered, should be five or six times the depth; the smaller end should form the nose or bow of the ship; and lastly, while proposing to use oars for propulsion, he expressed doubt as to human strength being sufficient to make them of any practical use.

The Duke de Chartres commissioned the brothers Robert (the Parisian mechanics mentioned in the first chapter of this book) to build him a fish-shaped balloon, and this vessel was constructed 52 feet in length, 32 feet deep, and to contain 30,000 cubic feet of gas. The envelope was made double, with the idea of better retaining the gas so as to perform longer journeys.

In July of the same year the Duke ascended from St. Cloud in his airship, accompanied by the brothers Robert, and another man named Colin-Hulin. The double envelope was so constructed that the gas could not overflow, presumably no neck being fitted and opened as in ordinary balloons, but the Duke promptly averted an almost certain accident by making a hole through both envelopes with a flagstaff, and so undoubtedly saved them from bursting as the ship ascended and the gas expanded. A satisfactory descent was made in the park at Meudon.

In this vessel three oars were fitted, but no rudder, and on a subsequent occasion, when the brothers Robert and Hulin made an ascent, they managed to propel the machine on an elliptical course during a calm. They also succeeded in deviating about 20 degrees from the direction of a light breeze by hard work at the oars, but they were of course quite powerless to travel against it, or to move in any desired direction.

The following year Professor Kramp of Strassburg, in an article on aerostatic machines, showed that the car should be fixed rigidly to the envelope if the work of the oars was to be transmitted to the balloon without much loss of power. Thus early we get an advocate of the rigid type of construction, of which there is much to be said and considered anon. The Academy of Lyons offered a considerable cash prize for the best essay submitted to them explaining the surest and most efficient method of steering an airship, but, as it is related that not one of the hundred or more papers sent in succeeded in solving the problem to the satisfaction of the Academy, there was probably no lucky recipient of the award.

It was gradually realised that, by comparison with the size and consequent resistance a balloon offers to the air, the tiny blades of oars unless worked with incredible rapidity could do little in the way of moving an airship in any desired direction, and of course the idea of using sails was quite absurd, for, as we already know, a balloon itself is always virtually in a calm, for it moves in and with any air-current; a vertical sail would therefore hang limp and inefficient, as we see them flapping against the mast when a ship is becalmed at sea.

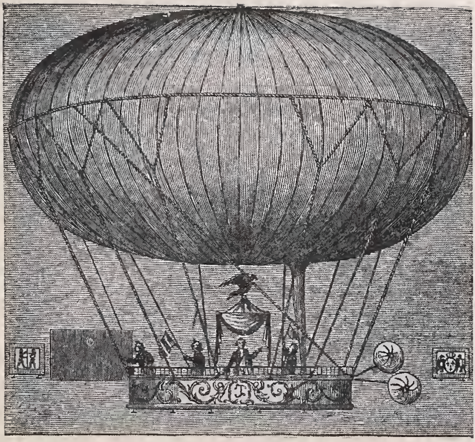
The idea of screw propellers worked by hand next cropped up as the best solution of a means of propulsion, and it is worthy of remark that shape, rigidity, and screws were thought of thus soon in the history of airships, on lines almost identical with those employed at the present time, but handicapped hopelessly by the lack of any suitable engine such as the motor, which now enables much better results to be obtained.

General Meusnier designed an egg-shaped dirigible balloon which embraced several excellent schemes, one of the most important being the introduction of air-bags (or ballonets, as they are now called) inside the envelope. By this means he hoped to keep the balloon tightly inflated, pumping air into these bags as the gas escaped, and so preserving the ideal shape and rigidity of his vessel.

He went even further into this subject, considering that by using compressed air in these bags he would be able to keep his balloon in equilibrium despite the gradual loss of gas. In these and other respects his projects were by far the most practical and advanced of any during the end of the nineteenth century, but the probable cost of building the airship he eventually designed prevented its ever being executed, and he himself was killed whilst fighting against the Prussians at Mayence in 1793.

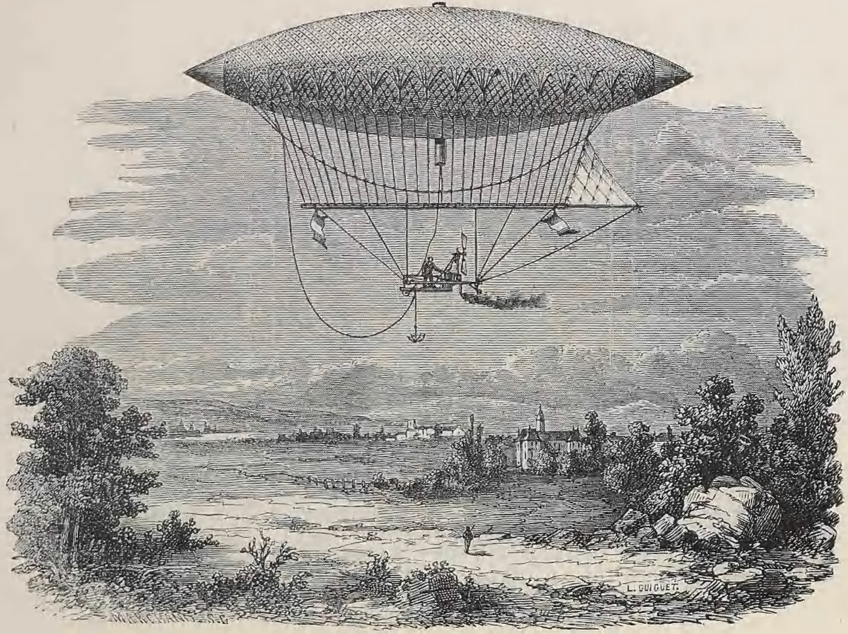
After this, interest in the matter of dirigible balloons began to wane, for it was recognised that the only known powers to drive them through the air were totally inadequate for the purpose.

During the next fifty years, though a few people in different countries designed and actually constructed airships of one shape and another, little real progress was made worth recording until we come to the work of Giffard in 1852. This individual was already known as an aeronaut, having made several ascents with Eugene Godard, and he subsequently invented the injector for steam-boilers, so may be fairly recognised as a capable engineer. In 1851 he succeeded in making a small steam-engine which weighed only 100 pounds, and was capable of developing 3 horse-power. Thinking this might prove



Duc de Chartres Dirigible.

Face page 98.



Giffard's Airship.

Face page 99.

of some use in connection with balloon work, he started upon the construction of an airship the following year in Paris.

It was somewhat the shape of a cigar, pointed at both ends, or perhaps a spindle gives a better idea of the form. It was 144 feet long, 40 feet in diameter at the centre or deepest part, and its capacity was 88,000 cubic feet. Excepting the extreme ends, the envelope was covered with a network terminating in stout lines similar to the leading-lines of a balloon, and to these was fixed horizontally a pole 66 feet in length and about 20 feet below the centre of the envelope. The rudder, which was in the form of a triangular sail, was fixed on one side to the rearmost line connecting the net with this pole, or keel as the designer called it, its lower side being fixed to a thin spar projecting backwards and in continuation with the horizontal keel. The car was slung centrally and about 20 feet further below the keel, and contained the small steam-engine which drove a three-bladed propeller, 11 feet in diameter, at the rate of 110 revolutions per minute. The engine with its boiler is said to have weighed 350 pounds, and the total weight of the balloon, including one passenger, was estimated at 1½ tons.

Calculating its lifting power in the ordinary way, this seemed to allow a margin of about 500 pounds for coal and water.

Giffard imagined that his engine would be of sufficient power to drive the airship at a speed of from 4 to 5 miles an hour if there was no wind at all, and, though he was able to give practical proof that this estimate was correct, it was quite evident that the weight of the engine was far too great by comparison with its horse-power, and the consequent speed obtained, to make the vessel of any real use, or to entitle it to the distinction of being called a dirigible balloon.

As the envelope was fitted with a neck like an ordinary balloon, Giffard realised the necessity of taking steps to obviate the chance of an explosion being caused by the gas escaping from his balloon and coming in contact with his furnace or the gases from the products of combustion. In front of the stoke-hole he fixed a piece of wire gauze, similar to that used in safety lanterns, and the furnace gases were taken through a chimney to one corner of the car and discharged downwards.

Three years later Giffard built another airship, narrower and longer than his first with a view of diminishing the air resistance. It was 230 feet in length, 33 feet in diameter at the centre, and had a cubical capacity of 113,000 feet. He used a special covering solution to stiffen the upper part of the envelope, and employed a net somewhat similar to the other, but no pole or keel was placed midway between the envelope and the car, the latter being suspended directly from the leading-lines of the net. The canvas rudder of this airship was attached on its upper side to the lower part of the envelope, and was nearly a third of the length of the latter. The same engine and propeller as before were used, and in a trial trip he succeeded in moving slowly against a light wind.

When he commenced to descend, the nose of the envelope tilted upwards, the weight of the car and engine broke the net away or slipped it off, and the envelope burst just before the ground was reached. Giffard and his companion, however, escaped with slight injuries.

Shortly after this time Giffard designed a gigantic airship which was to be nearly 2000 feet long, 100 feet in diameter, and to carry an engine weighing 30 tons, whereby he expected to obtain sufficient horse-power to drive this huge vessel on a calm day at a speed of over 40 miles an hour. This scheme, however, would have cost so much that it was abandoned, and Giffard devoted his attention once more to designing small steam-engines.

The next important advance in airship construction is found in 1872, when Paul Haenlein built in Vienna a vessel which in many respects closely resembled the most up-to-date French military dirigibles of to-day. It was of cylindrical shape in the centre with conical ends, the front tapering more gradually than the back. It was 164 feet long, its greatest diameter 30 feet, and its cubical capacity 85,000 feet. The car, which was suspended from ropes attached just below the equator of the envelope, was placed quite close up, so that each part might form as rigid a connection with the other as possible. The driving power was an innovation, being a gas-engine of the Lenoir type, with four horizontal cylinders, attaining a horse-power estimated by different writers at from 3 to 6 horse-power, with an hourly consumption of 250 cubic feet of gas. This gas was taken from the balloon itself, and the loss was made good by inflating ballonets inside the main envelope with air.

The engine drove a propeller, the blades of which were 15 feet in diameter, at 40 revolutions per minute.

Coal-gas was used to inflate the envelope, but the lift was very slight, and the vessel never ascended to any height, being kept captive by ropes held by soldiers during her trials. These resulted in a speed of about 10 miles an hour being attained in a calm, which was a distinct advance on any previous achievement. During the same year, whilst the Siege of Paris was in progress, the French Government commissioned Dupuy de Lôme to build a dirigible balloon of his own design. M. de Lôme was a marine engineer, and he constructed a vessel with several ingenious features, but which failed principally because he did not think of using any kind of engine for driving the propeller, but arranged for this work to be done by eight men, who could obtain about 20 revolutions a minute by dint of hard work, and consequently only develop a speed of travel which was estimated at from 4 to 5 miles an hour in a calm.

The balloon was egg-shaped, 118 feet long, 49 feet deep at the centre, and its capacity 122,000 cubic feet. The boat-shaped car was attached to the net by crossed lines from opposite ends, and by vertical lines from corresponding ends, by which means the designer secured a fairly rigid connection, so that the working of the propeller on the car acted almost directly on the envelope itself.

II

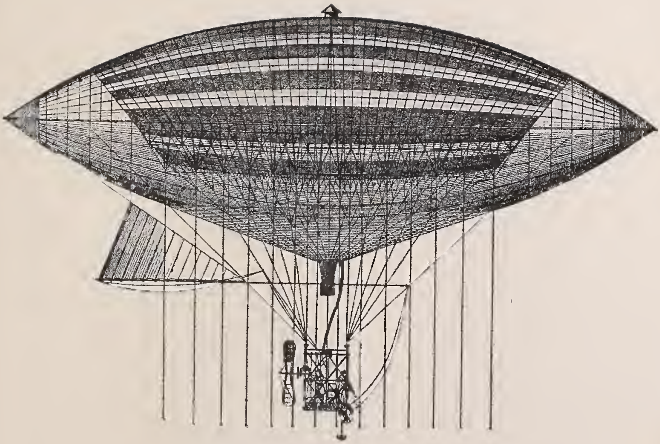
Progress from 1882 to 1897—Tissandier Airship—"La France"—Dr. Wölfert's Balloon—The Schwartz Aluminium Airship

For ten years after the production of the vessels described in the last chapter, little was attempted towards improvement in the design or construction of dirigible balloons, and there can be no doubt that the delay in progress was entirely due to the fact that a light engine, capable of developing adequate horse-power, had not yet been evolved. In 1882, however, two celebrated French aeronauts, the brothers Gaston and Albert Tissandier, built a dirigible which both in appearance and general principles was something between Giffard's and de Lôme's. It was the shape of a fat spindle, 92 feet long, 30 feet in diameter at the middle, with a cubical capacity of 37,500 feet. A wooden stay surrounded the equator of the envelope from point to point, to render it stiffer or more rigid in travelling through the air. The envelope was made of varnished cambric, with a large central top valve, and a central neck about 6 feet long and 2 feet in diameter. A net covered all but the extreme ends, and the leading-lines supported the car or basket, which hung some distance from the envelope, thus ensuring the centre of gravity being kept low, and tending to give additional lateral stability.

The car has generally been described as a cage, and its appearance and construction quite justify the appellation, for it consisted of a wicker tray at the bottom about

7 feet square and a few inches deep, out of which eight vertical bamboo rods, some 10 feet high and joined by transversals of the same kind, formed skeleton sides. The propeller behind this cage was driven at a speed of 180 revolutions per minute by a Siemens electric motor with a bi-chromate battery. This engine could only develop about 1½ horse-power, however, which was of little practical use, for in a dead calm the trials resulted in a maximum speed of 5 miles an hour being attained.

My readers must realise that quite a gentle breeze travels at ten miles an hour, and from 15 to 20 miles is an average force to expect. Strong winds are from 30 to 80 miles an hour, and a gale moves up to probably 150 miles an hour. Now, when we consider the size and consequent resistance offered by the envelope (not to mention the car and rigging which all count) it is obvious that, for use in ordinary weather, an airship must be capable of a speed of from 30 miles an hour upwards, to be at all useful as a craft steerable in any desired direction; and its speed against the wind will always be reduced by at least the speed at which the wind is travelling. Floating in the air, a balloon or airship has nothing to aid it in resisting the wind's movement as has a ship in the water, and its natural inclination is to move in the direction and at exactly the same rate as the wind. Consequently a big horse-power is always required, and even this is non-effective if a large heavy engine is used, for naturally the envelope must then be comparatively larger in order to support the weight. The success of a dirigible balloon, therefore, depends in the main on its being fitted with an engine as light, yet as powerful as possible, so there is nothing surprising in the want of success which attended all these earlier vessels, for the right kind of engine had not been evolved, and even now



Tissandier's Dirigible.

Face page 104.

the best type of petrol motor obtainable is far from being as efficient as complete power of aerial navigation demands. The introduction of an electric motor by the Tissandiers, however, marks a distinct epoch and advance in the construction of dirigibles, and their efforts were followed two years later by the production of a still better airship, designed and commenced by two French officers named Renard and Le Haye, the latter being succeeded by Krebs, who aided Renard in completing and testing the vessel.

This ship, which was christened "La France," was more the shape of Haenlein's design, being 165 feet long, about 27 feet in diameter at its deepest part, and having a capacity of 66,000 cubic feet. Its car, however, was of quite different style to any before used, the framework, made of bamboo, being 108 feet long, 6 feet high, and 4½ feet wide, and the sides covered with silk. An electric motor capable of developing 8½ horse-power drove a wooden two-bladed propeller some 23 feet in diameter, which was fixed in front of the car, and was the first aerial example of screw *traction* instead of screw *propulsion*. Practically rigid connection between the car and envelope was obtained by an attachment of diagonally arranged ropes. The envelope was torpedo-shaped, its greatest diameter being about a quarter of its length from the front, whence it gradually tapered off to the stern. The rudder was of peculiar design, consisting of two 4-sided pyramids with their bases placed together, and was fixed between the rear of the car and the envelope. As the propeller blades projected several feet below the level of the bottom of the car, their axis was so arranged that it could be raised, and thus prevent the blades being injured when the airship made a descent to the ground.

Captain Renard also took the precaution of using a long and heavy guide-rope or trail-rope, to prevent a violent shock when landing, the action of which I must try to explain. If ballast only is used to check the speed of a balloon's descent, it is extremely difficult to gauge just how much or how little should be thrown out. This is met adequately by using a heavy rope, from 200 to 300 feet long, which can be lowered out of the car, and which on touching the ground automatically relieves the craft of weight just like the discharge of ballast. If, however, the descent is somewhat rapid, the weight of rope is rapidly reduced and the balloon may regain lifting power, but it would only rise a short distance before the increased weight of rope it would be raising from the ground would check it and again bring it down. Another advantage of the trail-rope is that its friction against the ground checks the speed of the balloon or airship, and so gives the anchor a better chance of getting a good grip. A sliding-weight was arranged in the car which could be moved in order to counteract any shifting of the centre of gravity by a passenger changing his position, so keeping the vessel on a level and horizontal keel and preserving its stability.

On the 9th August, 1884, Captains Renard and Krebs made an ascent in "La France" from the Military Balloon Ground at Chalais-Meudon, and, although they did not dare to run their motor at its full power, they were delighted to find that the propellers visibly increased their speed of progress, and that the rudder could cause small changes of their direction. After covering a distance of about 2½ miles they turned round, returning against the light wind to a spot just over their starting-point. Opening the valve, they descended gradually from a height of about 1000 feet, until the guide-rope was caught by soldiers and the airship was safely landed, having travelled nearly 5 miles in 23 minutes. This was absolutely the first time any aerial craft had succeeded in making a journey and returning to the point of departure, a record which will always stand in the names of Renard and Krebs, whose success placed the seal of possibility on aerial navigation in its literal sense, and silenced the voices of those sceptics who had declared loudly that the problem of steering a lighter-than-air vessel was insoluble and could never be accomplished.

France thus got a start of other countries in regard to airships, and up to the present time she has more than held her own, though German invention and patriotism has enabled the Fatherland to achieve wonderful results recently. England and America lagged behind most lamentably, and it seems almost impossible to stir up any national enthusiasm amongst the English on the subject of aerial navigation generally. This is the more remarkable from the fact that England's safety from foreign invasion has always lain in her insular position, protected by a navy estimated capable of defending her from any attack. How is her position affected now that airships have arrived at a state of perfection sufficient to enable them to travel continuously for more than 36 hours at a speed of over 30 miles an hour? It should be obvious to every British subject that such a condition of things completely destroys England's insularity. Consider the work which could be effected by a few good dirigibles in time of war. Firstly, we should have scouts flying over our dockyards, fortifications, and arsenals, able to report by "wireless" or verbally on their return to their headquarters. These scouts could travel twice as fast as any fleet of ships in the water, and could advise their own ships as to the disposition of our various units, and so aid an enemy in making the best plans for attacking at any weak point.

Again, what would be the sensations of the citizens of London, Manchester, Birmingham, and other important towns, if they awoke one morning to see a few enemies' airships hovering a couple of thousand feet overhead, with the intimation that each craft was carrying a few tons—or even hundredweights—of lyddite, or other equally destructive explosive, or quantities of inflammable matter?

I fully believe that English pluck is as good as ever it was, but I consider that it would be foolhardy and not brave if the people went to their offices and business houses under such circumstances, and probably the tube railways, cellars, and any underground accommodation would be crowded to the uttermost. The moral effect of aerial craft above one would be enormous, apart from the damage they could probably inflict. Beyond that, however, one must realise the feasibility of airships destroying battleships, dockyards, and our principal means of offence and defence during the dark hours of night, when they would be in a virtually safe position in mid-air and out of sight, but everything below them would be clearly visible, marked out by lights which would form almost as good a map as one could wish.

Speaking as an Englishman, I can only express the fervent hope that this country and the Government will speedily awake to the huge importance of aeronautics, rapid development pointing to its exercising an ever-increasing influence on our national means of attack and defence, and it is to my young readers that I would especially appeal to give the subject their serious attention and thought, for it is to all of you that England must look in the next quarter of a century as her guides and leaders, just as much in aeronautics as in the army and navy.

I am perhaps digressing somewhat from the heading of this chapter, but after all there was a motive, and a strong one, too, in my attempt to write a boy's book which might tell boys something simple and straightforward about various aerial craft, that is to say, the desire existed of first interesting you, and, if successful in that respect, there was the underlying hope that the British spirit of emulation, love of adventure, and loyal patriotism might persuade at least some of you to determine upon adopting an aeronaut's life or profession, let it be in the Royal Air Marine, the Royal Aeronautical Department, or whatever corps may be ultimately created by England to perform such functions in the air as are carried out by our army and navy on land and sea. It will be an honourable and glorious profession, affording opportunities for distinction which could scarcely occur on the earth or sea-level, and becoming of greater importance almost every day.

Now to return to France and Captain Renard's airship, which I deserted after describing her first trial trip!

Seven journeys in all were undertaken, the earlier ones proving that a speed of over 14 miles an hour could be attained in a calm, and the two last trips she made from Calais were to Paris and back during the year 1885.

French experiments with airships now ceased for more than ten years, during which time considerable progress was made, however, with gliders and other heavier-than-air machines, to which reference is made in the next part of this book.

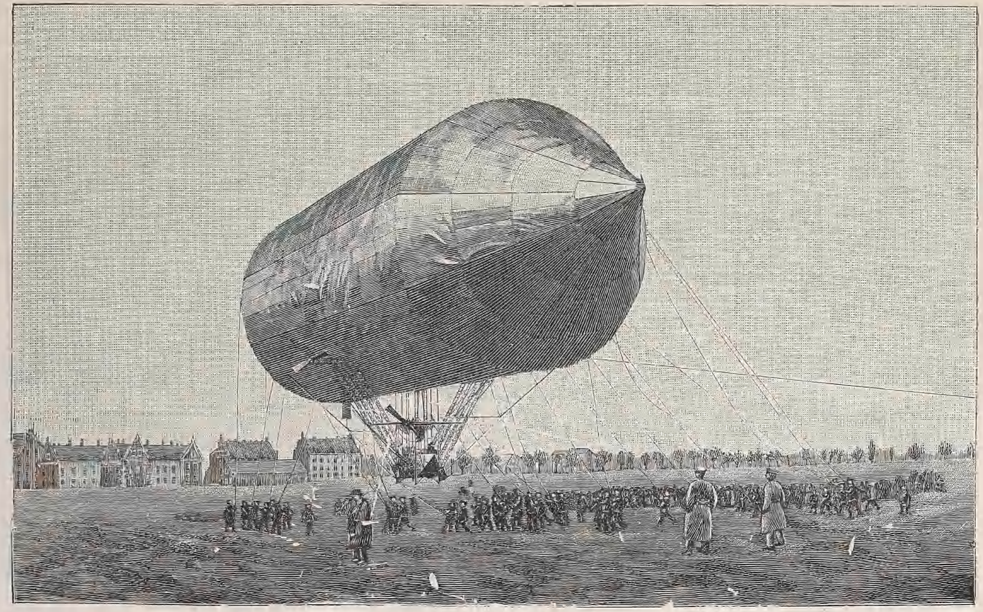
In 1879 Dr. Wölfert and Herr Baumgarten built a cigar-shaped dirigible in Germany, which was fitted with a Daimler benzine motor. This vessel ascended from

Leipsic in 1880, but was not a success. Three cars were attached to the envelope, and it had a propeller underneath to raise it vertically from the ground. A passenger carried in one of the outer cars destroyed the balance, the ship tilted on end, and came to the ground with a crash, the occupants luckily being uninjured, but the machine was practically destroyed.

Baumgarten subsequently died, but Dr. Wölfert continued to make experiments, and in 1896 completed another airship fitted with a benzine motor. The propeller blades were made of aluminium, combining lightness with strength, and a rudder of the same solid shape as Renard's was used. Tests showed that the motor was not satisfactory, and Wölfert tried to improve it by the addition of a vaporiser which he designed himself. Various authorities state that satisfactory preliminary experiments were made, and on June 12, 1897, it was arranged to make an ascent from the Tempelhofer Feld, the great German military parade ground near Berlin.

The airship rose to a height of 500 or 600 feet and drifted with the wind. Suddenly a flame was noticed, caused by the benzine vapour forming an explosive mixture with the air. There was a sharp report, the envelope burst, and the whole vessel fell rapidly to the ground, where it was completely destroyed by the flames, both Wölfert and his companion being killed on the spot.

From 1895 to 1897 an airship with a rigid aluminium envelope, designed by an Austrian named David Schwartz, was built in Berlin. It was of elliptical shape in cross-section, coming to a conical point in front, and rounded off at the stern. In the middle it was 46 feet deep and 39 feet wide, whilst its length was about 156 feet and its cubical contents 130,000 feet. The car was



THE SCHWARTZ AIRSHIP.

Face page 110.

THE "BAYARD-CLÉMENT" SAILING OVER BEAUMONT.

Face page 111.

rigidly attached to the envelope by trellis-work aluminium stays or girders, and the motor—which was also made of the same metal—had two vertical cylinders, was petrol-driven, and worked two propelling screws, one at each side of the centre of the envelope about midway between the central axis and the bottom. A large steering propeller was fixed behind and above the car, and these were all belt-driven.

Schwartz himself had died early in 1897, and his balloon was completed by the military authorities, who decided to give it a trial at the Tempelhofer Feld in November of the same year.

It is obvious that such a balloon as this cannot be inflated by simply letting gas into the envelope, for it is of course already full of air, and the result would merely be a mixture of the two. The filling of the Schwartz airship was entrusted to Captain von Sigsfeld, a well-known officer of the German Military Balloon Corps, and he employed one of the two following methods:

A number of silk bags are placed in the metal envelope, and gradually filled with gas. As they become inflated the air is gradually forced out, until the whole internal space of the envelope is occupied by gas-filled bags. These are then torn to pieces and pulled out, leaving their contents in the envelope free of any air. The other method is to put a linen or silk lining inside the metal casing, and to blow this inner envelope tightly out with air. Gas is then allowed to pass in between the aluminium and the linen, and the air is gradually pressed out of the latter until the metal case is full of gas and the linen bag is empty, when it is withdrawn.

A young mechanic named Platz volunteered to take charge of the engine and make an ascent by himself, which he was allowed to do. The vessel rose to a height of about 800 feet and was turned head to the wind, which was blowing at approximately 15 miles an hour, but the propellers could not force it forward, the driving belts quickly slipped from their pulleys, and the airship began drifting astern. The motor stopped, and Platz, fearing a similar accident to that which had befallen Wölfert, immediately opened the top valve, and descended rapidly. The shock on reaching the ground did a certain amount of damage, which the wind subsequently completed, the airship being reduced to a hopeless wreck.

III

Failures and Progress During the Nineteenth Century

In his "Pocket-Book of Aeronautics," Colonel Moedebeck summarises the various causes of non-success which attended the efforts made by different inventors of dirigible balloons from time to time during the nineteenth century, and there is little reason to doubt the accuracy of his deductions from anything which has occurred to enlighten us on the subject since he expressed his opinion.

He states that:

1. The laws relating to air resistance for different sizes and forms of surfaces are not sufficiently calculated and understood.

2. The power of the motors employed was over-estimated in comparison with the great head resistance to be overcome. (Laws regulating the resistance of the air, various formulæ computing the head resistance of bodies of various shape and size moving at different speeds, methods of determining different degrees of resistance, measurements of the same, etc., are dealt with at some length in Moedebeck's "Pocket-Book" and other works, the principal of which is probably Professor Lanchester's "Aerial Flight," Vol. 1, Aerodynamics.)

3. The action of propellers in the air was not understood. The question as to whether a large screw propeller rotating slowly, or a small rapidly rotating one worked most satisfactorily, remained undecided. The driving power required for the various screw propellers was also not worked out.

The difficulties encountered have given rise to some of the following opinions as to the solution of the problem of aerial navigation:

1. Many workers on the subject wish to make use of the rise and fall of a balloon in combination with inclined planes. "This idea exists only in theory at present," says Colonel Moedebeck.

2. Others conclude that the problem must be solved without the use of balloons. As supporters of the heavier-than-air principle, they oppose the adherents of the lighter-than-air designs.

Progress with airships became marked for the first time in the last quarter of the century, and this was brought about principally by the requirements of war, and the great use which was made of ordinary spherical balloons during the Siege of Paris, 1870-71. The advancement may be traced to the following causes:

1. Experiments at the cost of the State by the French Government (1872, Dupuy de Lôme; 1884-85, Renard-Krebs).

2. The organisation of military balloon corps, who attacked the problem zealously, supported experiments, and at the same time spread a proper knowledge of the subject of air-travel in general, and stimulated meteorological science to investigate the conditions of the atmosphere by means of balloons.

3. The development of the technique of small motors or engines, which itself marks out the various stages of the airship's progress—the steam engine, Giffard; the gas engine, Haenlein; the electric motor, the brothers Tissandier; the benzine motor, Wölfert.

4. The discovery of a cheap method of manufacturing aluminium and magnesium, and of the useful properties of different alloys of these metals.

5. The improvement of traffic generally, especially automobiles, which, besides leading to the steady improvement in motors, produces a class of man who is daily educated in forming rapid decisions and who gains ever-increasing courage and confidence, characteristics which a capable aeronaut *must* possess.

Since the beginning of the twentieth century Germany and France, indisputably the two leading countries in airship development, have gradually drifted into what may be termed two different schools of thought, Germany having devoted most attention to the rigid form of envelope, generally known as the Zeppelin type (fully described in a later chapter), whilst France has continued loyal to the non-rigid or collapsible envelope, or to this system made semi-rigid by various forms of rigging and other appliances.

IV

The Experiments of Santos-Dumont—His Fourteen Airships—Some of His Adventures—Winning the Deutsch Prize

Nobody during the last ten years has done such varied aeronautical work as the young Brazilian, Santos-Dumont, who commenced to make history in Paris during the year 1898, when he was only 25 years of age. Endowed with any amount of pluck, common-sense, and determination, besides ample private means, he possessed the principal attributes of a successful aviator or aeronaut, and for some years his name was almost incessantly before the public by reason of his exploits in mid-air, which early gained him the nick-name in France of the "man-bird."

In seven or eight years he produced no less than fourteen different dirigible balloons, of which Captain Hildebrandt publishes a summary in such compact form that I take the liberty of reproducing it on next page.

Tracing the career of M. Santos-Dumont, it is interesting to note that he progressed step by step with every successive airship, and, having apparently always gained useful knowledge and instruction from each vessel and during almost every separate ascent, he seems to have wasted no time in remodelling the old, but immediately set to work designing and building a completely new craft, embodying every improvement suggested by its predecessors.

The "Santos No. 1" may justly be said to have established a record as the smallest dirigible balloon ever constructed. Its length, being more than seven times its greatest depth, is another feature which has never been exceeded in the comparative proportions of any dirigible with a flabby or non-rigid envelope.

SANTOS-DUMONT'S DIRIGIBLE BALLOONS

Number	Shape	Volume in Cubic feet	Length in feet	Greatest diameter in feet	Motor
I.	Cylindrical; conical at back and front.	6,350	82	11.5	3 h. p. Dion Bouton.
II.	Ditto	7,060	82	12.5	Ditto.
III.	Cigar-shaped; filled with coal gas.	17,650	66	24.6	Ditto.
IV.	Cylindrical; conical at back and front.	14,800	95	16.7	7 h. p. Buchet.
V.	Ditto	19,400	108	16.4	12 h. p. with four cylinders.
VI. Winner of the Deutsch Prize	Elongated ellipsoid.	22,200	108	19.7	Ditto.
VII.	Ditto	44,500	164	26.25	60 h. p. weighing 2½ cwt.
VIII.	(Sold to an American; only made one trip.)				
IX. "The Balladeuse"	Egg-shaped	7,770	50	18	3 h. p. Clement (26 lbs.)
X. "The Omnibus"	Ellipsoidal	71,000	157	27.9	20 h. p.
XI.	Ditto	42,400	111	....	16 h. p. with four cylinders (3¼ cwt.)
XII.	(Placed at disposal of military authorities.)				
XIII.	Egg-shaped	67,109	62	47.7	....
XIV.	Cigar-shaped ...	6,570	134	11.1	15 h. p. Peugeot (57 lbs.)

Santos-Dumont abhored the number 8

The driving power was obtained by using a two-cylinder motor-tricycle petrol engine, which revolved a double-bladed metal propeller at 1200 revolutions per minute. The gas used to inflate the envelope was hydrogen.

Santos-Dumont made his first attempt to ascend in this midget airship on the 18th September, 1898, the Jardin d'Acclimitation in Paris being selected as a starting point. Inexperience caused an almost immediate failure, for the airship was liberated with its stern to the wind, the engine was started, and before the vessel had time to rise high enough to clear the surrounding trees, the double force of the wind and the propeller drove it among the branches, and some little damage was sustained.

In two days, however, the necessary repairs were effected, and another ascent was made, this time and always afterwards starting with the vessel pointing head-to-wind. After performing sundry evolutions at a small height from the ground, Santos-Dumont gained enough confidence to rise to about 1300 feet and steer off towards Longchamps. After a short time, and as the altitude was reduced, the contraction of the gas caused the envelope to slacken so much that it gradually collapsed in the middle, and with both ends closing upwards towards one another, the airship began to come down at a great rate.

Her pilot never lost his presence of mind, and shouted to some boys in a field below him to catch hold of his guide-rope and try to run off with it against the wind. This they did, and the air resistance thus formed checked the speed of the fall sufficiently to save a bad crash, and Santos-Dumont escaped without the slightest injury. His naturally cheery disposition took the occurrence quite philosophically, his first laughing comment on getting out of the car being, "I have varied my pleasures somewhat, for after ascending in a balloon I have come down in a kite!"

He of course had made the mistake of going too high in so small a craft; for the gas which fully inflated the envelope at the start, would overflow from the neck pretty considerably as it expanded, and then, as the descent was made and the contraction took place, the envelope was left half empty and flabby, so a broken back was almost inevitable.

"Santos No. 2" was built by May of the following year, and it only differed slightly from its predecessor, having 700 cubic feet greater capacity, and its air-ballonet was filled by means of a small fan instead of by a pneumatic pump, the latter having proved insufficient to fill its ballonet quickly enough during a descent, so as to retain the rigidity and shape of the envelope as the gas contracted.

Unfortunately, on the 11th May, when this vessel was put to the test of an ascent, a downfall of rain condensed the hydrogen in the envelope so rapidly that again the air-ballonet could not adequately perform its functions, the balloon shut up in the middle as the other had done, and the whole vessel was considerably damaged by falling in the trees, though Santos-Dumont again escaped unhurt.

This second experience was enough to determine him upon a new shape for his envelope, and "Santos No. 3" was of a much more stumpy design, being not quite three times as long as it was deep, instead of more than seven times, as the two others had been. The envelope, which was inflated with coal-gas instead of hydrogen, had more than double the cubical contents of the others. The same engine as before was used, but a bamboo rod was placed between the car and the envelope with the idea of aiding the latter to maintain its shape and thus prevent another collapse.

This vessel made its maiden voyage from the Champ de Mars in November, 1899, and Santos-Dumont handled it admirably, making several turns round the Eiffel Tower before eventually bringing it safely to ground, curiously enough, in the very field where "Santos No. 1" had landed after the accident.

After making a series of trial ascents in this airship, he designed and constructed No. 4, which was in shape more like the early ones, being cylindrical with conical ends, and nearly six times as long as it was deep. A new design of car was employed, the pilot being seated on an ordinary bicycle saddle, with pedals to control the motor. This was a 7-horse-power Buchet engine, and drove a propeller fixed in front instead of at the back, so using traction instead of propulsion as the motive force. Hydrogen was again used to inflate the envelope. This new airship was exhibited in Paris during September, 1900, before the International Commission, and Santos-Dumont made several satisfactory journeys in it from the grounds of the Aero Club at St. Cloud, where he had built a large "hangar"—as a shed for balloons or airships is called in France.

Just about this time considerable excitement had been created in Paris by an announcement in the press that M. Henry Deutsch de la Meurthe, a well-known member of the French Aero Club, had offered a prize of one hundred thousand francs (£4,000) to the first person who could complete a journey by airship from the Club's grounds, round the Eiffel Tower, and back to St. Cloud within 30 minutes.

Such a generous offer naturally did much to stir up further public interest in the performance of Santos-

Santos Dumont Rounding the Eiffel Tower.

Face page 120.

Dumont, who seemed to be the only individual at that time who had any chance of gaining the award. He immediately started to construct "Santos No. 5," which was of the same cylindrical shape with conical ends as No. 4, but was longer and of greater capacity. He introduced a 4-cylinder, 12-horse-power engine, and constructed a keel 59 feet long, which was made of pinewood stays covered with wire. In cross-section this keel had the exact form of an equilateral triangle. The joints were of aluminium, and, whilst the whole was designed to be absolutely rigid and to keep the envelope when connected to it in a similar condition, it was extremely light, only weighing about 90 pounds, and could be readily disconnected from the envelope.

An ascent with this latest airship took place on July 12, 1901, when Santos-Dumont first travelled ten times round the Longchamps race-course (a distance of 22 miles), and then steered for the Eiffel Tower. One of his rudder-lines getting broken on the way, he at once descended in the Trocadero Gardens, where, aided by a few willing volunteers, he soon repaired the damage, and re-ascending, proceeded onwards, circled the Eiffel Tower, and returned to the Aero Club grounds after a journey which had lasted altogether for one hour and six minutes.

After this success, Santos-Dumont felt fairly confident of being able to gain the Deutsch prize, so he notified the authorities that the next day he should make an attempt to perform the journey in the time stipulated by the conditions.

The motor did not work well on this occasion, and the airship came down in the middle of a large tree, in a park belonging to Mr. Edward de Rothschild, on the way back to St. Cloud, having successfully covered more than half of the distance, and circled round the Eiffel Tower.

After a few weeks' interval for repairs and tuning up of the motor, the attempt was again made on 8th August, when Santos-Dumont reached the Tower in good time, turned, and got back quite close to St. Cloud, the spectators already confident that the prize was won. Suddenly, however, the motor stopped, and the airship fell rapidly on the roof of the Trocadero Hotel, in the Rue Alboni. The crowd which had assembled at the Aero Club grounds hurried off on foot, bicycle or motor-car to the scene of the accident, fearing the worst had happened. M. Deutsch, with Prince Roland Bonaparte, was among the first to reach the spot, the former already accusing himself of being the involuntary cause of the plucky young aeronaut's death.

To everybody's relief, however, on arriving at the hotel where the accident had taken place, they perceived Santos-Dumont perched on the roof, quite composedly directing the salvage of his vessel, which was being undertaken principally by members of the Paris Fire Brigade. The envelope, completely destroyed, and most of the wreckage was hanging over the edge and down the side of the building, but, like a good captain of a ship at sea, nothing would persuade the intrepid Santos-Dumont to quit his perch until the whole of the damaged machine had been safely brought to the ground.

He was warmly congratulated by everyone who could get near him on his fortunate escape, and complimented on his pluck, to which he laughingly replied that he should begin again and let nothing discourage him, for he intended finally to conquer his bad luck.

Only three weeks after this experience the "Santos No. 6" was completed, so palpably no time was lost in designing and constructing this vessel. She was slightly deeper than No. 5, and had consequently a larger capacity, but was fitted with a similar keel or rigging, and the same engine; the envelope was made of Japanese silk, in the shape of a long ellipsoid, just five and a half times as long as it was deep. Like its predecessor, the arrangement for balancing or keeping it on a level keel consisted in a movable guide-rope, which could be shifted backwards or forwards at the will of the pilot.

After several experimental ascents and short journeys at Longchamps, Santos-Dumont once more notified the authorities that he would attempt the trip round the Eiffel Tower to try and win the Deutsch Prize, and on the 19th October, 1901, he started in the afternoon from the Aero Club ground at St. Cloud, travelled over the fixed route, circling round the great tower just below the level of its summit, and descended again at his starting point in 30 minutes 40 seconds.

This excess of 40 seconds over the stipulated half-hour for the journey was the subject of much discussion, some saying that, as the trial was of a sporting rather than an actual speed-testing nature, the question of a few seconds more or less should be ignored, whilst others considered that the prize should not be awarded unless the exact conditions were fulfilled.

Eventually, however, the committee of the Aero Club adopted the former view, and Santos-Dumont was the recipient of the £4,000 presented so generously by M. Deutsch, and was congratulated from all parts of the world.

It is pleasing to recall the fact that three-quarters of this amount was given by the gallant aeronaut to the poor of Paris, and the remaining £1,000 divided among the mechanics and workmen who had built his airship and generally aided him in achieving his success.

The Brazilian Government presented him with a specially struck gold medal and £5,000, which sum he devoted to the building of new airships.

During the following winter he took "Santos No. 6" to Monaco, where a large shed had been built for its reception. He made several successful ascents and trips over the Mediterranean on fine days, but on February 14, 1902, in consequence of the air-ballonet not being filled quickly enough to make up for the loss of gas, the balloon tilted over and fell into the sea, where Santos-Dumont was found up to his waist in water, and was picked up by a boat belonging to the Prince of Monaco, which also rescued the wrecked vessel.

Of the eight airships which Santos-Dumont built subsequently probably the small egg-shaped "Santos No. 9" was the best known, for in this vessel he performed several feats to the vast surprise, amusement, and delight of the general public.

On one occasion he went in this balloon to the racecourse of Longchamps, where he descended and watched the races, afterwards re-ascending and returning home by air.

On another occasion he landed on the pavement in front of his own house, where he breakfasted, and then continued his journey.

Once when the French troops were being reviewed by President Loubet, Santos-Dumont appeared in his airship opposite the grand-stand, and, after firing a salute with small toy cannons, he sailed off again.

These and similar feats naturally drew an immense amount of attention to the subject of aerial navigation, besides creating a widespread interest in the matter from a sporting standpoint.

THE MALECOT AIRSHIP BEING TOWED BACK TO ITS HANGAR.

Face page 124.

V

Roze's Double Airship—The Pax—Severo's Death —The De Bradsky—Another Fatal Journey

During the year 1901, the doings of Santos-Dumont stirred up a considerable spirit of emulation in the minds of other inventors, which resulted in numerous airships of various designs being constructed which were more or less impracticable.

Mention must be made of some of these, one of the most curious examples of mistaken principles being found in the double-envelope machine built by a M. Roze in Colombo.

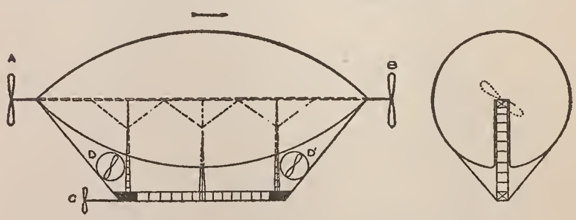
In this vessel the car, engine, and propeller were placed midway between two cigar-shaped balloons of equal size, the designer imagining that this arrangement would do away with any tendency to roll or pitch. He failed to realise that he would incur a very large head resistance by thus practically doubling his sectional area, neither did he calculate on the total weight requiring more lift and driving power.

Accordingly, when the day for trial arrived, it is not surprising to learn that the "Castor & Pollux"—as the vessel was named—could only be got to rise a small distance from the ground by the exercise of much muscular energy, and then fell back heavily on the assistants who were trying to get it up, nearly crushing them beneath its mass. Furious at this mishap and failure, the people who had financed the inventor would have nothing more to do with the idea, even refusing to allow the sale of its material, preferring to see it broken up and destroyed. M. Roze was thus deprived of any chance of renewing his experiments, and saw he could not hope to raise fresh subscriptions to try any other type of vessel, so one has heard no more of him in matters aeronautical up to the present day.

Another dirigible balloon was designed at this time by Augusto Severo, a Brazilian, like Santos-Dumont, who had an official appointment in Paris which enabled him to watch the progress of his countryman, and whose achievements he soon sought to emulate.

His principal idea was to make the propeller act directly on the longitudinal axis of the balloon itself instead of on the car, whereby he expected to obtain a greater thrust, and to save any loss of power which might arise from the non-rigid connection between car and envelope.

The shape of his envelope, divided in the lower half to give access to the pylons or frame-work from the car to the bamboo pole which formed the axis, can be best understood by a glance at the accompanying diagram.



The "Pax," as his balloon was called, was built by Lachambre, and the envelope was made virtually rigid by an inner frame-work. Its cubical capacity was nearly 85,000 feet, and a propeller was placed at each end of the pole which formed the longitudinal axis. The front propeller was 13 feet in diameter and was intended merely to push aside the air and thus reduce the resistance when travelling; the rear or driving propeller was 22 feet in diameter. These were driven respectively by connection through the pylons with a 16- and a 24-horse-power Buchet petrol motor in the car, which latter was just half the length of the envelope, and was built up of bamboo rods, steel and aluminum tubes, covered in with cotton material to reduce the friction. The envelope itself was made of a very strong French silk, its most peculiar feature of course being its central slit throughout the lower half. Severo's idea of making the centres of propulsion and resistance coincide with one another was carried out far more rationally than by Roze's method, his great and fatal error being in having the car with the motors attached much too close up under the envelope, just as poor Wölfert had done with his airship.

Between each end of the car and the envelope were fixed double-bladed propellers in pairs, revolving in opposite directions, and intended for steering purposes in lieu of a rudder.

Early in May, 1902, the vessel was completed, and, after two preliminary trials, the first ascent proper was fixed for May 12th. This was to take place from the Parc de Vaurigard, and it was intended that the airship should travel to Issy, where military manœuvres were in progress, and, after performing some evolutions over the troops, return again to the starting point.

Severo, accompanied by a young French mechanic named Saché, mounted the car and took his place by the front motor, whilst Saché stood at the other.

For a couple of minutes the airship carried out some tests while held captive by ropes, and as everything appeared to work perfectly, she was then released, some ballast was thrown out, and she rapidly rose. Suddenly the rear propeller stopped revolving, and the vessel commenced turning round on its minor axis. It was seen from the ground that more ballast was thrown out, and again the vessel ascended higher and higher.

Herein lay the danger, for the envelope was inflated with hydrogen at a greater pressure than usual, the ascent of course caused rapid expansion, the bottom valve allowed the gas to escape, and its close proximity to the motors greatly increased the risk of fire.

Suddenly a flame was noticed, followed by a violent explosion, and in a moment the whole vessel was on fire, the gas of course was consumed, and the burning wreck with its two unfortunate occupants fell with terrible velocity into the Avenue du Maine. There is no doubt that their death was instantaneous, but their remains were terribly scorched by the flames, and their end was the most horrible tragedy in the whole history of aeronautics.

Baron von Bradsky-Laboun also had an airship built in Paris by Lachambre, but his design differed from the "Pax." The envelope was 112 feet long, had a capacity of 30,000 cubic feet, and its lifting power was only just sufficient to raise the dead weight of the complete machine. A propeller under the centre of the car, and working on a vertical axis, was to effect any desired upward or downward movement, a stern propeller was the method of propulsion, and a small vertical rudder was attached to the centre of the back of the envelope, which had a wooden stiffening frame surrounding it just below its equator, and from this frame the car was suspended by 50 piano wires. There was, however, practically nothing in the way of diagonal connection, which omission appears to have been the cause of the fatal accident that befell the vessel on the occasion of its first experimental ascent. The engine was a 16-horse-power Buchet motor.

On October 13, 1902, Bradsky, accompanied by a young engineer named Morin, started his journey, and though he attempted to steer head to wind he found it impossible to do so, and the airship drifted over Paris. Having arrived over Stains he descended to a height of about 300 feet, intending to find a suitable landing-place, but suddenly Morin moved towards him in the car, which seemed to overturn, and the connecting wires breaking, both occupants were hurled to the ground and killed.

One hour afterwards the envelope came to ground of its own accord, some 19 miles distant from where the car had fallen.

In consequence of these dire calamities, and recognising the fact that even far greater damage might have ensued had the accident to the "Pax" taken place later in the day instead of at 5.40 in the morning, when the street was practically deserted, the French Aero Club issued instructions that in future, until more knowledge and experience had been gained, all experiments with aerial craft should take place in the direction of the country, and journeys over Paris should not be attempted.

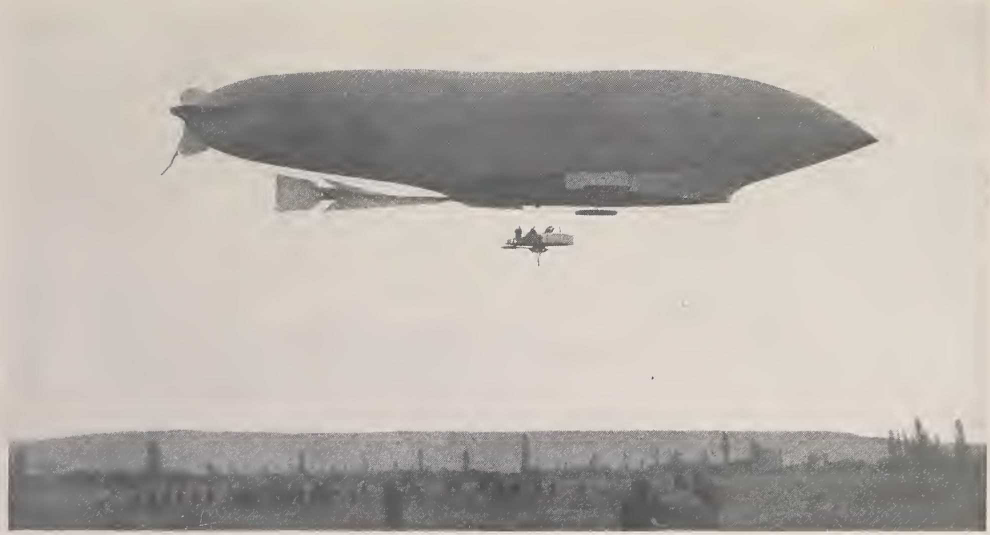
VI

A Short Description of the "Lebaudy" Airships

Despite the fact that to Santos-Dumont probably belongs the credit of all the earlier successes and by far the longest journeys up to the year 1902, none of the vessels which he designed and built were suitable for military purposes. It is really to the enterprise and generosity of the brothers Lebaudy that France principally owes her present aerial fleet, and has been enabled to maintain her reputation as being the foremost nation of the world in aeronautics.

These gentlemen, blessed with considerable wealth, their enthusiasm fired by the achievements of the little Brazilian and others who had met with some degree of success, in 1899 commissioned a capable engineer named Jouillot to set to work with all the information at his disposal and see if he could evolve a good practical design for a large airship. Two years later they commenced to build a vessel in accordance with his ideas, and in October, 1902, its first ascent took place.

The envelope was cigar-shaped, 187 feet long, 32 feet in diameter at the deepest part, and had a capacity of 80,000 cubic feet. It was made of a bright yellow calico and was generally known in France by the name of "Le Jaune." The bottom of the envelope was fastened to a rigid floor or platform made of steel tubes, which was about 70 feet long, 20 feet wide, and elliptical in shape. The idea of this flooring was, firstly, that it would act somewhat as a parachute, so breaking the fall if anything should happen to the envelope, and secondly, that it



"La Russie," Built in France by M. M. Lebaudy.

Face page 130.

"La Russie," Seen from the Front (on the Right) and from the Rear End (on the Left).

Face page 131.

would give the whole vessel greater stability and prevent rolling or pitching. Hung from this flooring by steel rods, and about 19 feet below it, was a car some 16 feet long and $5\frac{1}{2}$ feet wide, in which was carried a Daimler motor giving 45 horse-power, and on each side of which was a twin-bladed screw propeller, the blades of which were just over 9 feet from tip to tip.

During the next thirteen months more than thirty experimental ascents were made, and improvements in details of construction were continually being introduced. The longest voyages accomplished were 23 miles in 1 hour 36 minutes; 38 miles in 1 hour 41 minutes; and 61 miles in 2 hours 46 minutes.

In November, 1903, the vessel travelled from Paris to Chalais-Meudon at an average height of 500 feet. In coming to the ground it dashed into a tree, the envelope being torn and practically destroyed.

The "Lebaudy" of 1904 was constructed with an envelope of different shape to her predecessor, remaining pointed in front, but being rounded off at the stern. Its capacity was about 14,000 cubic feet greater owing to this enlargement of the afterpart, and it had greater stability due to the addition of horizontal and vertical sails, some of which were fixed and others movable.

The calico envelope of the former vessel had acted so well that similar material was again employed, but this time with the addition of a coating of rubber both inside and out to render it more hydrogen-tight. In France the hydrogen is made from sulphuric acid and iron filings, which method has the disadvantage of allowing small quantities of the acid to remain in the gas, and this acid gradually destroys the calico. The inner rubber coating served to protect the material from being thus gradually eaten away.

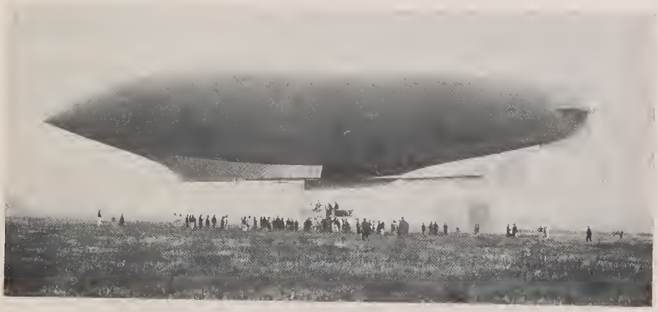
During 1904-5 this airship made numerous ascents and performed several long voyages from one place to another. It was found to be exceedingly stable, and could always be brought to the ground with ease and safety. The French Minister of War carefully watched the progress which was being made, and, being anxious to ascertain its possible uses for military purposes, he appointed a commission of three officers from the Balloon Corps to investigate, with the full consent of MM. Lebaudy.

The commission suggested that the vessel should proceed under its own power to the military camp at Chalons, and there go through various tests and experiments, after which it was to proceed to Verdun. This programme was carried out, and on arrival at Chalons the airship was anchored, but being exposed to a strong wind, broke away from its moorings, and, after travelling a little distance, dashed into some trees which soon destroyed the envelope.

Immediate steps were taken to repair it, and two months later further experiments were carried out, the vessel on one occasion attaining a maximum height of well over 2000 feet. On the 24th October, 1905, for its seventy-sixth journey, the Minister of War with his adjutant, Major Bouttiaux, Captain Voyer, and two others were in the car.

MM. Lebaudy now suggested that the airship should be taken over by the military authorities. The Government naturally accepted this splendid offer, and thus derived the benefit and result of three years' preliminary work and experiment at practically no expense to the nation.

The First Trial of the "Lebaudy" in 1908.



The First Trial of the French Military Airship "Republique"

Face page 132.

Italian Army Dirigible.

Face page 133.

VII

French Military Dirigibles—The "Patrie"

Subsequent to the generous offer of MM. Lebaudy and their gift to the French Government of "Lebaudy No. 3," the French Military Balloon Department at Chalais-Meudon, under Commandant Bouttieaux and Captain Voyer, lost no time in commencing to construct the aerial fleet whose rapid growth and ever-increasing importance has since been most remarkable.

The first type, which bore the name of "Patrie," was developed by Joulliot, and resembled in almost every respect "Lebaudy No. 3," though the envelope was slightly larger. Such a comprehensive description of this and other types of airships was given by Major George O. Squier, of the United States Army Signal Corps, in a paper dealing with the present status of military aeronautics, presented at the New York Meeting (in December, 1908) of the American Society of Mechanical Engineers, that I cannot do better than quote largely from his writings on the subject.

The envelope of the first "Patrie" was built by Surcouf, at Billancourt, near Paris. The mechanical part was built at the Lebaudy Sugar Refinery. Since then the envelopes have been made at the Lebaudy balloon shed at Moisson, under the direction of their aeronaut, Juchmés. The "Patrie's" envelope was 197 feet long, with its maximum diameter of 33 feet 9 inches about two-fifths of its length from the front; its volume was 111,250 cubic feet. It will be noticed that its length was approximately six times its greatest diameter, and this relation, together with the cigar-shape, is in accordance with the plans of Colonel Renard's dirigible, built and tried in France in 1884.

The first "Patrie" was pointed at the rear, which is generally considered to be the proper shape for offering the least resistance, but to maintain stability it was found necessary to fix a horizontal and vertical plane, so that the back of the envelope had to be made in the form of an ellipsoid to give attachment for these planes.

The ballonet for air had a capacity of nearly 23,000 cubic feet, or about one-fifth the total volume. This was calculated to permit reaching a height of about a mile, and to be able to return to the ground keeping the envelope always fully expanded and rigid. To descend from the height of a mile, gas would be released from the valve, then air pumped into the ballonet to keep the envelope rigid, the two operations being performed alternately. On reaching the ground from this height the air would be at the middle of the lower part of the envelope, but would not entirely fill the ballonet. To prevent the air rolling from one end to the other of the ballonet if the airship should pitch, thus producing instability, a method of short suspension was adopted, the weight of the car being distributed over only about 70 feet of the full length of the envelope. To effect this an elliptical-shaped frame of nickel steel tubes is attached to the bottom of the envelope, and steel cables connect it with the car. This frame or platform is held in position under the envelope by a net which in turn is secured to the envelope by toggles attached to loops in a strong canvas band which is sewn to the envelope itself. By this means the platform can be easily detached if it is desired to do so for transportation. The connecting steel cables are arranged in triangular shape, which is a sure means of preserving rigidity.

The objection to this method of short suspension is that the envelope is slightly deformed, and it will be noticed that a distinct curve is plainly visible on top of the envelope in the picture reproduced.

The car is boat-shaped, about 16 feet long, 5 feet wide, and 2½ feet high, made of nickel steel tubes, and it is suspended about 11 feet below the envelope. To prevent any chance of fire from the engine communicating with the hydrogen in the balloon the steel frame-work under the envelope is covered with a non-combustible material. The "Patrie" was driven by a 60-70 horse-power 4-cylinder Panhard & Levassor benzine motor, making 1000 revolutions per minute. This motor was placed in the middle of the car, the pilot standing in front and the engineer at the back. A strong steel structure was built in the form of a pyramid, pointing downward, under the car, so that in landing the point comes to the ground and protects the car and propellers from being damaged. To reduce air resistance the car was covered, but being so low, most of the body of the aeronaut, the engine, etc., remained exposed, and the total resistance was considerable.

Two steel double-bladed propellers, 8½ feet in diameter, were placed at each side of the engine, and to avoid any tendency to twist the car they were arranged to turn in opposite directions.

The gasolene tank was placed under the car in the pyramid frame-work, the gasolene being forced up to the motor by air compression. The exhaust was placed under the back of the car and pointed downward, being covered with a metal gauze to prevent any flames coming out. The fan for driving the air into the ballonet was run by the motor, but there was also a dynamo to keep the fan working in case the motor should break down or be stopped. By these means the pressure could always be maintained inside the envelope, so that the latter would remain rigid and keep its proper shape, a most essential point. There were valves both inside the ballonet and in the envelope, which opened automatically at certain pressures, but those in the ballonet opened at a lower pressure than the others, so that when the gas expanded all the air would be driven out of the ballonet before any gas could be lost.

Vertical stability was maintained by means of fixed horizontal planes. One, with a surface of 150 square feet, was attached to the rear of the envelope, and being at a considerable distance from the centre of gravity it acted very efficiently. The elliptical frame or platform attached under the envelope had an area of 1055 square feet, but its proximity to the centre of gravity rendered it of little use in preserving stability. Just behind this platform was a horizontal plane of 150 feet area and a vertical plane of 113 square feet. Another vertical plane with an area of 108 square feet ran from the centre of the platform to its rear extremity, both these vertical planes being intended to maintain horizontal stability, that is to say, to enable the airship to move forward in a straight line without veering from side to side. There was also a vertical frame of 150 square feet area fixed at the rear of the envelope itself. This and the horizontal plane were fastened to the envelope by cloth flaps, which were in turn sewn to the envelope.

The rudder, which had a surface of about 150 square feet, was fixed below the rear of the envelope. A small movable horizontal plane, fixed near the centre of gravity above the car, was used for rising or descending by being turned in the desired direction, and by this means the loss of either gas or ballast was reduced to a minimum.

After she had been enlarged in September, 1907, the "Patrie" made a number of long journeys, mostly at an altitude of between 2000 and 3000 feet. In November of that year she travelled from Paris to Verdun, near the German frontier, a distance of about 175 miles. A light wind was blowing from the northeast, and, as her course lay in an almost easterly direction from Paris, it naturally tended to check her speed, notwithstanding which the journey only occupied about 7 hours, giving an average of 25 miles an hour, by no means a bad performance.

Later in the same month, during a flight near Verdun, the motor stopped owing to some difficulty with the carburetor, and the "Patrie" drifted with the wind to a village about 10 miles distant, where she was safely landed and anchored. The following day a strong wind sprang up and, tearing up some of the iron posts to which she was anchored, caused the airship to swing broadside on to the wind; she then tilted over considerably to one side and some of the ballast bags fell out. Thus lightened the vessel rose in the air, and, despite the efforts of nearly 200 soldiers who were hanging onto her ropes, she dragged them along the ground until the officer in charge ordered them to let go, considering he was risking their lives.

Directly she was released the "Patrie" rose and was blown across the north of France, the English Channel, and into the north of Ireland, where she struck the ground and broke off one of her propellers, after which she again rose, drifted out to sea, and was never seen or heard of again.

This was the tragic end of a really good airship, but there is this much satisfaction to be derived from the incident—firstly, that no lives were lost, and secondly, that a lesson was taught which should have been taken to heart on all future occasions. I refer to the evident advisability of deflating the envelope of any large airship which is obliged to anchor in the open through any mischance, unless it is obvious that the existing weather conditions are unlikely to do any damage. It is surely better to lose the value of the gas, and re-inflate when any necessary repairs have to be completed, than to leave such a huge surface exposed to the wind which might increase in force at any moment, so rendering it almost impossible to prevent the vessel from either knocking herself to pieces or dragging her moorings.

"Ville de Nancy" and "Republique" Manoeuvring over French Troops at Longchamps.

Face page 138.

The First Trial of "Ville de Paris"

Face page 139.

VIII

The Ville de Paris

M. Deutsch de la Meurthe, previously mentioned as the donor of the £4,000 prize gained by Santos-Dumont, has always done a great deal in France to encourage aerial navigation, and in 1902 he had an airship built called the "Ville de Paris" on plans drawn up by an aeronautical engineer named Tatin, but it was not a success, so in 1906 he had another built at Billancourt, on very similar lines to Colonel Renard's airship, the "France," which I have previously described.

After the "Patrie" was lost, M. Deutsch, in a most patriotic spirit, offered his vessel to the military authorities, who accepted his suggestion and "Ville de Paris" became a government airship.

I must now try to describe this vessel which, as our picture shows, is very different in appearance to any of the others.

The envelope has a total length of 200 feet, with a maximum diameter towards the front of 34½ feet, giving a length of about six times the greatest depth, as in the "France" and "Patrie." Its volume is 112,847 cubic feet, and it is made of German Continental Rubber Fabric like the "Patrie." The middle section is cylindrical, with a conical point in front, and a smaller cylindrical rear part with a round end. Attached to this rear cylinder are eight smaller cylinders, which add greatly to the vessel's stability, though their appearance is certainly somewhat comical.

The air ballonet has a volume of just over 21,000 cubic feet, about one-fifth of the total contents of the envelope, and is divided into three compartments as in the "Patrie."

There are five valves in the envelope, made of steel and about 14 inches in diameter; one on the top, like the spherical balloon valve, is operated by a valve-line from the car, whilst two others are placed underneath and near the back of the envelope; these work automatically when the gas pressure becomes excessive, but can also be operated by hand from the car. There are two valves in the ballonet which similarly work automatically or by hand, and they open at a lower pressure than is needed to open those in the rear of the envelope, thus ensuring all the air being driven out of the ballonet before any gas is lost.

The method of "long" suspension is adopted, which means that the weight of the car is practically distributed along the entire length of the envelope. This is effected by strong canvas bands being sewn along the envelope nearly from stem to stern, one just below the equator and another, slightly shorter, a few feet lower down. Lines from these bands run to points half-way between the bottom of the envelope and the car, then radiating from these points to different parts of the car where they are attached. This gives a very rigid connection between the car and envelope, and there is none of the deformation which is so noticeable in the top of the "Patrie's" envelope.

The car is 115 feet long, nearly 7 feet high at the middle, and a little over $5\frac{1}{2}$ feet wide at its widest part. It is built of wood, with aluminum joints, and weighs 660 pounds. Major Squier considers this car unnecessarily large and heavy. The motor and mechanic are placed well in front, whilst the helmsman and his steering wheels are placed at about the centre of gravity. The motor, which is a 70-75-horse-power "Argus," is also extremely heavy.

The propeller is placed in front of the car, the designer considering that more power can be obtained by traction than by propulsion, as the propeller acts on air which is in no way disturbed. The two blades are nearly 20 feet from tip to tip and are made of cedar wood with steel strips to give added strength. The propeller only makes 250 turns a minute when the engine is making 900 revolutions, the great diameter and width of the blades compensating for this low speed.

The rudder has a surface of 150 square feet like that of the "Patrie," but instead of being placed close up under the envelope it is attached over the stern of the car. Two pairs of horizontal planes are fixed above the car to direct the airship upwards or downwards without loss of gas or ballast. The larger pair, which each have a surface of 86 square feet, are just above the car near the centre of gravity; the other pair, with a surface of 43 square feet each, being situated above the car towards the stern.

A guide-rope 400 feet long is attached to the front of the car, and another 230 feet long hangs below the centre of gravity. There are three steering wheels, one controlling the vertical stern rudder, and one for each pair of horizontal planes.

The stability of the "Ville de Paris," which is obtained from the eight small cylinders attached to the back part of the envelope, is said to be superior to that of the "Patrie," but there is a grave objection to this method of obtaining stability, for these cylinders offer considerable air resistance with a consequent loss of speed. It is estimated that the "Ville de Paris" has probably never travelled more than 25 miles per hour in calm weather, which means, of course, that in windy weather she would have little or no efficiency.

IX

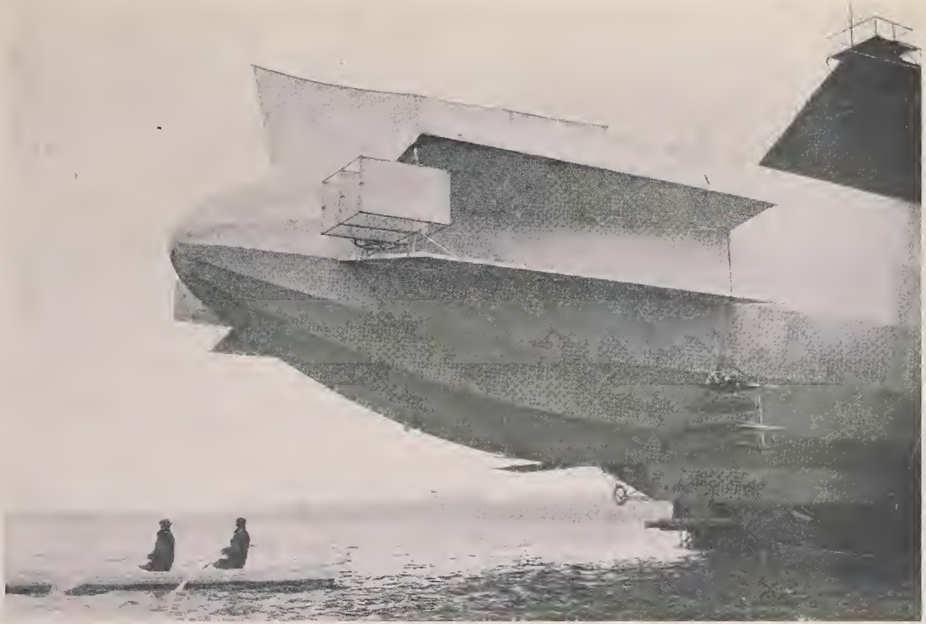
Count Zeppelin and His Airships

Amongst the interested spectators of the attempted ascent with the "Schwartz" airship, in 1897, was Count Zeppelin, a general who had gained considerable distinction during the Franco-Prussian War. It is impossible for me here to enter into any details concerning his career, interesting though they are, and I need only take up the thread of his life's history from the time when he began to engage actively in the study of aeronautics and the construction of dirigible balloons, which have made his name a household word in Germany, and attracted the interest of the whole civilised world.

Convinced that the "rigid" type of airship possessed many advantages over those with a non-rigid or collapsible envelope, he immediately started to design a vessel of gigantic proportions, on lines which he had been considering for many years. He formed a limited liability company for the purpose of raising sufficient money to construct this huge dirigible balloon, putting the bulk of his private fortune into the enterprise. That the King of Wurtemburg should give tangible proof, both of his patriotism and of his confidence in Count Zeppelin's scheme, by becoming a large shareholder in this company, must have tended in no small degree to encourage the Count in carrying out his programme.

The shock resulting from an airship with a rigid envelope coming to the ground had been exemplified disastrously with the "Schwartz" vessel, so Count Zeppelin thought it would be more judicious to construct his new ship in a large floating shed on Lake Constance, thus enabling trial flights to be started and terminated over and on the water in preference to taking the risk of destroying any part of the machine by a too rapid descent on *terra-firma.*

In 1898 the building of an airship far bigger than anything which had been previously attempted was accordingly commenced on the lake not far from the town of Friedrichshafen. The envelope was prismatic, with 24 surfaces, 420 feet from end to end, and 38 feet in diameter, coming to a gradual point at each extremity. The frame-work of the envelope was of aluminium lattice-work made with 17 transverse partitions, the divisions being formed by thin sheets of aluminium. This frame-work was covered with linen and silk material treated with pegamoid. In each of the 17 compartments were linen gas-bags, together capable of holding some 400,000 cubic feet of hydrogen, leaving an air-space between them and the outer covering which would prevent any sudden alterations of temperature and consequent ascending or descending of the vessel. Two cars about 22 feet long were rigidly attached below the envelope, less than a quarter of its length from each end, and to give additional strength and rigidity a triangular keel of aluminium lattice-work was attached below these cars, and from this was suspended a movable weight worked by a winch, enabling the bow of the vessel to be directed up or down. In each car was a 16-horse-power motor, driving two 4-bladed screw propellers fitted with reversible gears, so that the airship could be driven either ahead or astern. The main verticle rudder was fixed to the stern of the envelope, whilst for steering purposes and intercommunication the cars were fitted with electric signal bells and telephones.



"ZEPPELIN I," SHOWING STERN ELEVATING PLANES.

Face page 144.

Members of the Reichstag Watching Zeppelin Manoeuvres at Friederichafen (over Bodensee).

In July, 1900, the first ascent was made over Lake Constance and was attended by a series of mishaps. The winch controlling the sliding-weight broke, the framework connecting the cars bent sufficiently to prevent the propellers from revolving properly, consequently full speed could not be attained, and although there was practically no wind whatever, the vessel only travelled at a rate of about 9 miles per hour. The steering-lines getting entangled also rendered it impossible to direct the course as desired. These defects could not be rectified in mid-air, so the airship descended on the surface of the lake, without sustaining any damage except a minor injury caused by her running into a pile.

All necessary repairs having been effected, and the frame-work strengthened by the addition of transverse aluminium stays, further experiments were carried out three months later, when the airship travelled for short distances over the lake at a speed of about 20 miles per hour.

Captain Hildebrandt points out that, owing to the necessity of making continual turns to keep over the lake, it was impossible to develop full speed, but despite this fact the first Zeppelin airship had travelled faster than any dirigible of earlier date. Colonel Moedebeck remarks that the envelope was not sufficiently gas-tight to prove really satisfactory, and also the motors required to be more powerful by comparison with the total weight carried.

Five years later Count Zeppelin turned out another airship, constructed on similar general principles, but with several important improvements introduced. The development of the motor industry was naturally a great advantage to him, for he was able in the second vessel to use two engines no heavier than those first employed, but each capable of giving 85 horse-power instead of only 16 horse-power. The envelope was of similar shape, but contained 16 gas-bags instead of 17, holding 367,000 cubic feet of hydrogen, or about 32,000 cubic feet less than before. The total weight of the vessel was approximately 9 tons, or 1 ton less than its predecessor. Vertical and horizontal planes made of linen, both in the bow and in the stern, were added to aid in steering either to right or left, or for rising or descending.

The first ascent took place over Lake Constance in November, 1905, when the vessel was taken out of her shed, placed on pontoons, and towed into the centre of the lake by a motor-boat. It was driven forward by a strong wind and quickly overtook the boat which had been towing it; the tow-rope was accordingly cut, and the propellers set in motion. At this moment the bow was pointing downwards, consequently the airship dived onto the surface of the water, and the valves were opened to prevent it re-ascending.

The next trip was attempted in January, 1906, when the lifting force was so great that the airship rose at once to a height of 1500 feet. Some gas was let out, the engine was started when she had fallen to a lower level, and a course was shaped due to windward. It was found that she could make fair headway against the strong breeze which was blowing, but the pilot, owing to lack of experience, was unable to keep on the desired course, a very small movement of the various steering appliances taking considerably more effort than had been expected. Meanwhile the vessel had reached the borders of the lake, and, the engines having been stopped for some reason, she was carried by the wind over the ground. A descent was made, the only damage sustained being a slight rent in the covering caused by brushing against a tree.

"Zeppelin No. III" followed in due course, and with this vessel many successful journeys were made which far exceeded anything previously accomplished, both as regards duration and distance covered.

The story of "Zeppelin No. IV" and her disastrous end is so fresh in the minds of everybody that it seems almost superfluous to relate it here, but it has so much bearing on subsequent events in the history of dirigible balloons that I must briefly refer to it.

Her general construction was similar in most respects to the one I have already described, the main point of difference being that the triangular keel, instead of being attached below the cars, was attached to the bottom of the envelope, running nearly its entire length, with the two cars suspended below gaps in it. These cars were built like boats, about 20 feet long, 6 feet wide, and 3½ feet high; they were placed about 100 feet from each end of the envelope, and were made of an aluminium alloy.

The power was furnished by two 110-horse-power Daimler-Mercedes motors, one placed in each car, and each weighing about 550 pounds; sufficient fuel could be carried for a run of 60 hours at full speed.

Opposite each car, and firmly attached to the frame of the envelope, was a pair of 3-bladed metal propellers about 15 feet in diameter. In addition to a large vertical rudder in the stern, numerous horizontal planes were attached to the sides of the envelope, arranged to look much like aeroplanes, and there were also vertical planes to aid the main rudder in steering to the right or left.

Major Squier in his description of this ill-fated vessel makes the following remarks:

"Its best performances were two long trips performed during the summer of 1908. The first, on July 4th, lasted exactly 12 hours, during which time it covered a distance of 235 miles, crossing the mountains to Lucerne and Zurich, and returning to the balloon-house near Friedrichshafen, on Lake Constance. The average speed on this trip was 32 miles per hour. On August 4th, this airship attempted a 24-hour flight, which was one of the requirements made for its acceptance by the Government. It left Friedrichshafen in the morning with the intention of following the Rhine as far as Mainz, and then returning to its starting point, straight across the country. A stop of 3 hours 30 minutes was made in the afternoon of the first day on the Rhine, to repair the engine. On the return, a second stop was found necessary near Stuttgart, due to difficulties with the motors, and some loss of gas. While anchored to the ground, a storm arose which broke loose the anchorage, and, as the balloon rose in the air, it exploded and took fire (due to causes which have never been actually determined and published), and fell to the ground, where it was completely destroyed. On this journey, which lasted in all 31 hours 15 minutes, the airship was in the air 20 hours 45 minutes, and covered a total distance of 378 miles.

"The patriotism of the German nation was aroused. Subscriptions were immediately started, and in a short space of time a quarter-of-a-million pounds had been raised. A Zeppelin Society was formed to direct the expenditure of this fund. Seventeen thousand pounds has been expended in purchasing land near Friedrichshafen; work-shops were erected, and it was announced that within one year the construction of eight airships of the Zeppelin type would be completed. Since the disaster to "Zeppelin IV" the Crown Prince of Germany made a trip in 'Zeppelin No. 3,' which had been called back into service, and within a very few days the Emperor of Germany visited Friedrichshafen for the purpose of seeing the airship in flight. He decorated Count Zeppelin with the Order of the Black Eagle. German patriotism and enthusiasm has gone further, and the 'German Association for an Aerial Fleet' has been organised in sections throughout the country. It announces its intention of building 50 garages (hangars) for housing airships."

By January, 1909, the Zeppelin Fund amounted to well over £300,000, and, pending the construction of an entirely new vessel, it was decided to bring out "Zeppelin III" once more. In the middle of March this vessel, carrying in all 26 passengers, made a voyage of 4 hours' duration over and around Lake Constance, covering a total distance of about 150 miles, and rising to a greatest altitude of 650 feet.

Later in the month it was decided to make a voyage from Friedrichshafen to Munich, and a start was made at 4 o'clock in the morning, Count Zeppelin, with four military officers, accompanying the remainder of the crew. So that the voyagers might have as much aid as possible to guide them through the darkness, the lights of railway stations along the route were left burning, and bells were rung in the towns and villages. Munich was reached by 9 A. M., the inhabitants giving the huge vessel and her occupants a most enthusiastic welcome. Arrived over the Palace, Princess Maria Terese and her daughter greeted Count Zeppelin from the roof, and an attempt was then made to land at the Oberwiesenfeld Parade Ground, but unfortunately a strong southwesterly wind prevented this from being done, and the airship was driven away before a semi-hurricane. By dint of skilful handling Count Zeppelin eventually managed to land his craft safely near Dingolfing, at about three o'clock in the afternoon. The following day, the wind having considerably abated, the airship again ascended and proceeded to Munich, where the original intention of landing on the Parade Ground was carried out. Count Zeppelin was greeted by the Prince Regent, and received a decoration at his hands. About 3.30 P. M. the airship ascended and was headed for home, Friedrichshafen being reached without incident about four hours later.

A few days later the airship again left her shed, with the idea of carrying out a 24-hours' trial, but after about 9 hours travelling she returned home, the officer in charge considering that the wind was freshening so much as to make a longer journey injudicious. The following night the vessel started for a trip which lasted over 13 hours, the details of which, however, did not leak out.

In order to give this vessel an official title corresponding to the H. M. S. placed before the name of ships belonging to His Majesty's Navy, the German Emperor decided that this airship should be named and known hereafter as "S. M. S. Zeppelin I."

While these trials and manœuvres were being executed with the reconstructed old vessel, rapid progress was being made with the building of the new "S. M. S. Zeppelin II," whose dimensions were slightly larger than any of her predecessors, being 446 feet in length, 42½ feet in diameter, with a capacity of 530,000 cubic feet. On the 25th May, 1909, her 17 compartments were filled with hydrogen, and preparations made for her maiden voyage. The following day she "took the air," and the working of her steering arrangements, etc., were tested by a series of manœuvres carried out over Manzell.

A week later "Zeppelin II" made the remarkable trip

"ZEPPELIN III." VOYAGE TO BERLIN: LANDING AT TEGEL.

Face page 150.

"Zeppelin II" after Collision with Tree at Göppingen.

Face page 151.

of 940 miles, which must be fresh in the minds of everybody at the present time. With her famous designer on board she started from Lake Constance on the evening of Saturday, May 29th, and travelling over Ulm, Nuremberg, Leipzic, and Bitterfeld in the direction of Berlin, was obliged by a strong head wind to turn back from the latter place, and, passing over Weimar, Heilbronn, and Stuttgart, she eventually descended just outside Göppingen, having been in the air for almost 38 hours.

Unfortunately, just as she landed a mishap occurred, the airship coming into sudden collision with a large pear-tree, which tore open two sections of the envelope and smashed the aluminium bows very considerably. Some attributed this accident to a sudden gust of wind, and others to the steersman having failed to notice the tree, which seems a very reasonable solution under the circumstances, for every member of the party on board "Zeppelin II" must have been completely worn out with fatigue after their long and strenuous journey.

Within 24 hours temporary repairs were carried out on the spot, and by removing all the forward steering apparatus so as to lighten the airship in front as much as possible, she was enabled by using only the aftermotor, to commence the return journey to Lake Constance, where she eventually arrived in safety.

Whilst I am writing, "Zeppelin II" is being put in a state of perfect repair, and ere many weeks have elapsed and probably long before these lines are in print, Count Zeppelin will have fulfilled one of his greatest ambitions, by journeying in his airship from Friedrichshafen to Berlin, where he wishes to land on the Tempelhofer Parade Ground, in the presence of the German Emperor.

Before concluding this chapter I must lay some stress on the advantages and disadvantages of the Zeppelin or "rigid" type of airship. Count Zeppelin's primary object was doubtless the construction of a vessel capable of performing long journeys, and this he knew required, firstly, a ship sufficiently large to carry engines and fuel for the purpose, and, secondly, one which would be navigable under any reasonable climatic conditions.

There can be no disputing the fact that a rigid or non-collapsible envelope, affording a perfectly rigid connection between itself and the car, engine, and propellers which have to drive the entire vessel forward, reduces the loss of power to a minimum, and thus enables greater speeds to be attained than vessels of the non-rigid type can hope for.

On the other hand, landing in anything but the calmest weather seems to present innumerable difficulties, and to be attended with such risks that serious accidents are most likely to ensue. Even should a safe landing be effected, the chances are against a vessel whose envelope cannot be altered in shape even though it be deflated, for it is obvious that letting gas out of a "Zeppelin" still leaves its huge area as a wind-resisting surface, whereas deflating a cotton, silk, or skin envelope, which collapses, immediately eliminates this defect.

Unless, therefore, adequate sheds, docks, pits, or harbours of some kind or another are provided in all parts of the country, it certainly seems that vessels with rigid envelopes must always be subject to considerable danger in anything but calm weather.

X

The "Parseval"—The "Gross"

Major Von Parseval, like Count Zeppelin, is a retired officer of the German Army, who has devoted considerable time and study to the design and construction of airships. He patented certain devices in connection with this work, and the vessel he built was bought from him, together with his various patents, by a syndicate called "The Society for the Study of Motor Balloons." It is stated that the German Emperor largely instigated the formation of this body, being much interested in the progress of aerial navigation, whether it be carried out officially or by private enterprise.

The Society has fine premises, adjoining the military balloon grounds at Tegal, where the "Parseval" airship has always had its headquarters, making frequent trips, and demonstrating to the German public its general good qualities, and particularly its dirigibility. The people, therefore, have become quite accustomed to seeing airships manœuvring overhead, for besides the "Zeppelin" and the "Parseval," there is another type called the "Gross" (which I describe later), and these vessels have doubtless done much to convince Germany that the conquest of the air is no longer a mythical object impossible of achievement, but a hard reality, which necessitates considerable funds being devoted to its development and improvement.

In England, I regret to say that, as I pen these lines, very little has been done to prove either official or private interest in the matter, but it cannot be long ere the country awakes to the fact that an aerial fleet is quite as necessary as a submarine flotilla, and steps must obviously be taken to make up some of the lost ground. There is no denying the fact that England has been terribly casual and lethargic in dealing with aeronautics, so she is considerably handicapped by comparison with France and Germany, who have been steadily progressing, and training men all the time in order to have an experienced and efficient corps ready to handle their airships as they are built.

Though descriptions of different airships may be found rather tedious, there is no alternative but to continue on these lines if my readers are to glean some idea of what has been done in the past, and what at present exists. With this object in view I only give somewhat sketchy accounts of the principal types, and, with apologies to those whom I may be boring in the attempt, I will revert to the "Parseval," and explain her distinctive features.

The envelope is cylindrical in shape, with a rounded front and pointed rear, 190 feet long, 30½ feet deep, and containing 113,000 cubic feet. Like the French vessels, it is made of Continental Fabric, though in this case it can be said that the material is "home-made"! At each end of the envelope is an air-ballonet of about 10,600 cubic feet capacity, the air being driven into them by a fan which is worked by the motor. Before an ascent, the rear ballonet is filled with air so as to give the head of the airship an upward tendency. A valve under the centre of the envelope enables the engineer to fill or empty either or both of these ballonets, whilst automatic valves allow the air to escape at the requisite pressure.

German Military Dirigible "Parseval."

Face page 154.

On the top of the envelope, in the middle, is a valve for letting out the gas, which can be opened from the car, and also opens automatically at a certain pressure for safety. Near each end of the envelope, on opposite sides are two ripping-panels, which can be torn open by rip-cords from the car, and so quickly deflate the envelope as in an ordinary spherical balloon.

One of the curiosities of the "Parseval" is the system of attachment between the car and envelope, called "loose" suspension. On each side of the car are two trolleys, running on steel cables, and the car can run backwards and forwards on them, thus changing its position with relation to the envelope automatically, according to the thrust of the motor and the degree of air resistance. The steel cables are joined to hemp ropes which are connected to a strong canvas band sewn around the envelope, so that the weight of the car and engine is distributed equally over the full length of the balloon.

The car is 16½ feet long, built of steel tubes and wires, and holds besides a Daimler-Mercedes motor of 110-horse-power, three or four persons, with sufficient petrol for a 12 hours' full-speed run. The patent propeller, like the suspension, is peculiar to the "Parseval" type of airship. It has four cloth blades, which hang limp when not revolving, but when the engine is started centrifugal force causes them to fly out, and, owing to the disposition of leaden weights fixed to them, they assume a proper shape and position. Its diameter is nearly 14 feet, and it is placed above and behind the car, making 500 revolutions per minute to the 1000 of the motor. Of the three different "Parsevals" which have yet come into existence, none can be said to have shown either the speed or the dirigibility in a breeze attained by Count Zeppelin's rigid ships, but this must not be taken as a convincing argument that the rigid type is the best, or will ultimately become universal, in face of the defects to which I referred in the last chapter.

The third type of airship that Germany can boast is one designed by Major von Gross, and known by his name. It follows very nearly the lines of the "Patries," and the boat-shaped car is similarly suspended from a steel and aluminium floor or platform attached to the bottom of the envelope. The photograph reproduced shows the dip or deformation along the top of the envelope caused by this method, and such distortion from the true shape must be extremely detrimental.

Stability is attained by an arrangement of horizontal and vertical planes, much the same as in the "Lebaudy" vessels, though the first "Gross" had no horizontal plane at the rear of the envelope. Experiments with this airship in 1907 led to Major von Gross building a second and improved vessel in the following year, considerably larger, and driven by two 75-horse-power Daimler motors.

On September 11, 1908, "Gross II" left Berlin at 10.25 P. M. with four passengers on board, and returned the next day at 11.30 A. M., having travelled 176 miles in approximately 13 hours, which is described by Major Squier as the longest trip, both in point of time and distance, ever made up to that date by an airship returning to its starting-point.

Subsequent performances of these vessels have been recounted so fully and frequently in the newspapers that I need not allude to them, except to remark that improvement and progress has been plainly noticeable, and can doubtless be attributed to the practice and experience gained by the crews who have manned them.

German Military Dirigible "Gross" Flying over Berlin.

Face page 156.

New Portable Balloon Shed for German Military Airship, "Gross III."

Face page 157.

Having now described the principal French and German airships, I will commence another chapter before dealing with English and American dirigibles, though neither of these two countries can as yet show results to be in any way compared with the former.

XI

England's Airship—The "Nulli Secundus"

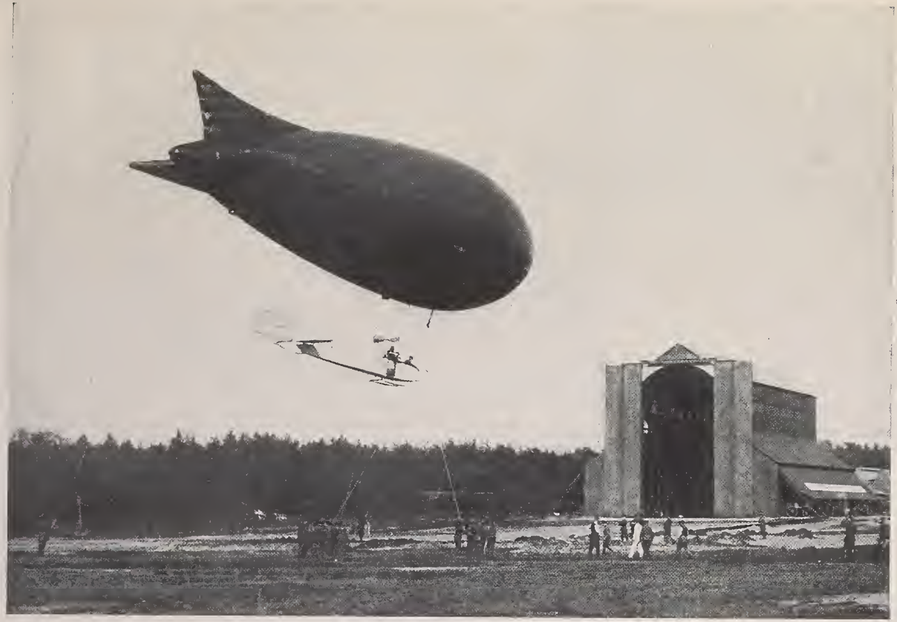
As far back as 1902, Colonel Templer, superintendent of the Army Balloon Department at Aldershot, designed a small airship, and commenced the construction of an envelope composed of skins (the so-called gold-beaters' skin) on the same principle as he had for several years been making service balloons.

Always realising the advantage of hydrogen over coal-gas, it was clear that a hydrogen-tight envelope would add considerably to the efficiency of any such vessel; there was another point of supreme importance secured by the skin material, viz., the possibility of inflating it up to a considerable pressure, and so obtaining an almost rigid result, for several thicknesses of skin were found to be strong enough to withstand far greater pressure than would cause bursting in the case of cotton or silk.

Hampered and restricted by the meagre and totally inadequate funds allotted to the Department, Colonel Templer could only make very slow progress with his airship, but soon after he retired from his command in 1907 (being retained by the War Office as Consulting Engineer), she was completed by his successor, Colonel Capper, R. E.

Although the original designs were adhered to in the main, it is curious that the engine specially built for this vessel in the balloon factory was never used, but a French 8-cylinder "Antoinette" substituted.

The "Nulli Secundus," as she was christened, was cylindrical with spherical ends, being 112 feet long, 31½



THE BRITISH ARMY "BABY" DIRIGIBLE.

Face page 158.

feet deep, with a volume of not quite 85,000 cubic feet. Her shape and colour quickly appealed to the mind as resembling a monster sausage, whilst four wide silk bands passed over the envelope added to her general somewhat peculiar appearance.

It was not considered necessary to fit her with an air-ballonet, as she was thought capable of withstanding any increase of internal pressure up to a considerable height. Below the envelope was a steel frame-work suspended partly by wires from the four silk bands, and partly by other wires attached to various parts of the envelope itself; to the upper parts of this frame were attached the rudders and horizontal planes, whilst to the lower part was fixed a boat-shaped car, some 30 feet long, with a steel pyramid-shaped frame-work below it (as in the "Patrie") to protect both car and propellers when landing.

On each side of the car was a double-bladed aluminium propeller 10 feet in diameter, driven by belt transmission from the motor, and *both revolving in the same direction!* I lay stress on this point as being perhaps one of the most curious mechanical defects ever perpetrated in the construction of any dirigible balloon, for the inclination of a light vessel floating in air must obviously be both to heel over and to turn her head in the same direction as these propellers revolve.

Three large horizontal planes were fixed over the vertical stern rudder, as can be clearly seen in the picture, whilst on each side of the frame-work well forward was an arrangement, similar to a Cody kite, to aid in maintaining stability and in rising or descending.

Before she made her first appearance on Cove Common, Farnborough, the envelope of the "Nulli Secundus" had been inflated with hydrogen for about a month; the good gas-holding qualities of the skin being proved by the fact that during this long period the internal pressure never appreciably diminished.

After a few preliminary short trials at Farnborough, she left there on October 9, 1907, manned by Colonel Capper and Mr. Cody, travelled with a light breeze over Bagshot, Staines, and Chiswick to London, where she circled the dome of St. Paul's Cathedral, turned back for her homeward journey, and struggled as far as Wandsworth against the wind. Then, however, it was found that her power was insufficient to get her back in the face of the breeze, so Colonel Capper decided to land in the grounds of the Crystal Palace, which was then to leeward of him. A descent was made in perfect safety, and the vessel was moored to some stakes in the middle of the cycle-track.

Here she stayed for two or three days and the mistake was made of leaving her in such an exposed position at night without deflating the envelope, and with only a very few men to look after her, for early one morning the wind freshening, she dragged her moorings, bumped herself on the ground, and did a certain amount of damage to her frame-work, until the sergeant who had been left in charge, seeing that he could not control the tugging monster in such a wind, deflated as speedily as possible, thereby probably saving the airship from making a solitary ascent and being lost, as happened to the "Patrie" a month later.

This setback did probably more harm to aerial navigation in England than one can imagine possible, for the public, almost to a man, condemned the unfortunate vessel as being useless, whereas the damage done was solely due to the lack of experience and foresight of those in command.

It is quite true that she could not make any progress against the wind when its strength was about 17 miles an hour, and probably the best speed she could develop in a calm was only 16 miles per hour. That, however, was due partly to the engine—of reputed 50 horse-power—not really obtaining half that result, and partly perhaps to the great resistance offered by the steel frame-work when travelling through the air.

The "Nulli Secundus" was then taken back to Farnborough, and hidden away in her shed like a naughty child until the following summer. This was quite enough to justify those who knew no better in believing that she was broken to pieces, irrevocably damaged, no use at all, etc., as was widely stated in many badly informed newspapers; whereas, in reality, the damage sustained was of so slight a nature that repairs could have easily been effected and the airship brought out for another journey within a week.

Whatever may have been the reason for this policy, it certainly tended to decrease public interest in the subject of airships in England, and is, therefore, a matter of regret to all who have been keen and anxious to see Brittannia asserting her supremacy in the air as well as on the sea.

Not until July, 1908, did the "Nulli Secundus" again emerge from the cover of her big shed, but during the interval her rig and appearance had been considerably changed. A silk hull—if I may use the nautical term—was fixed to the envelope about half-way up, and coming downwards on each side, completely covered in the steel frame-work—which had been reduced in weight—and gave the general look of a ship's hull and keel.

The horizontal planes still remained in the stern, but a double vertical steering rudder was substituted for the original single one. The kite arrangements on the bows of the vessel were removed, and a large horizontal plane about 14 feet wide and 4 feet deep was fixed right in front, for directing the course upwards or downwards.

When I inspected her, I noticed with surprise that the propellers were still allowed to revolve in the same direction instead of against one another, and, once in the air, it was palpable that what seemed so obvious in theory was borne out in practice, for the airship had a decided inclination to "go with the screws."

A circular trip of about 6 miles was performed in 18 minutes, giving a mean speed of 20 miles per hour, but then the engines were suddenly stopped owing to one of the driving-belts slipping, the airship drifted off with the wind, and the officer in charge promptly selected a suitable landing-place, valved, and descended safely; her leading-lines were caught by men of the Balloon Department, and she was walked back to her shed.

In the picture of the rebuilt "Nulli Secundus," over the public school camp at Farnborough, it may be noticed that she has a decided pitch downwards, which was due to the car being slung too far forward, and to no provision being made in the shape of a sliding weight, or some such device, for ensuring her balance on a level keel.

When freed in the air, and directly the engines were started, she naturally had a tendency to follow her nose and dive! To obviate this it was necessary to incline the big horizontal bow plane upwards at a considerable angle, which of course detracted from her speed and made her more difficult to turn to the right or left. Handicapped by these sundry minor defects, which could easily and quickly be put right, there was no great cause for dissatisfaction at the result of the trial, and further tests were expected to take place.

"Nulli Secundus" over the Public School Camp at Farnborough.

Face page 162.

"Nulli Secundus II"

Face page 163.

Once again, however, for some totally inexplicable reason, the one and only English Army airship was condemned to solitary confinement and seclusion, so the public began to think that the building of airships was quite outside the scope of our Balloon Department, even if it was not an unfeasible proposition altogether!

Any English boys who take the trouble to read this book, have now got my candid opinion why we are so far behind at least two great continental powers in aerial navigation, and summarised briefly the case may be stated as follows: Firstly, the Government never afforded Colonel Templer any chance of carrying out his schemes, keeping him short of funds, and failing to give him any encouragement whatever, either moral or practical.

Secondly, either through lethargy, conservatism, ignorance, or want of observation and appreciation of what was being achieved abroad, they would not aid the Department to any greater extent after Colonel Templer's retirement, and instead of continuing experiments with "Nulli Secundus," or even using her as a training-ship for men, she was condemned to remain shut up, prevented from justifying her existence, and deprived of obtaining any credit for her designer or constructors.

Considering the high position which Colonel Templer held as one of the greatest aeronauts of the day, a reputation which he had fairly established by his work in developing army ballooning on lines imitated by all other nations, it seems incredible that such scanty recognition should have been bestowed on the lifelong services of a man who had done for England much what the Tissandiers, Lebaudys, Santos-Dumont, Zeppelin, Ferber, Renard, and others had done for France and Germany.

Colonel Templer is without doubt the pioneer of ballooning and airship work in England, yet one never hears his name mentioned in the same breath as Count Zeppelin, and his very existence remains unknown to the great majority of people, more's the pity.

XII

The United States "Dirigible No. 1"

American balloon work is carried out by a branch of the U. S. Signal Corps, whose headquarters are at Fort Myer, and, like the English Balloon Department, the development of airships has been kept back by lack of funds.

In January, 1908, however, specifications were sent out by the U. S. Government for tenders for an airship not to exceed 120 feet in length, and capable of travelling at a mean speed of 20 miles an hour. Captain Thomas S. Baldwin secured the contract, and in August of the same year he delivered his dirigible balloon at Fort Myer. Whilst the general design of the envelope, rigging and car was Captain Baldwin's, the engines were designed and built by Mr. Glenn Curtiss, the well-known motor engineer and now famous aviator.

The envelope is spindle-shaped, 96 feet long, and 19½ feet in diameter at its greatest depth, with a volume of 20,000 cubic feet. It is made of two layers of Japanese silk, with a layer of vulcanised rubber between them, and contains an air-ballonet of 2,800 cubic feet capacity.

The car is made of thin spruce beams, and is 66 feet long, 2½ feet wide, and 2½ feet high. It is attached very close up below the envelope, and carries a 20-horse-power water-cooled Curtiss motor, which drives a propeller nearly 11 feet in diameter, built of spruce, and placed in the extreme front of the car, at 450 revolutions per minute.

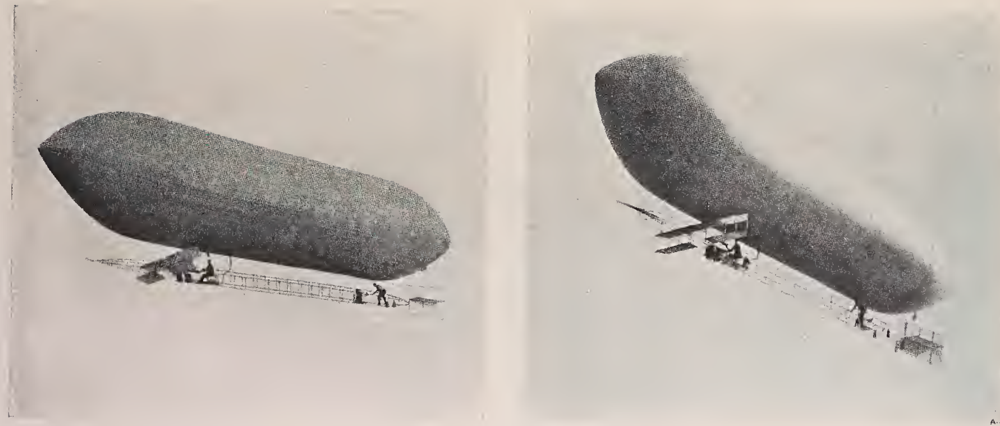
A large fixed vertical plane is attached to the back of the car, and from each of its sides are smaller horizontal planes, the former to prevent any veering to right or left, and the two latter to minimise pitching. Almost at the front of the car is fixed a double plane (one surface above and one below the car), which has the appearance of an aeroplane, and which can be tilted up or down to make the vessel ascend or descend, and which also aids in minimising any pitching motion.

Being so close to the envelope, there is little resistance in the suspension rigging of the car, and the propeller is brought quite near the centre of resistance of the whole vessel.

Inflated with hydrogen, the airship has a lifting power of 1350 pounds, and as its total weight is but 850 pounds, this leaves a margin of 500 pounds for passengers, ballast, fuel, etc. When officially tried a speed of 19.6 miles per hour was attained, and, during an endurance run of two hours, she maintained 70 per cent. of her maximum speed.

She was taken over by the authorities and named "Dirigible No. 1," being soon used as a training-ship for officers and men of the corps, and thus serving a most useful purpose.

At Berlin, in October, 1908, I had the pleasure of a long talk with General Allen, Chief of the U. S. A. Signal Corps, who gave me much interesting information on the subject of aerial navigation generally, and expressed his approval of "Dirigible No. 1" as a small type of airship, of which he seemed to hope America might soon possess a regular fleet. He moreover dropped a hint that he was having a good look at the large French and German airships, as he considered no army could be properly equipped in the future without several of these



BALDWIN U. S. "DIRIGIBLE NO. 1."

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larger aerial craft, as well as those of the "Baldwin" species and dimensions, and I fancied he had great hopes of obtaining a substantial grant from Congress to enable his department either to purchase or construct a thoroughly up-to-date and efficient aerial fleet.

Though very little has been done in this direction up to the present (for the U. S. Government would not pass the vote for a large sum to be devoted to dirigible balloons), I am convinced that America, the most wonderful land of inventions, progress, and activity, will soon be carrying out a programme on the lines suggested by General Allen and his staff, and will not be far behind Europe in both the development and possession of first-class dirigible balloons.

PART III — HEAVIER-THAN-AIR MACHINES KITES, GLIDERS, AND AEROPLANES.

I

A Brief History of Early Experiments—Wenham; Von Helmholtz; Lilienthal; Pilcher; Chanute; Hargrave's Kites; The Wrights

The subject of human flight or aviation as it is commonly termed, is such a large one and the space which remains for me to deal with it in this book so limited, that I am constrained to devote only a very few pages to the early essays of those whose work has doubtless paved the way for the far more successful achievements of present day aviators.

As I write these lines such extraordinary progress and improvements in the art of flying and in the development of heavier-than-air machines is being made, that it is quite impossible to attempt even a brief description of all the existing aeroplanes of various types, or to compile a history dealing with the subject unless a very large book be devoted to this subject only.

Bearing in mind my original intention of not attempting in these pages to discuss aeronautics fully in an either historic or scientific manner, but only to try my best to gain the interest of young readers possessing little or no knowledge of the subject, I hope to be excused by those who trouble to read these words, and who have studied sufficiently to have acquired more technical knowledge than is herein contained, for anything which they may regard as glaring omissions or palpable shortcomings.

Before dealing, however, with a few simple experiments connected with gliding and flying, and before describing what I consider the most interesting and advanced distinctive types of present day aeroplanes, I must at least make brief reference to the extraordinarily interesting work, both practical and theoretical, of some who led the way and, unfortunately, in more than one case, sacrificed their lives in the endeavour to advance the science of human flight.

Tracing back through historical records to the time of the sages, one finds conclusive proof of how, through thousands of years, men have attempted to solve the problem of artificial flight.

Those who have never read the legend of Daedalus and Icarus should certainly do so, for they will find in it a strong indication of the idea of flying being prevalent in the mind of man from virtually pre-historic times.

Similar legends may be found in the folk-lore of almost every civilised nation, besides innumerable narratives describing attempts to fly by artificial means from hill-tops, towers and houses, most of which terminate in a tale of disaster.*

Naturally enough the earliest ideas of the best way for a man to attempt flying were based on the action of the wings of a bird. It is related that Leonardo da Vinci, in the latter half of the fifteenth century, devised

* Much of interest may be read of these earlier performances in Turnor's "Astra Castra" and Chanute's "Progress in Flying Machines," published in New York in 1893.

several apparatus in which the man could place himself in a horizontal position, and work bat-like wings with his arms and legs.

Probably the next design which marks an important epoch in the history of flight, was that of Wenham, who first propounded the theory that lifting power of a large carrying surface might be attained by a number of small surfaces arranged in tiers one above another. He derived this line of thought from constant study of a bird's wing, and was forced to the conclusion that a single surface large enough to support the weight of a man was impossible of human control through its unwieldiness, so he considered that his idea of small surfaces in tiers was the best artificial imitation of nature, and the only possible means of copying a bird when flying.

Working on this theory Wenham built a flying machine with a light rigid wooden framework, and six thin holland surfaces arranged one above the other. He tested the lifting power of this contrivance by standing with his head and shoulders through an aperture at the bottom, and facing the wind, when he was lifted from his feet and thrown violently backwards. At the front of his machine two propellers were placed which the aviator could work with his legs by a string passing over pulleys. He made several interesting experiments, and obtained much valuable knowledge relating to the driving and lifting power of surfaces arranged in this manner, without however being ever able to actually accomplish a flight.

His machine was patented in the year 1866.

Six years later a book was published by H. Von Helmholtz, which contained a summary of his investigations on human flight, and in which the author expressed the opinion that, with an increasing size of body, the work or power required for soaring upwards increased in a much greater ratio than the volume of the body, and therefore more than the muscles which would be called upon to exert the motive force. He believed that it would be impossible for birds beyond a certain size to fly at all, and that nature aided in demonstrating the truth of this theory.

To quote from his own writing, he concludes his remarks on the subject of human flight with the following words: "Under these circumstances it can scarcely be considered probable that man, even with the help of the most ingenious wing-like mechanism, depending on his own muscular force as the driving power, will be placed in a position to be able to raise his own weight in the air and to retain it there."

This very definite and adverse criticism of all previous flying experiments which had been carried out appears to have somewhat damped the ardour of would-be aviators in all directions, and little more was heard of mechanical flight until the publication of a book by Otto Lilienthal in Berlin in the year 1889, which contained the results of many years' work he had carried out with his brother. This book related how they had discovered that arched surfaces driven against the wind had a tendency to rise.

Otto, born in 1848, was consequently at this time 41 years of age, and in proof of his theories commenced to show by personal experiments that one must first begin by "gliding," or sailing through the air, to acquire the art of balancing.

His advice to experimenters may be briefly stated as follows: Soaring or gliding give much instruction and are an excellent preliminary to any attempts at flying in a heavier-than-air machine driven by mechanical power. For a start small wings only should be used and attempts made in gentle breezes, for, when soaring with only 86 square feet of sustaining wing surface, he was frequently overturned in mid-air. He thinks that one should always be able to slip free of the apparatus instantly if necessary, so that if the wind takes control and the wings seem likely to be tilted upwards, the flyer can let go and probably save himself from a severe accident. He considered that a velocity of 23 miles an hour is the strongest wind in which experiments at gliding should be made. The breadth of the wings from tip to tip should be limited to a maximum of 23 feet, so that equilibrium can be easily maintained by changing the position of the centre of gravity, which is done by moving the legs backwards and forwards, or to the right or left, so as to counteract the action of air resistance or sudden eddies. He believed that wings with a depth of about 8 feet and a total area of not more than 150 square feet, weighing approximately 44 lbs., would be found sufficient to support the weight of an average man. He explained that the machine could be controlled to a considerable extent by an intelligent experimenter, as an example of which he explained that if one wing is rising by the effect of an air-current, the natural tendency would be for the legs to hang towards the lower wing, but this is exactly the wrong action, for if the legs are moved towards the wing which is rising, the consequent change of balance will cause the higher side to resume the horizontal position. He believed that it does not take very long before anyone can glide at heights from 6 feet to 60 feet above the ground and feel perfectly safe, even at the greater altitude, by dint of practice and becoming acquainted with the different motions necessary to preserve equilibrium.

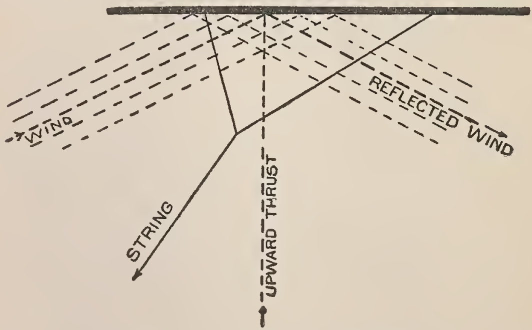
Lilienthal used to make experiments in gliding from the summit of a hill, which he had constructed for his own purposes near Gross-Lichterfelde, some 50 feet high, at a slope of about 30° from the surrounding level ground.

After reaching considerable proficiency in the art of gliding, he thought he might try the effect of a small motor which was to flap the wings. But unfortunately when experimenting at a height of 40 or 50 feet from the ground, on the 9th of August, 1896, through some mistake in one of his adjustments, the machine turned over, and, falling heavily to the ground, poor Lilienthal was killed on the spot.

Mr. Percy S. Pilcher experimented with some success in England for about six years with machines made on much the same lines as those of Lilienthal, but instead of attempting to start from a height and gain impetus by running along the ground, he employed the method of a kite, getting men to hold the cord or rope and then run as fast as they could with it against the wind.

Everybody knows that if there is sufficient wind a kite will go up into the air, although it is heavier than air, and without a string attached to it would probably be blown a short distance and then fall to the ground. Why is this? In case all my readers cannot answer the question I will try to explain the simple cause of a kite rising higher and higher.

Any light, flat surface or plane, if tilted at an angle to the wind will be forced backwards, but if it is held by a string, so that it cannot be blown backwards, and also in such a way that the lower part cannot be blown to a horizontal level with the upper edge, as in the case of a kite, the force acting on the surface must tend to lift it upwards. The accompanying diagram will, I think, clearly demonstrate this fact. We know that the angle of reflection is equal to the angle of incidence, and this applies practically to wind, as it does to other forces. If therefore the kite is held at a certain angle and the wind strikes it horizontally, the dotted lines mark the angles of reflection and incidence respectively, and the lift or upward thrust acts upon the



kite in the direction of the line bisecting the angle formed by the two dotted lines. In the diagram the kite is attached to its cord by two lines, the lower of which prevents the bottom part of the kite from rising and the kite from assuming a horizontal position. A similar effect can of course be obtained by a single line attached to the kite about one-third from the top, and by adding a tail to the bottom of the kite, the weight of which prevents the bottom from rising to a horizontal position level with the front or top edge.

Mr. Pilcher was another unfortunate victim whose life was sacrificed during his experiments, for by falling one day from a height of over 30 feet, he sustained fatal injuries.

In Chicago Messrs. Chanute and Herring made many experiments with gliders. Chanute introduced an elastic rudder, which was so arranged that the inclination of the wings or sails was adjusted to counteract the pressure of variable gusts of wind. Herring went even further towards the present-day idea of an aeroplane, by the introduction of a motor, driven by compressed air and placed between the two plane surfaces of his apparatus. This machine actually flew for a few seconds, but could not continue, owing to lack of compressed air or motive power.

Mr. Lawrence Hargrave of Sydney, New South Wales, tackled the problem of flying in heavier-than-air machines by means of kites which he designed and which have always borne his name. They were of "box" pattern, made of calico, stretched over frames of American redwood. He connected four of these to a strong line, and a sling seat was suspended from the lower kite. Several trials were made when the wind was blowing at a velocity of about 18 miles per hour, when a spring balance indicated that an upward pull of about 180 lbs. was being exerted; with a wind of 21 miles per hour the balance indicated a lifting force of 240 lbs.

The plane surface of these four kites was 232 square feet, their total weight 38 lbs.; the seat and line weighed 7 lbs., and Mr. Hargrave 166 lbs., making a total weight of 211 lbs. He stated that in winds of 20 miles an hour and upwards, he could safely experiment, making ascents and descents without fear of an accident, the kites preserving their stability and apparently needing no particular adjustment. Fuller particulars of Hargrave Kites may be found in *Engineering* of February 15th, 1895, Vol. LIX.

Before concluding this brief history of gliding experiments I must of course refer to those of the celebrated brothers, Wilbur and Orville Wright, who, proceeding on the lines of Chanute and Herring, assiduously pursued a course of study and practical tests with machines constructed on what is now commonly known as the biplane principle, that is to say two plane surfaces joined together by stays or frets and placed one vertically above the other.

The Wrights are natives of Dayton, Ohio, and carried out their gliding experiments along the shores of the Atlantic, where a steady wind prevails almost all the year round. In these trials they directed their attention mainly to the solution of three problems. (1) Whether it is better for the flyer to stand in the vertical position adopted by Lilienthal, or to lie flat and face downwards; (2) Whether stability is gained better by shifting the position of the centre of gravity or by the application of some special steering device; and, (3) What effect can be produced by a rudder placed in the front of a machine.

Plodding along with their keen determination, to which we can surely attribute the wonderful success ultimately achieved, these two hard-working and brilliant Americans soon decided that lying in a horizontal position was best for their gliding experiments, that the plane surfaces which they first tried of a slightly concave shape would act better if flat, that a vertical rudder in the rear of these main planes was the best method of steering to the right or left, and that a horizontal rudwhew!

der or small plane in the front was the most sure and handy way of directing the machine up or down.

The apparatus they used during the year 1901, had a surface area, according to Captain Hildebrandt, of 172 square feet; in 1901-2 this was increased to an area of 312 feet, and in the year 1903, when they first introduced experiments with a motor, the size was again raised to 625 square feet.

The glider used in 1901-2 was 35 feet wide, and each of its main planes 5 feet 3 inches deep from front to rear. The vertical rudder, somewhat the shape of a bird's tail, had an area of 14 square feet, which was subsequently halved, by which alteration the apparatus was found to become more stable. The total weight was 117 lbs., and the angle of flight, or upward tendency when gliding, varied from 5° to 7°. The longest distance travelled in this glider was 200 yards in 26 seconds.

Oh me

1 min. 11 seconds

No mention of Dec. 17, 1903

Amongst other names which have since become celebrated by reason of their achievements with the motor-driven aeroplanes of the present day, must be mentioned Captain Ferber of the French Army, who, in 1898, started imitating Lilienthal, and successively built several gliders of somewhat different designs, experimenting with more or less success.

Mr. Robert Esnault-Pelterie, whose R.E.P. motor and monoplane are now so widely known, made sundry tests with a gliding machine, similar to that of the Wrights, near Wissant in 1904. He obtained results practically equal to those of the Wright brothers during the first year of their experiments. He demonstrated that it was possible to glide at an angle of one in ten, and much useful experience was gained generally.

II

Principles of Gliding—Simple Models and how to Make Them—The "Weiss" Machine

Having scampered through the history of human flight in its succeeding stages and advancement from the commencement up to the time when the introduction of the petrol-motor rendered it possible to convert the glider into the aeroplane proper, I think it will be as well, before dealing with men-carrying machines of various types, to consider the why and wherefore of sundry points with which the man in the street is unfamiliar, and with which therefore I must assume my young readers are not fully conversant.

How often have all of us demonstrated the theory of a glider, quite unconsciously at the time, and probably through laziness?

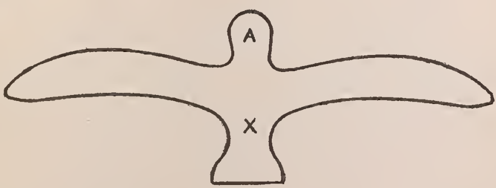
Have you ever had a letter in your hand, probably for a brother or sister or some pal whom you treat with equal lack of ceremony, which, instead of handing to him or her in the approved polite manner, you have chucked horizontally across the room? Has it ever struck you that the envelope and its contents, forming a plane surface of considerable spread by comparison with the weight, is in reality a modified form of glider, and, as it skims across the room with the impetus given by a sudden movement of the wrist, it affords a simple but convincing example of the idea that a flat surface, if propelled with sufficient force, will travel easily and rapidly through the air, although it is not buoyant?

If one were able to make the propelling force continuous, it is logical to expect that the envelope would go on gliding for an indefinite distance.

This contention may not be strictly accurate, for experiment has proved that it depends upon shape and balance in the construction of a plane to ensure prolonged flights or glides being feasible.

One of the things which struck me as being most curious when first making simple experiments with bits of paper, cardboard, thin wood, etc., was the fact that far better results could be obtained when weights were placed on the models, which naturally made them heavier and, as one would think haphazard, less likely to sustain themselves in the air.

An extremely simple example of my meaning can be tested as follows: Take a piece of stout and stiff paper or thin card, and cut it out in the approximate shape of a horizontal section through the middle of a bird when flying.



Holding this little flat bird between the thumb and first finger at X, throw it gently away from you and observe the result. You will find that it may skim through the air for a yard or two, then lose its balance, and, according to its height, turn a succession of somersaults until it falls to the ground. There is evidently something wrong in principle with this attempt at a glider, and the remedy is merely addition of weight in the centre, rather forward, at about A. Heat some sealing wax, allow a few drops to fall on this spot on the model, and try another glide, when you will find that, though possibly not yet really a success, the bird will travel much further than before, prior to tipping over and falling. Add more sealing wax in the same place, and by degrees you will find that your extremely crude model will glide from end to end of a good-sized room, and with extraordinary rapidity, considering the small amount of impetus which should be given it at the start in order to attain the best results. However carefully you may have cut out your model to make each side symmetrical, you will probably find that, in gliding through the air, it has a tendency to swerve either to the right or left, or to dive downwards. These defects can be remedied by slightly bending the wing tips. If the model has an inclination to turn to the left, the left tip should be bent slightly downwards, the right tip slightly upwards, and *vice versa* to counteract a turn to the right. To prevent the downward dive, the head should be slightly bent upwards. By cutting out half a dozen such models of various sizes and slightly differing shapes, by adding sealing wax in greater or lesser quantities, and by bending the wings of each as requisite, you will soon arrive at a satisfactory glider, and will be surprised at the distance these tiny and simply constructed toys will travel through the air, and also I think be pleased at the graceful curves they make en route, sometimes making a long downward dive, then rising and diving again before falling to the ground.

All sorts of gliders of every size can be made at home without much difficulty, and any boy of a mechanical turn of mind, who would like to employ himself in this

Weiss Glider Prior to Start.

Face page 180.

way and at the same time gain a thorough insight into the question of gliding, the best shapes and proportions of size to weight, etc., cannot do better than purchase a small pamphlet entitled "Model Aeroplanes: How to Build and Fly Them," by E. W. Twining, published by Percival Marshall & Co., of London, which, together with sheets of full-sized working and detailed drawings and instructions for building three model flying machines, can be obtained at the moderate cost of one shilling.

The most interesting simple gliding model which I have ever seen is the one designed and constructed by José Weiss, which was first exhibited to the public in the Aero Show, held at Olympia, London, in March, 1909. It consists of a bird-like framework and covering, about 12 feet from tip to tip of the outspread wings, made of bamboo and varnished silk, with a canoe-shaped body prolonged to a point to form the tail for preserving longitudinal balance, but with no front projection corresponding to the bird's head. The body and tail are rigid, as are the front curves of the wings, the back curves being pliable, so that each wing in principle of design much resembles that of a bird. The weight of this glider is 12 lbs., and, if taken to the summit of a tower, high building, or hilltop and then propelled into the air, it would turn over and over whilst falling quickly to the ground, just after the manner of the little paper bird, previously described, before any sealing wax or weight is placed on its head. The addition of a piece of lead, weighing no less than 16 lbs., and fastened securely in the centre of the body between the two wings and rather far forward, enables results of a totally different character to be attained.

By placing one hand on the body under this weight and the other hand further back, you can balance the apparatus over your head, and then, launching it forward with all your strength, it will soar for a remarkable distance, frequently rising to a greater height than that from which it started. The picture on the opposite page shows this machine gliding in the distance, after having been launched from a tower.

The construction of this very excellent model can be far better understood by a brief inspection than by pages of description, and I recommend any reader who finds the time and opportunity to pay a visit to Mr. Weiss' ground near London, where the machine can be seen and probably a demonstration of its soaring ability demonstrated by the inventor, whom I have always found most kind in exhibiting either this glider or the "Weiss" aeroplane (which is built on very similar lines), to anyone interested in the subject of flight.

Weiss Glider in Flight.

Face page 182.

WEISS GLIDER IN FLIGHT.
(NOTE WIND BLOWING FIRE IN DIRECTION CONTRARY TO THAT OF THE FLIGHT.)

Face page 183.

III

Practice and Theory—Sir George Cayley's Ideas—Stringfellow's Model

Despite the rapid progress which is being made in the science of aviation, and despite the fact that some of the cleverest mathematicians and experts of the present day have expended enormous trouble and an infinity of time and patience upon calculations and experiments, I feel convinced that much yet remains to be discovered before anything like the ideal design of an aeroplane is definitely decided, and anything like finality arrived at regarding shape, size, devices for gaining stability, and other details.

Although the application of various theories and principles regarding flight in heavier-than-air machines has been rendered feasible and demonstrated only in the past four or five years, I am perhaps wrong in stating above that extraordinary progress has been made with flying-machines, as it is impossible to forget that there exists in the South Kensington Museum a machine constructed by Henson and Stringfellow, designed on data provided by the writing of Sir George Cayley, a prominent English scientist, who just a hundred years ago had worked out theoretically most of the principles on which the construction of present-day aeroplanes is based, and who, despite the fact that steam engines, much less petrol-motors, were non-existent and almost undreamt of, possessed sufficient foresight to anticipate the advent of such a machine, which would readily generate sufficient propelling force to drive an aeroplane safely through the air.

It is with great satisfaction, as an Englishman, that I relate the following details of Sir George Cayley's investigations, for it is somewhat of a relief to our national pride to find that at least one man was capable a hundred years ago of anticipating the conquest of the air, and of propounding an almost perfect solution of the problem of human flight, whilst England has otherwise had to take off her hat in this respect certainly to France, and probably to other nations also.

Let me at once say that France, undoubtedly the pioneer nation in matters regarding human flight, has not hesitated to do Sir George Cayley justice, for M. Tatin, writing in the *Elements d'Aviation* paid this tribute to his work and ingenuity:

"It would be difficult to construct a machine to-day which did not embody the majority of the features indicated by Cayley. His contributions to the theory of flight form a work of reference which it is well not to ignore."

In 1874, another Frenchman, M. Penaud—himself well known as a pioneer in flight—paid a special visit to England on purpose to make research among Cayley's writings, and on his return to France presented his discoveries in the following eulogistic terms before a meeting of the Société Française de Navigation Aerienne:

"Sir George Cayley seems to have appreciated almost every side of the problem of aerial navigation. He foresaw the difficulties associated with dirigible balloons on account of their enormous size, but he pointed out how they might be made to ascend and descend in the air without loss of ballast.

"In 1796 he constructed a model helicopter with a pair of lifting screws revolving in opposite directions, and expressed his conviction that it would be possible for a full-sized man-lifting machine to be made on these lines. He anticipated the advent of aeroplanes, and, knowing that great lifting effect could be obtained from surfaces moving through the air at slight inclinations to the horizontal, he pointed out the importance of making what are now known as 'lift and drift' experiments. He suggested the use of a tail as a means of obtaining automatic longitudinal stability in aeroplanes, and he further showed how the pivoting of that tail would enable it to be used as an elevator for ascent and descent. He deduced the advantage of wing flexion from his observations of 'bird flight,' and he carried his investigations on the subject of propulsion into a close study of the theory of screws. Having invented a hot-air engine (and that probably, the first of its kind) he foresaw possibilities in the use of gaseous mixtures, which have since been more than realised in the development of the petrol engine. On the question of steam he was even more precise, for he definitely suggested the use of a tubular boiler and surface condenser, both of which principles are now common in practice."

The time was not then ripe for the realisation of his ideas, but some thirty years later, in 1843, an engineer named Henson drew out designs for a steam-driven monoplane based on Sir George Cayley's data.

A model of Henson's machine, which he constructed in conjunction with Stringfellow, is on exhibition at the South Kensington Museum.

This design was patented in 1842, and is thus officially decribed in the Museum:

"The model consists of an extended surface or aeroplane of oiled silk or canvas, stretched upon a bamboo frame made rigid by trussing both above and below. A car is attached to the underside of the aeroplane to contain the steam engine, passengers, etc. It has three wheels to run freely upon when it reaches earth. Two propellers, 3 feet in diameter, are shown with their blades set at 45 degrees. They are operated by endless cords from the engine. Behind these is a fan-shaped tail stretched upon a triangular frame capable of being opened out, closed or moved up and down by means of cords and pulleys. By this latter arrangement ascent or descent was to be accomplished. A rudder for steering sideways is placed under the tail, and above the main aeroplane a sail was to be stretched between two masts rising from the car, to assist in maintaining the course. When in motion the front edge of the machine was to be raised in order to obtain the required air support. To start the model it was proposed to allow it to run down an incline, *e. g.*, the side of a hill, the propellers being first set in motion. The velocity gained in the descent was expected to sustain it in its further progress, the engine overcoming the head resistance when in full flight. Experiments were eventually made on the Downs near Chard, in Somerset, and the night trials were abandoned, as the silk became saturated from a deposit of dew. After many day trials, down wide inclined rails, the model was found to be deficient in stable equilibrium for open-air experiments, little puffs of wind or ground currents being sufficient to destroy the balance. The actual machine was never constructed, but in 1847-8 F. Stringfellow built a model which is supposed to be the first flying-machine to perform a successful flight."

As stated above, I do not believe that perfection or finality has been anything like reached, and I imagine that continued practice in actual flying will do far more to demonstrate the good and bad points of aeroplanes, which must be respectively preserved and eliminated, than any amount of theoretical study, mathematical calculations or laboratory experiments, for these latter can only attain advantageous results granted they are based upon reliable data, and it seems to me that such data can only be provided by the man in the air himself and the information which he can afford to the scientist as a basis from which to make calculations in theory.

To put it briefly, therefore, while not posing by any means as an expert, I cannot refrain from expressing an emphatic personal opinion that an ounce of practice is worth a ton of theory in matters relating to human flight, and I believe that almost every calculation and theory upon the subject which can prove of any great use in advancing the science, has already been arrived at, if not to a state of absolute completion, at all events sufficiently to answer the purpose.

Any of my readers who are desirous of acquiring an insight into the fundamental principles of artificial flight can do so without troubling to make personal experiments and calculations, but by reading the principal text-books which have been written from time to time dealing with this subject. I would suggest "Artificial and Natural Flight," by Sir Hiram Maxim, and Moedebeck's "Pocket Book of Aeronautics" (so frequently referred to in these pages), as being two of the most useful and concise works for perusal and study of theory.

IV

The Best Form of Plane—Effects of Curved Surfaces—Lift and Drift

There is little reason to doubt that the best form or shape of plane has already been decided upon with considerable accuracy, although no one can say positively that it is perfect.

Everybody knows what wind-pressure is, for walking along on a windy day you frequently experience the sensation of being blown horizontally backwards, forwards or sideways, as the case may be. "Drift" is a short alternative word to express such wind-pressure, introduced, I believe, by Sir Hiram Maxim and generally adopted by experts and dabblers in the science of aeronautics, and for convenience I shall use the term in these pages.

Wind, of course, is air in a state of motion, and its effect produced upon objects against which it blows may be reproduced exactly if the objects are moved at varying speeds through still air. Experiments on a small scale can therefore be made either by drawing a model through the air in a room or laboratory, or by subjecting it to an artificial draught created by a fan, blowpipe, or any other simple means.

Generally speaking, drift is a force which the wind exerts in a horizontal direction; but there is another and more important attribute of the wind, namely its capacity for lifting objects of a certain shape upwards, while apparently blowing straight across them. Sheets of paper, cardboard, or other light material will be lifted by the wind when placed edge on to it if the front edge is slightly higher than the back, and it has been found that if the surface of the material is curved so as to become slightly concave, the wind will still exert a lift, while the front and back edges of the model will remain on the same level.

To those who know all about component forces, and who have made a study of dynamics, these facts are probably quite familiar, but to the ordinary individual and possibly to the majority of my young readers they are not equally clear, because their attention has never been drawn to this underlying law, which is, in reality, the fundamental basis of human flight as practised to-day.

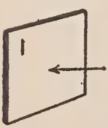
In the year 1885 Mr. Horatio Phillips (a well-known member of the Aeronautical Society of Great Britain) carried out a series of very interesting experiments, which practically determined what shaped section of plane gives the greatest "lift" for a given size. Some years later Sir Hiram Maxim by similar experiment arrived at a like result, while Mr. José Weiss (another member of the Aeronautical Society mentioned before), who has made a number of successful models, arrived at the same conclusion by independent and different methods. I here take the liberty of reproducing a table with explanatory diagrams of Sir Hiram Maxim's lift and drift experiments, compiled from his book, and published in *Flight*, Vol. 1, No. 6:—

Test Piece			Results			
Diagram No.	Width	Inclination	Wind Velocity	Lift	Drift	Ratio Lift: Drift
	ins.	°	m. p. h.	lbs.	lbs.	
1	0	90°	49	0	2	....
2	2	0°	49	0	5.16	....
	2	0°	40	0	4.56	....
3	2.83	0°	49	0	5.47	....
4	2	0°	49	0	2.97	....
	2	0°	40	0	2.8	....
5	9	0°	40	0	0.78	....
6	9	0°	40	0	1.22	....
7	9	0°	40	0	0.28	....
8	9	0°	40	0	0.42	....
9	9	0°	40	0	0.23	....
	9	1:4½°	41	4.45	0.47	9.5:1
10	9	0	40	0	0.59	....
	9	1:4½°	41	2.54	0.76	3.3:1
11	12	0	40	0	0.19	....
	9	1:2¾	41	7.08	3.23	2.2:1
	9	1:3 9/10	41	4.53	0.78	5.8:1
	9	1:6 7/10	41	3.37	0.5	6.8:1
12	....	0	....	....	....	....
13	12	0°	40	0	0	....
	12	1:20	40	3.98	0.3	13.1:1
	12	1:16	40	4.59	0.53	8.7:1
14	16	1:10	41	9.94	1.12	8.9:1
	16	....	41	10.34	1.23	8.5:1
15	12	1:14	41	5.28	0.44	12. :1
	12	1:12	41	5.82	0.5	11.6:1
	12	1:10	41	6.75	0.73	9.2:1
	12	1:8	41	7.75	1.0	7.7:1
	12	1:7	41	8.5	1.25	6.8:1
	12	1:6	41	9.87	1.71	5½.8:1
16	12	1:12	41	6.12	0.54	11.3:1
	12	1:12	41	6.41	0.56	11.5:1
	12	1:16	41	5.47	0.37	14.8:1
	12	1:10	41	6.97	0.7	10 :1
	12	1:8	41	8.22	1.08	7.6:1
	12	1:7	41	9.94	1.45	6½.8:1
	12	1:6	41	10.34	1.75	5.9:1
	12	0°	41	2.09	0.21	10 :1
	12	1:18	41	0	0	....
17	8	0°	40	1.56	0.08	19 :1
	8	1:20	40	3.62	0.21	15 :1
	8	1:16	40	4.09	0.26	16 :1
	8	1:16	47.33	5.0	0.33	15 :1
	8	1:14	40	4.5	0.33	14 :1
	8	1:12	40	5.0	0.43	12 :1
	8	1:10	40	5.75	0.60	9.6:1
	8	1:8	40	6.75	0.86	7.9:1

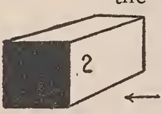
Table of Results

The diagram numbers refer to the illustrations. All test pieces were 3 ft. in effective length, that is to say, they were subjected to a draught 3 ft. wide. The inclination is the slope of the plane to the horizontal wind, the front edge being raised except in the case of negative inclination. Figures are not available for No. 12, but the lift was positive with zero inclination. The results are expressed in total lbs, lift and drift for the full 3 ft. of each test piece, having a width as stated in the table. The width is the distance from front edge to rear edge, measured through the section.

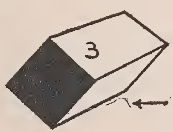
DESCRIPTION OF TEST PIECES



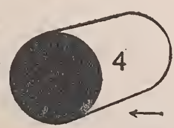
No. 1. Plain board, 6 ins. square, placed vertically in the wind.



No. 2. Bar of square section (2-inch edge) set so that the wind blows directly on to one face.



No. 3. Same bar as No. 2, set edge on to the wind.

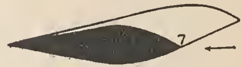


No. 4. Round bar having cross-sectional diameter of 2 ins.

No. 5. Bar having a kite-shaped cross-section. The bar is 9 ins. wide, the distances from each edge to the point of maximum thickness being 6 ins. and 3 ins., respectively.

No. 6. Same bar as No. 5, but set with the thin edge to the wind, in which position it offers much more resistance.

No. 7. Bar of similar proportions to No. 5, but having curved surfaces.



No. 8. Same bar as No. 7, but placed with the thin edge to the wind, in which position it offers far greater resistance.

No. 9. Bar having a bottle-shaped section of similar proportions to No. 7, than which it offers less resistance.

No. 10. Same bar as No. 9, but with the thin edge to the wind, in which position it offers greater resistance.

No. 11. Bar having a symmetrical elliptic cross-section with sharp edges. The bar is 12 ins. wide, and has less resistance than any of the above shapes. Being symmetrical, the resistance is the same with either edge facing the wind.

No. 12. Bar having a triangular cross-section, fairly deep in the centre and with a rounded top edge. With either of the thin edges facing the wind a decided *lifting* effect is produced.

No. 13. Bar 12 ins. wide representing a flat aeroplane. The under-

side is flat, and the upper side slightly convex. No resistance is offered to the wind when the bar is horizontal.

No. 14. Bar 16 ins. wide, representing a thin aeroplane. The underside is slightly concave.

No. 15. Bar is 12 ins. wide and slightly thicker than No. 14.

No. 16. Bar of the same width as No. 15, but more cambered. When horizontal, the wind still exerts a considerable lifting effect and very slight drift.

No. 17. Bar only 8 ins. wide, which exerts a greater lift in proportion to the drift when horizontal in the wind than does No. 16, but is less advantageous when inclined.

Note.—All the above test pieces were tested in the same machine which produced a draught 3 ft. in width; the area upon which this wind played, however, varied with the width of the test pieces. The most effective aeroplane section—that illustrated in No. 17—was 8 ins. wide, the area in this case being 2 sq. ft. The lift produced by this section at an inclination of 1 in 16 was about 2 lbs. per sq. ft.

Naturally the ideal of the aviator is a plane which will give the maximum lift and the minimum drift, so all these experiments and deductions made by independent tests which arrive at a similar decision as to the best shape of plane surface are of the greatest use, and should save designers or inventors a lot of work when considering details of construction for their machines.

In the foregoing table of results it is worth noticing that the thick edge of a bar of kite-shaped section (Fig. 5) offers less resistance to the wind than a thin edge of the same bar (Fig. 6). The same applies with bars shaped as in Figs. 7, 8, 9 and 10, for the experiments prove that there is always less resistance when the thick edges are placed in front with all these shapes.

Figures 1 to 12 really deal more with shapes and forms of bars or struts which it may be necessary to use in an aeroplane, showing which should offer the least resistance, and be most suitably employed. Figs. 13 to 17 deal more particularly with plane surfaces, and I here reproduce an enlarged diagram of No. 17, which in the case of these small testing models gives the very best results.

It will be noticed that the highest point of the section of this plane is about one-third of the distance from the front edge.

Obviously, the more this plane is tilted from the horizontal wind direction when lifting any given weight, the greater will the "drift" become, and the "lift" less. As a matter of fact it has been found that its most efficient angle for maximum lift and minimum drift is between 1 in 14 and 1 in 16 upwards from the horizontal line of direction of the wind.

Phillips says that the wind striking the somewhat blunt nose of this plane glances upwards and causes a partial vacuum above that part of the upper surface behind its highest point, whilst the air striking underneath the plane tends to force it upwards, in which

VANIMAN'S TRIPLANE.

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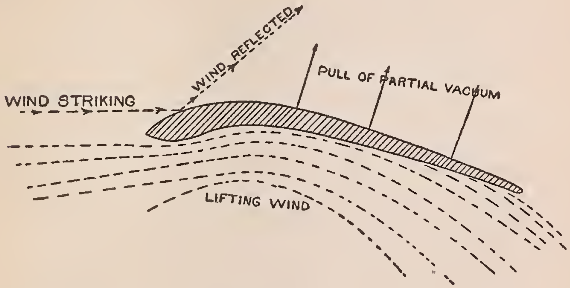
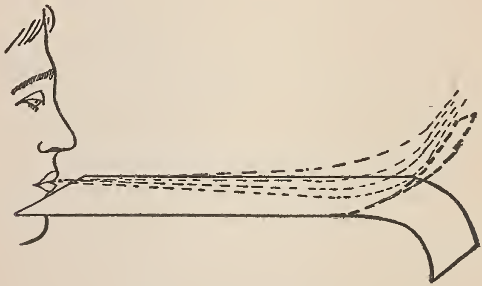
action assistance is naturally given by the partial vacuum above. This idea may perhaps be clearer if illustrated thus:-



An extremely simple little experiment, by which you can satisfy yourself that wind blowing over the top of a curved surface tends to lift it, may be carried out in this manner. Take a piece of softish paper, say 10 inches long and 4 or 5 inches wide. Lay it along a book or any hard flat surface with one end overlapping 4 or 5 inches. Curve this end downwards by taking the paper between the first and second fingers and pulling it with a circling motion downwards until it hangs in the position and shape shown below. If you then blow along the top of the paper you will find that this curved end rises up and up to the position shown by the dotted line, proving that, for some reason at all events, the wind, passing horizontally along the surface of the book and reaching the curved end of the paper, tends to lift the latter very considerably. Now try the effect of blowing along the paper horizontally from below, and you will find that, though the curved end will rise to about a level with the horizontal, it will not lift nearly so much as when blown upon from above, which latter, without trying the experiment, one would expect to have the effect of blowing it downwards.



I am not aware if it has been accurately determined what exact proportion of lift is attributable to the partial vacuum above the plane and what to the concave lower surface, but it is obvious from the foregoing that both contribute in greater or lesser degree in attaining the desired result.

There is such an enormous quantity of theory and calculation to be gone through before arriving at really definite ideas upon the construction of aeroplanes, such as methods of determining the laws relating to air resistance and deductions therefrom, bodies falling through air and retardation of the fall, fundamental laws of aero dynamics, influence of the wind and varying air-currents on flight, etc., etc., that I do not intend to devote any more of my limited space to the discussion of these deep problems, which can obviously only be adequately dealt with and appreciated by much study and by reading some of the numerous hand-books and authorities which have been published, and which treat exclusively on these points. It is hardly even necessary to here suggest the best books of reference for those who desire to pursue the subject further in this direction, but anyone seeking information as to what works would prove most useful can obtain reliable advice by writing, in England, to the Secretary of the Aeronautical Society of Great Britain, Victoria Street, Westminster, S. W., and in other countries by communicating with the secretary of any similar body, or of their respective Aero Clubs.

V

Aeroplanes Proper—Santos-Dumont, the Pioneer—The First Flights on Record

Aeroplanes of so many different types have been built in various countries during the past four years, and especially since the end of 1907, that it would be quite impossible to attempt giving a description of all the machines which have been evolved and proved successful in anything but a large book devoted entirely to this subject alone. Novel designs and improvements come to light, if not daily, certainly week by week, and the progress now being made is so remarkable that one can hardly conceive the degree of possibility which human flight may attain in the course of two or three years from the present time. I must candidly admit that I find it extremely difficult to make a selection of the most interesting machines for brief description in these pages, and if my choice does not meet with the approval of my readers, I will ask them to believe that I have done my best to mention those which seem to me the most important, but that this point is one on which opinion could not possibly be unanimous.

There can, I think, be no doubt about the first "power-driven" aeroplane of Santos-Dumont deserving special recognition, for this intrepid aviator, already rendered famous by his arduous work and numerous hair-breadth escapes when testing his different air-ships, may I think fairly claim the title of Pioneer of aviation of Europe by reason of his performance on October 23rd, 1906, when he accomplished a flight of nearly 200 feet in his aeroplane "No. 14 bis," at Bagatelle near Paris.

This machine, an exceedingly interesting contrivance, was of the biplane type, having two superposed main plane surfaces. An 8-cylinder 50 H. P. Antoinette motor was used to drive a two-bladed aluminum screw propeller, the blades of which were 6 feet from tip to tip. The span of the main plane was just over 39 feet, and the total lift surface 860 square feet. The weight of the complete machine without its pilot was 353 lbs., of which the engine weighed 158, working out at 3.16 lbs. per H. P.

The first time Santos-Dumont actually left the ground in this machine was during the previous month of July, when he drove the machine across a field at a speed of about 25 miles an hour, for a distance of just over 100 yards. Then, by inclining his horizontal rudder, the two front wheels of the chassis first left the ground, then the rear wheel, and the aeroplane flew for a distance of 16 or 20 feet, but in striking the ground it was badly damaged.

When the October flight of 200 feet was made, the aviator could probably have gone a greater distance, but cut off the ignition and stopped his engine, firstly because he noticed a crowd of people right ahead of him, and secondly, because he thought the aeroplane had a rolling tendency. If this difficulty did exist it was probably due to the machine not being provided with a vertical stern rudder.

Prior to these achievements of Santos-Dumont, however, the famous brothers, Wilbur and Orville Wright, had been quietly and almost secretly continuing their experiments with gliders, and in 1903 had fitted a 16 H. P. engine to one of their machines. This bi-plane was about 36 feet wide, the planes some 6 feet deep from front to rear, and the total weight generally given as 744 lbs.

Rumours got about and appeared in the columns of some of the American papers to the effect that a flight had actually been made, and though as a matter of fact the brothers did succeed in flying, and in flying a considerable distance as the following brief table will show, their achievements were, I am afraid, generally discredited, due doubtless to the fact that, unlike the majority of people who achieve successes, the brothers plodded along aiming always at two things, progress and privacy. I have had the privilege of meeting both the wonderful men from time to time, and can fully endorse all that has been said of their modesty, frankness and good-nature in combination with their extraordinary ingenuity, perseverance and success. Amongst their innumerable acquaintances they seem never to forget old friends and past favours, and though always somewhat reticent about themselves and their work, are ever ready to aid beginners with advice when asked for it and with the most kindly encouragement.

The following little table gives a summary of the achievements of the brothers Wright in the wilds of the Kill Devil Hills from 1900 to 1905:

1900. Commenced with gliders.
1902. Glide of 300 yards.
1903. First flight with motor aeroplane.
1905. Flight of 24¼ miles.

Their successes at last became such that the privacy they had always sought was denied them, and there was no further possibility of doubting the fact that they had actually conquered the air, and were able to rise from the ground, fly for several miles and land in safety.

By dint of constant experiment and trial they were able to make a little improvement here, a little improvement there, until at last their machine arrived at the form which is now known throughout the world as the Wright biplane, pictures of which have appeared in almost every illustrated paper, and the general appearance of this aeroplane is probably more familiar to the public than that of any other design.

It is worthy of remark that the brothers brought their machine to a pitch of efficiency nearly approaching perfection without any elaborate manufacturing tools and mechanical appliances, the workmanship and various parts of their aeroplane, though thorough and complete, being for the most part crude and simple in the extreme.

VI

The Wright Aeroplane

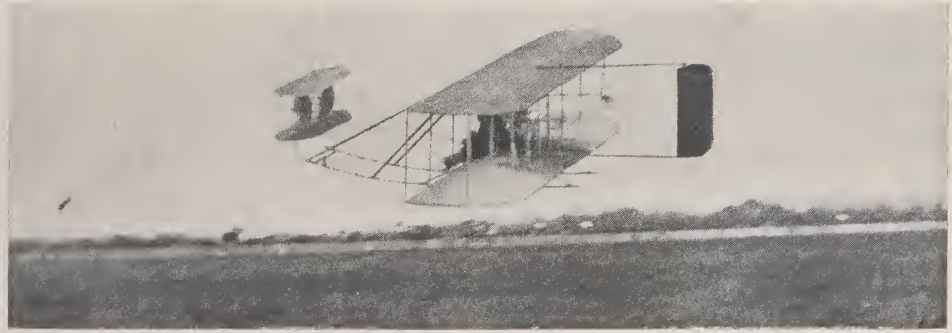
By kind permission of my friend Mr. Griffith Brewer, whose name has appeared frequently in earlier parts of this book, I am able to quote from the very full description of the Wright biplane which he wrote and which was published in the *Field* of January 9th and 16th, 1909.

I may add that Mr. Brewer has always acted as patent agent for the Wright Brothers in England, and probably no one in this country is so completely *au fait* with the details of their machine.

He described the machine very fully as follows:

" That the art of flying is not difficult is proved by the fact that Mr. Wright has already taught Count de Lambert to fly in less than twelve hours, and he assures me that, so far as the actual manipulation of the machine is concerned, no more skill is required in mechanical flight than in riding a bicycle. Like a bicycle, the younger one learns the easier it will be, and a little girl of twelve will probably learn more quickly than anyone, a boy of the same age, slightly slower, and as the pupils commence to learn at later ages they will require more time to pick up the knack and to operate the controlling levers.

" The Wright, Voisin, and Bleriot flying-machines are all of the aeroplane type, *i. e.*, machines having surface which when propelled through the air at a suitable angle of inclination support the weight of the machine after the manner of a kite, the string of which, however, is



WRIGHT MACHINE IN FLIGHT.

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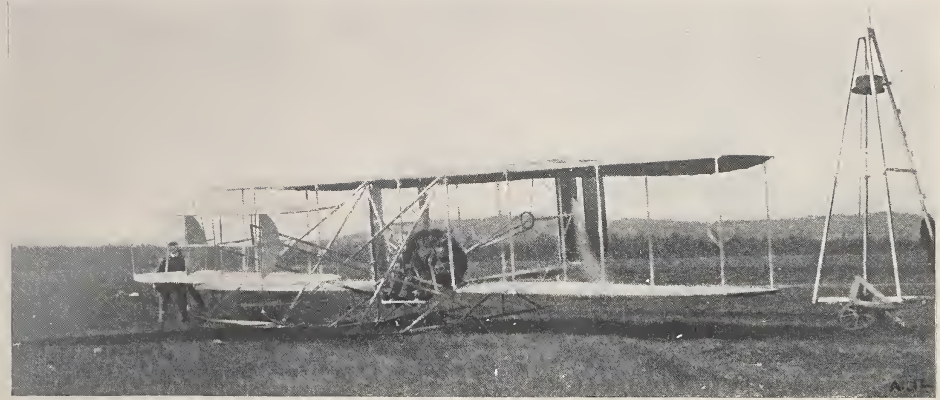

Wright Starting with Passenger.

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replaced by a propelling force comprising a motor and propeller. The aeroplane principle of support in the air is broadly very old, having been invented more than sixty years ago by Henson, whose machine was built on the monotype principle, and has been copied in this respect by Maxim and Bleriot. In 1904, however, the Wright brothers in their experiments at Dayton, Ohio, introduced a machine on which two superposed surfaces were employed, this construction giving the greatest strength for the least weight per area of lifting surface, and enabling the machine to be built more completely.

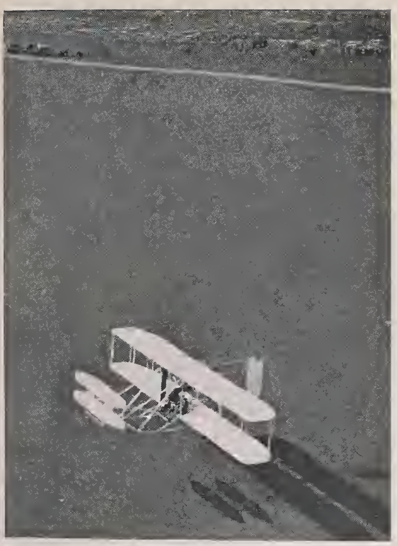
" Since then the best performances have been made on bi-plane machines, and the Wrights themselves have demonstrated to thousands not only that they themselves can fly and that they can carry passengers on their machines, but that pupils can be taught to drive and manage the machines as easily as the first cyclists may have been taught by the inventor of the boneshaker.

" Before describing the Wright machine in detail I will first mention the salient features of the machine and the method of flight and manipulation.

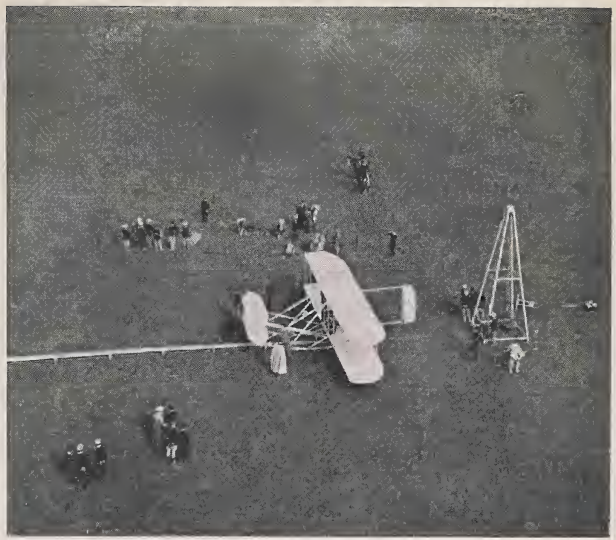
" The machine, which weighs about 900 lbs., consists of two canvas-covered wings arranged one above the other, each 40 ft. wide and 6 ft. 6 in. from front to back, the vertical distance between these wings being about 6 ft. Ten feet to the front of these main wings are situated two horizontally arranged planes, which are capable of being given an upward or downward inclination for the purpose of steering the machine upwards or downwards, and two vertically arranged rudders are carried on a projecting portion of the frame at the rear of the machine for the purpose of steering the machine to right or left. The motor, radiator, and the petrol tank are carried on the frame between the two main wings, as are also the seats for the operator and the passenger, and it is interesting here to note that whilst the constant necessary weights, such as driver, motor, and radiator, are mounted in positions to balance each other, the centre line is reserved for the weights which vary or which may not necessarily be present on all occasions. Thus the passenger's seat is on the centre line, as is also the petrol tank. The machine is therefore in equally good balance, both when the petrol tank is full and a heavy passenger is being carried, and when the tank is empty and the passenger's seat is empty. There are two twin-bladed propellers carried in bearings equidistant from the centre line at the back of the main wings, and these are driven in opposite directions by means of chain gearing. In order to sustain flight, the machine must travel through the air at a sufficient speed to cause the air against which it is being forced to react as a lifting agent beneath the wings, and as the Wright machine does not carry any wheels whilst in flight, but only sleigh runners on which to effect a landing, it is necessary to allow it to make its first advance on a land-supported carriage, and this is effected by means of a little trolley running on a rail, the forward movement being effected by the propellers, aided on most occasions by a towing rope drawn forwards by the stored energy of a descending weight.

"The above insight into the machine, aided by the illustrations, will be enough for many of my readers to carry the general arrangement of the main features in their minds, and so before going into the details of the construction I will indulge in the relaxation of a flight with Wilbur Wright, and we can afterwards go back to the shed and study the mechanism in detail.

"The machine stands on the little two-wheeled trolley



Wright Machine Rising Just after Leaving the Rail.



A Wright Machine Starting Down the Rail.

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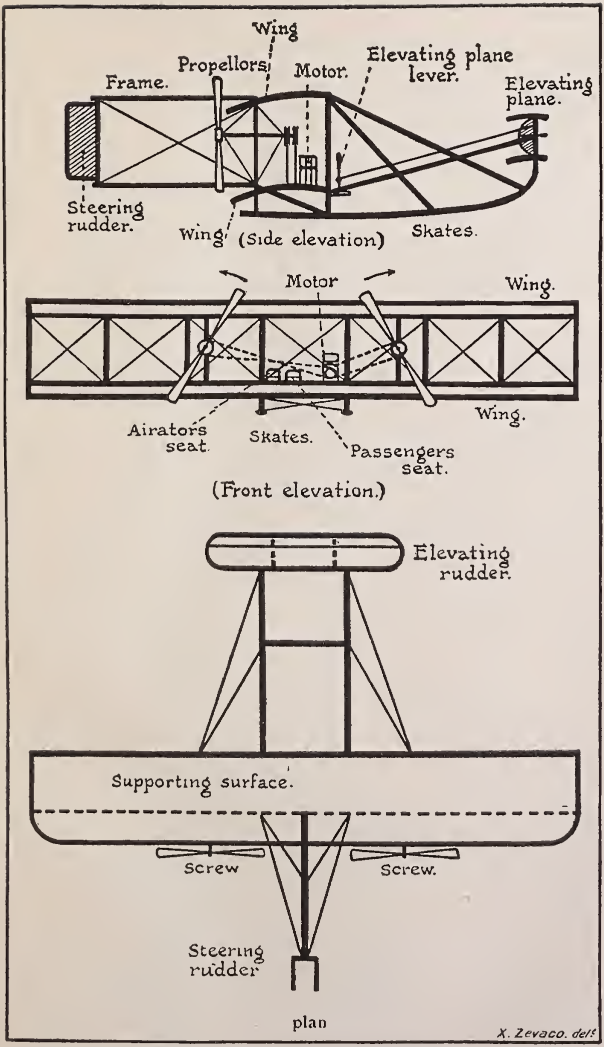
on the rail, with the rope attached, and the trigger ready to be let go. The two assistants grasp the propellers, and when the passenger and Wilbur Wright have taken their seats and the latter is ready to take charge of the machine, they twist the propellers so as to start the engine, and immediately they buzz round at a speed of about 400 revolutions per minute. On the release of the trigger the machine glides forwards under the joint influence of the propellers and the falling weight, but before reaching the end of the rail the tow-rope is tripped, whilst the machine rises and continues forwards under the power of the propellers only. First the machine travels in a straight line forwards, covering the first half mile in less than a minute, the height above the ground being regulated by slight backward and forward movements of the left hand lever, which increases or decreases the angle of incidence of the front planes, and tends to cause the machine to follow an upward or downward path in proportion to the angle of inclination at which the machine is made to travel. Then the time arrives to take the turn at the end of the straight run, and the right-hand lever is now brought into action, to perform the duplex function of tilting the machine to an angle on its side, simultaneously with adjusting the rudders to give the turning movement. At first sight the object of the tilting of the machine on its side may not be recognised, but a moment's thought will suffice to show that without this side tilting of the machine, the turning of the vertical rudders would only turn the machine on a vertical axis without altering its direction of travel, and a side slip or skidding effect would be the result. An analogy to this tilting of the machine may be seen in Brooklands track, where the road is built at an angle in proportion to the sharpness of the curve. It would have been possible to have built the Brooklands track with the road level throughout, and the skidding of the cars could have been prevented by providing each one with non-skidding devices; but let me hasten to assure those who race on the track in question that I do not advocate such a change in the construction of racing tracks. Wright fully recognised the advantage of tilting the track at the curves, and so instead of putting in numbers of vertical planes, as others since have done, in order to prevent side skidding, he thought of the ingenious device of tilting the aerial road on which the machine travels, to suit the acuteness of the curve to be turned; so, regarding the air as his own particular road to be freshly made on each occasion, he cuts its surface to the exact angle of inclination to suit the acuteness of the curve and the speed of turning it, thus allowing the vertical rudders to work with advantage, and without giving any skidding tendency to the machine. The length of this digression has been enough not only to turn the machine from one direction to the reverse direction, but to make several complete circles of 200 yards diameter, for we must remember that the machine is travelling at a speed of forty miles an hour, so the lever controlling the tilting and steering mechanism is brought back, until its effect on the tips of the wings is to cause that side which is highest to descend, whilst that side which is lowest is caused to rise, until the flyer is once more on an even keel.

"The particular mechanism for operating the wings and the vertical rudders will be found later on, but it is necessary to explain here the construction of the wings whereby the tilting effect is obtained, in order that the general operation of the machine may be understood.

I have already explained that a flying-machine of the aeroplane type derives its support in the atmosphere after the manner of a kite by the pressure of the air on its under surface, and this pressure increases with the speed of travel of the machine through the atmosphere and the angle at which the wings are set. It is obvious that where a surface 40 feet wide is being propelled, with one of its broad edges at its front edge, that if the front edge is straight (and not dipped down in the centre so as to secure automatic stability) it is necessary for the entire surface to be maintained at a mathematical uniform inclination in order to prevent one portion of the wing lifting more than any other portion, because if one portion lifts more than another and therefore rises quicker, the machine would get on its side and ultimately upset. Variations in the amount of lift in the centre of the machine are of small importance in the balance of the machine, because they tend to lift or lower the whole apparatus bodily, but when alterations in lifting power take place far away from the centre line they have a tremendous effect on the balance, and it is necessary, therefore, to have the lifting power of the tips of the wings under control if we are to have the power to keep the machine on an even keel or to tilt it at our pleasure. It is the discovery of these requirements and the providing of suitable means for adjusting the angle of incidence of the ends of the wings that has given the Wright machine the marvellous power of control possessed by no other machine. The means employed to effect this necessary adjustment is as simple as it is clever. The two wings are held apart by distance rods, and wire cross stays hold the entire front edges and the central portion of the machine comparatively rigid, but these cross stays are omitted from the rear tips of both the upper and lower wings, with the result that these are free to be bent upwards or downwards. The distancing rods, however, are retained at these outer rear tips of the wings, so that if the lower tip of a wing is depressed the adjacent upper tip must also be depressed, and so as to secure uniform action relatively between the right and the left wings connecting wires running over pulleys on the frame work connect the rear tips of one side to the rear tips of the other side, so as to compel the right-hand rear tips of the wings to move simultaneously with and in reverse direction to the left-hand rear tips. It is now easy to couple a lever to the connecting wire, in such a manner that a movement given to the lever depresses the tips on one side, and at the same time lifts the tips on the other side, thus altering their angle of incidence, and causing one side of the machine to rise in the air at a quicker speed than the other side. When travelling on a straight course, the very slightest movement is sufficient to keep the machine on an even keel, and the passenger during the long straight run we are making, will have found it impossible to detect any more movement of the right-hand lever than the almost imperceptible movements of the handle bar of a bicycle steered by an expert rider when on a straight run, but the unconscious movements are there all the same in both instances. On coming to our second curve, however, the passenger, who is now more qualified to appreciate the controlling mechanism, observes that the right-hand lever is given a considerable movement, causing the right-hand tips to increase their angle, and the left-hand tips to decrease in steepness, whilst simultaneously the same lever causes the vertical rudders to be also turned to the left, and the effects of this compound movement is to cause the machine to tilt up on its side and turn to the left, bending naturally to

split lever



From "The Conquest of the Air," by Alphonse Berget. Courtesy of G. P. Putnam's Sons.

DIAGRAM OF THE WRIGHT BROTHERS AEROPLANE.

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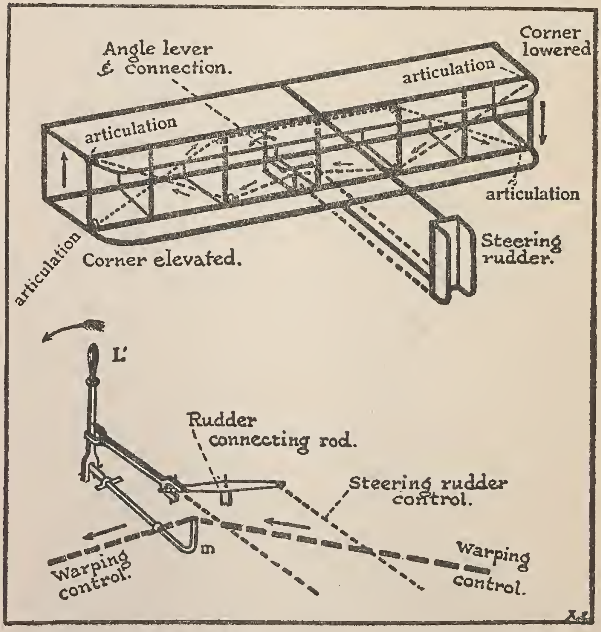
the curve in a manner similar to that of a bicycle rounding the end of a track.

"If Mr. Wright is in a kindly mood, and I have never known him otherwise, the passenger, who by now has lost all sense of fear in his delight at the perfect control of the manipulation of the machine, is taken for two or three complete circuits of the Camp d'Auvours, and on the last run home when at a height of 50 feet the engine is stopped and the machine glides down like a soaring bird, and lands on the sand with no more shock than that experienced in a train brought to rest by the application of powerful brakes. This ability to soar on a descending incline, with no other power of propulsion than that of gravity, is one of the features that make the Wright flyer the safest in the air, because, should the engine stop unexpectedly, the machine can be run down to earth on an incline of one in six, and if flying at a sufficient height a suitable spot for a landing can be chosen before reaching the ground.

"Having landed, the machine is placed on its wheels, pushed into the shed and we now have the opportunity of examining the construction more minutely. The upper and lower wings are six feet apart and are held so by a system of uprights fixed to the wings by universal joints. These uprights and the cross wire stays, that prevent the wings from twisting, are clearly shown by the diagram. The diagram also gives a side view of the aeroplane and shows the vertical steering rudder behind, the propeller with its careful bracing and the runners or skates on which the machine rests when on the ground. These runners are continued forwards and carry two adjustable horizontal planes. A lever, which the operator works with his left hand, moves these up or down.

"There is another lever that controls both the rear tips of these planes and the vertical rudder, so that to turn the machine to the left, for instance, a twist of this lever depresses the right-hand rear tips of the planes and



From "The Conquest of the Air" By Alphonse Berget. *Courtesy of G. P. Putnam's Sons*

DETAILS OF THE WING WARPING ACTION IN THE WRIGHT AEROPLANE

raises the tips on the left, thus increasing the angle of incidence of the right-hand portion of the wings and decreasing the angle of incidence of the left with the effect that the right-hand part of the machine is raised. A thrust of this same lever forward simultaneously turns the vertical rudders to the left, and the biplane swings round, banking the air beneath just as an automobile flies around a banked turn on a track.

"The two main wings have a spread of 40 ft. by 6 ft. 5 in., making a surface approximately combined of 500 sq. ft., and the front planes have an area of about 60 sq. ft., and two semi-circular planes are arranged vertically between the front planes for the purpose of facilitating the steering of the machine. The wings are thick in front, having a semi-circular front edge, and gradually decrease in thickness as they curve downwards towards their rear edges, and these wings are built up with cross frames built to the curve required, and the canvas is applied to the upper and lower surfaces, so that both sides are smooth. The canvas instead of being applied so as to run lengthways or sideways is applied at an angle of 45°, so that the warp and weft of the fabric form cross stays in both directions, and hold the frames of the wings rigid. The frame carrying the back rudder is movable, connected to the main frame of the wings in such a manner that it can be deflected upwards against the resistance of a spring, so as to enable the rudder to strike the ground on making a descent without smashing the rear frame. The whole of the framework of the machine, and in fact all the woodwork of the apparatus, is made of spruce pine, the only exception being the curved portions of the frames at the front ends of the wings, which are made of ash. The motor weighs about 200 lbs., and develops a 25 H. P. when running at 1400 revolutions. There are four cylinders, and the valves are operated mechanically. Ignition is by means of a high-tension Eisemann magneto machine, and the petrol is supplied to the engine by gravity from a tank situated above the engine slightly to the side, quite close to the right shoulder of the passenger sitting on the central seat.

"The radiator is attached to one of the standards of the machine and consists of a series of flattened tubes. The two propellers, which are carried on horizontal shafts, receive their power from the motor by way of sprocket-wheels, chains and pinions. In order to reverse the direction of these propellers, which are respectively right- and left-hand screws, one of the chains is crossed and the other not crossed, and the chains are sufficiently long to prevent this crossing having any detrimental effect. The chains, however, are made to run in steel tubes, in order to prevent them from catching the rubbing.

"The launching is effected on a single rail about 25 yards long, the machine being balanced on a small trolly, which is released prior to the machine leaving the rail, and the weight used for assisting in attaining sufficient velocity for flight while the machine is on the rail is drawn up to the top of a derrick, and weighs about 1500 lbs., the amount of drop allowed for the weight being about 15 ft. The front end of the tow-rope is attached to a jointed rod carried on the lower portion of the frame of the machine, and the eye of the tow-rope is situated on a pin projecting at right angles on the under end of the jointed rod in such a manner that when the jointed rod drops as the tow-rope increases in angle and intercepts a cross-bar of the machine, the eyelet is knocked off the projecting pin, thus completely releasing the machine from the tow-rope.

"The machine is really so very simple in construction that it would appear easy, after studying the machine for a day or two, to go away and build one like it. If one observes a particular part, however—such, for instance, as the universal joint connecting one of the upright rods with the main frame of the machine—and appreciates the thought and work expended on that particular joint and the reason for every part of it, many details which were not noticed in the general survey of the machine gradually develop, and these will be recognized as essential to success. So it is with all the various details of this mechanism, which has taken so many years' constant study and experiment in order to work each part out to the best advantage."

VII

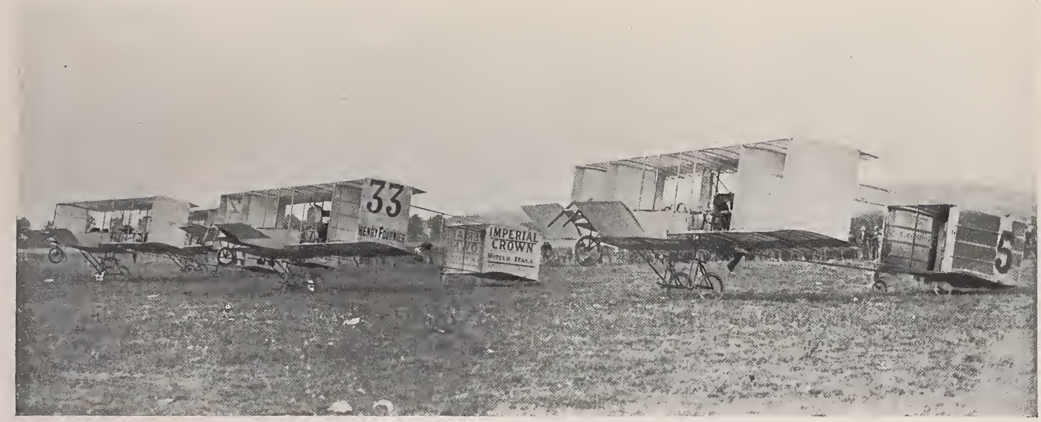
The Voisin Biplane—How It Differs From the Wright Machines

In the year 1904 MM. Voisin constructed some large-sized cellular kites for Mr. Archdeacon very much in the same form as their present aeroplane. These were tested by being towed about by a motor launch on the River Seine, and from the results of these experiments much data was provided which was afterwards utilized in the construction of the aeroplane which has since brought the name of Voisin into public prominence, and which was first successfully flown by MM. Henry Farman, and Delgrange.

In conjunction with MM. Voisin must be mentioned their engineer or works manager, M. Colliex, who, I believe, is largely responsible for the principal designs, and these three gentlemen always acknowledge that they based their work principally on that of such designers as Lilienthal, Langley, and others. On the other hand much of the final alteration and perfection is based on their own researches and they usually arrived at their final ideas by testing small models with an artificial wind.

The approximate weight of a Voisin machine is 1450 lbs.; it has a total supporting surface of 535 sq. feet, and a maximum velocity in calm weather of about 38 miles per hour.

Whilst the Voisin machine has two main superposed planes or supporting surfaces, like the Wright machine, it has in addition two smaller planes, generally called



At Rheims. Some Voisin Machines Ready to Start.

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the tail-piece, which also aid in sustaining the machine and in giving longitudinal stability, though I believe the upward pressure acting on the main planes is considerably greater than that acting on the tail.

In addition to these horizontal planes there are a number of vertical planes which are intended to preserve and control the direction of flight and to give increased lateral stability. Whilst the main supporting planes are about five times as long as they are wide, the horizontal tail planes are almost square.

The aeroplane is propelled by a single screw some 7 ft. 6 in. in diameter keyed direct to the motor shaft. The motor originally fitted to all Voisin machines was an 8-cylinder Antoinette, stated to give approximately 50 H. P. at 1100 revolutions per minute; its weight being given as 265 lbs.

The two great differences in the construction of Voisin and Wright biplanes are:—

A. The Wright machine has no tail-piece to give it longitudinal stability.

B. The Wright machine has two long runners on which to alight in place of the four pneumatic-tired wheels attached to the chassis below the main planes of the Voisin machine.

The Voisin machine is also about 40% heavier than the Wright, and the engine power approximately double that used by the latter.

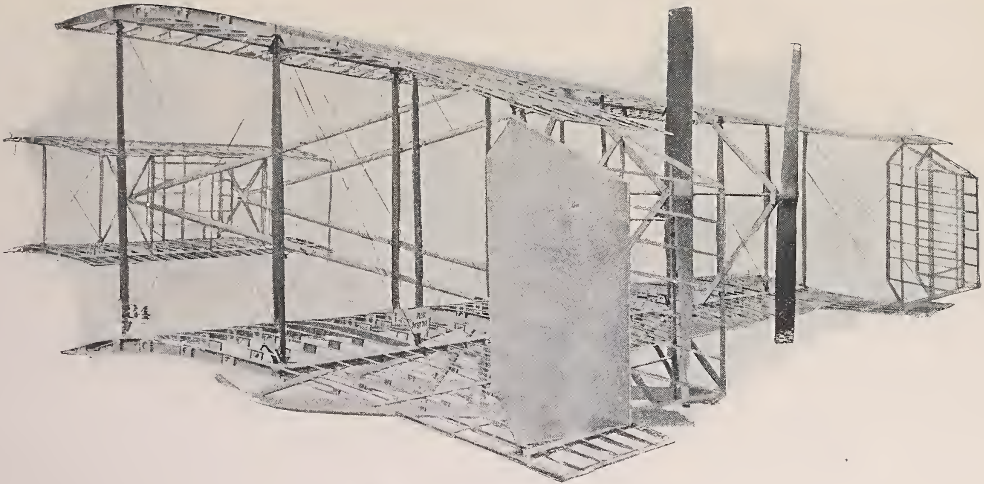
Let us consider what different effects result from these varying designs:

Firstly, the Voisin machine with its supporting tail-piece moves through the air with very little pitching motion, whereas one notices that the Wright machine is negatived by the aviator moving the horizontal elevating planes in front of the machine, upward when the machine pitches down, and downwards when the machine is tending to rise.

In plain language, the Wright machine has two factors of longitudinal stability; namely, that which is attained by the main planes and the elevating planes in their horizontal positions, and the centre of gravity of the whole machine, whilst in the Voisin type a third factor, consisting of the tail-piece fixed at a considerable distance behind the main planes, obviously tends in a great degree to nullify any pitching motion, thus really giving increased longitudinal stability by the leverage it exerts.

The second point of difference lies in the fact that, whilst the Voisin machine can run along any fairly level ground on its wheels by its own motive power, and can generate sufficient speed to lift it bodily from the ground and commence flight, the Wright machine is practically unable to perform this evolution on its long runners, and is almost invariably started by the aid of a rail (consisting of a 2-inch plank fixed vertically along the ground for a distance of about 100 feet), the body of the aeroplane resting on a small trolley which slides down this starting rail. As the end of the rail is reached, sufficient velocity has been attained to take the aeroplane off the ground (the engine, of course, running meanwhile); the machine rises from the trolley, the latter falling over almost immediately the machine is clear.

There does not appear to be a very great difference in the efficiency of the Wright and Voisin machines when comparing their weights, lifting power, and horsepower, for each has proved itself able of carrying at least one passenger of normal weight in addition to the pilot, and whatever engine is used in the Voisin machine is usually about double the horse-power employed



Framework of Short Biplane.

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Farman Machine Prior to Start.

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by the Wrights to drive their machine, which is very considerably the lighter of the two.

I believe I am near the mark when I say that the Wright design aims at lightness, speediness, handiness, and the ability to glide to the ground from any height should the motor miss fire and the engine stop, or should the aviator desire to "cut-off" at any time and glide to the ground. The acknowledged lack of longitudinal stability is counteracted by the aviator himself, and from all I have seen this can be accurately done, although it entails the almost unceasing working of the controlling levers and is, therefore, likely to prove somewhat tiring to the pilot.

On the other hand, the Voisin machine was undoubtedly designed to obtain as much automatic longitudinal stability as possible, and its steadiness in the air by comparison with the Wright machine is very noticeable, and consequently involves far less manipulation and hand control. I have been informed that the great defect of the Voisin and Farman aeroplanes (the Farman machine is described in the next chapter) is their inability to glide with perfect safety from any considerable height. Several of the leading aviators at Rheims informed me that these machines, with their tail-pieces giving longitudinal stability, can only glide down about 100 to 150 feet before they would attain a velocity which would cause them to follow an upward curve, and at so rapid an angle that in all probability the course would assume a loop and the machine would lose all sustaining power and fall backwards.

Whilst I am hardly prepared to argue the pros and cons of this contention, I believe there must be a good deal of truth in it, for my authorities were of the highest. I can only say, therefore, that the opinion they all expressed of Mr. Henry Farman when competing for the altitude prize and rising to a height of over 300 feet was that he performed a feat of extreme danger, and at all events was exhibiting extraordinary pluck, with the possibility of such an accident taking place as described above should his engine suddenly miss fire when he was at a great height from the ground.

FARMAN IN FLIGHT.

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THE FIRST CROSS-COUNTRY FLIGHT. FARMAN FLYING FROM ROMILLY TO RHEIMS.

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VIII

The Experiences and Trials of Esnault-Pelterie —The Evolution of the R. E. P. Machine

On January 26th, 1909, M. Robert Esnault-Pelterie, already famous as the inventor of the R. E. P. motor and well known to those interested in aeronautics as having made numerous tests since the year 1904 with gliding machines and aeroplanes, delivered a most interesting lecture at the Royal Automobile Club, London, to the members of that institution and of the Aero Club of the United Kingdom.

For nearly four hours he entertained his audience, first with a cursory history of the early gliding experiments of Lilienthal, Pilcher, Chanute, and others, and then with a similar résumé of his own work in this direction, accompanied by a series of splendid bioscope pictures, some of which are most exciting and gained enthusiastic applause.

I only wish that space would allow me to reproduce his lecture in full, as I have received his kind permission to make use of all or any part of the notes he used, but as this is impossible I will refer only to one or two points of his personal experiments which struck me as being particularly instructive.

Having studied the work of the pioneers above referred to, and all the available information relating to the gliders of the brothers Wright, he first constructed a machine somewhat similar to the latter, and with this apparatus carried out practical experiments from the side of a hill near Calais. Bad weather, however, prevented him from obtaining much in the way of satisfactory trials, so, as a means of obtaining an artificial draught to enable him to ascertain the lifting power of curved surfaces when moving through the air at different velocities, he utilised a motor-car, to the top of which he attached his glider by a rope so that it should act somewhat like a kite.

M. Pelterie, however, forgot one little detail of considerable importance to himself, and that was to establish any means of rapid communication between his glider on which he was perched and the chauffeur driving his motor-car. This omission nearly cost M. Pelterie his life, for, having satisfactorily risen in the air on one occasion, his shouted directions were not heard by the chauffeur, and the glider pitched head-foremost to the ground. To this day he is unable to explain how he escaped being fatally injured, but fortunately he did escape, and merely registered a vow that for the future he would abandon this particular form of investigation.

M. Pelterie was, however, still intent upon establishing fundamental data which he considered would be of great value, and while recognising that a glider towed by a motor-car was no safe place for his abode, he felt sure that he could acquire much useful information by rigging the apparatus in a different manner and taking observations of various results from the motor-car itself. He forthwith erected four uprights for the body of his motor-car, on the top of which rested an aeroplane surface so attached that its movements could be watched and recorded on instruments carried in the car itself. The car was driven at varying speeds at a rate which, I

M. Esenault-Pelterie's Early Experiment.

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believe, would be quite impossible in England with any regard either to the law or the safety of the public, but by this means a quantity of data was collected about the behaviour of planes of different shapes under varying conditions of speed. The little picture, which I am able through M. Pelterie's kindness to reproduce on the opposite page, shows this motor-car racing along a roadway with an aeroplane surface overhead just rising from the uprights.

Sundry mechanical devices such as elastics and weights attached to these planes enabled the investigator to determine the comparative lifting effects of differently shaped surfaces when travelling through the air at various speeds.

During his earlier experimental work M. Pelterie had discovered that wire offers resistance to the air when passing through it quite disproportionate to its thickness; to quote his own words, "a piece of wire as thick as the lead of a pencil seems to offer as much resistance as a solid piece of wood as thick as a man's arm." Though this is of course a rough and ready statement, it has been generally agreed by numerous experts that wire, presumably owing to vibration, does indeed offer resistance equal to that of a solid bar perhaps twenty times its thickness.

Being convinced that a biplane could only be constructed by the use of much wire between the two main surfaces, M. Pelterie early decided to abandon this design of flying machine for the monoplane or single surface apparatus, and decided that this would have to be built with wings of sufficient strength to be entirely self-supporting from the point of their attachment to the body of the machine. Having laid down these fundamental principles, he evolved the R. E. P. monoplane, the characteristics of which make it almost unique.

The following is a brief description of the main features of this aeroplane as described by M. Pelterie himself:

The propeller is in front; the rudders, both horizontal and vertical, are at the stern. Transverse equilibrium is maintained by twisting the rear part of the main planes. The longitudinal stability is maintained by means of an elastic adjustment on the stern fixing the point of the wing.

The motor is in the body of the machine behind the propeller, and the pilot sits in the body with his head appearing through and above the centre of the main planes. Under the body are two wheels like bicycle wheels, one fixed under the motor and the other on the stern, whilst a light wheel is attached to the outer extremes of the main plane.

Before leaving the ground the machine rests on these two central wheels and on one or other of the wing wheels. The propeller is started and as its speed increases the machine commences to move along the ground. By twisting the main planes transverse equilibrium is obtained, the aeroplane running like a bicycle evenly balanced on the two centre wheels. As the speed gradually increases it leaves the ground.

Once in the air the machine is controlled by a single lever which, when placed in different positions, acts upon various parts and thus causes general changes of direction or movement.

The principal part of the framework of this machine is made of steel, other materials used being aluminium and wood. Of necessity this aeroplane is heavy by comparison with the surface area of its wings.

The "R. E. P." in Flight.

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THE "R. E. P." AFTER AN ACCIDENT.

Face page 223.

Its dimensions are as follows:—Width from tip to tip of main plane 29 feet; length from propeller to rear horizontal plane 25 feet; surface of planes 150 square feet; total weight 946 pounds, which gives as a result an average weight of 6.4 pounds per square foot of lifting surface.

IX.

The Curtiss-Herring Biplane—Antoinette Machines—The Blériot Monoplane

In America pictures and descriptions of "The June Bug" and the Curtiss-Herring biplane have doubtless been published in large numbers, so residents in the United States are far more familiar with these two excellent aeroplanes than we in Europe.

Until the great Aviation Week at Rheims which has just ended I had no opportunity of seeing the Curtiss-Herring biplane, but was immediately attracted towards it by M. Latham telling me he felt sure Mr. Glenn Curtiss possessed a machine of extraordinary speed which would, he thought, defeat the Antoinette in the competition for the Gordon Bennett Aviation Cup.

The first point which struck me about this wonderful machine was its smallness; then I noticed that to a considerable extent its principles resembled those of the famous Wright machine, and lastly I was impressed with the beautiful workmanship and finish, which was apparent from stem to stern, and from tip to tip of the wings.

In the Wright machine the propellers are placed behind the main planes without any obstruction to the flow of air from the front excepting the struts and wires between the main planes. In the Curtiss machine, however, the single propeller is apparently shielded to a great extent by the motor, the radiator, and the body of the pilot. It is believed that, owing to the suction produced, the

THE "JUNE BUG," AMERICAN BIPLANE.

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THE CURTIS-HERRING BIPLANE. WINNER OF GORDON BENNETT AVIATION RACE AT RHEIMS.

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air directly behind these resisting parts moving with the machine gives the propeller increased thrust.

Rigged well out in front of the main planes is a front control somewhat similar to the Wrights', consisting of two double surfaces each 2 feet wide and 6 feet deep, pivoted horizontally and controlled by the pilot. Rigged out similarly in the rear and at about an equal distance from the centre of the machine is a horizontal surface 6 feet wide and 2 feet 3 inches deep, with a vertical rudder below it 2 feet deep and 3 feet 4 inches from front to back.

This rear horizontal plane does not, as we know, exist in the Wright machine, but it appears to me to possess the distinct advantage of giving increased longitudinal stability when travelling through the air, and so prevent the excessive pitching motion which is noticeable in the case of any Wright aeroplane when flying.

The main planes are not quite 29 feet wide, 4 feet 6 inches deep, and 4 feet 6 inches apart, their frame work being covered with "Baldwin" rubber-silk material. The total area of both planes is only 258 square feet, the machine when viewed by the side of a Voisin, Farman, or other biplane, looking almost like a big toy model.

The methods of control are more like those of the Voisin than the Wright machine. The pilot has before him a steering wheel like that of a motor-car, and by pushing this outwards or pulling it towards him the front controlling planes are deflected and the machine follows their direction upwards or downwards. The wheel is turned to the right or left to alter the direction of travel just as in a motor-car, and simultaneously with the turning of the vertical stern rudder the little ailerons, which are fixed midway between the main planes at their outer extremities, are tipped, one up and one down, which causes the machine to bank over in the same manner as the Wright machine assumes this position by flexing the outer ends of the upper main plane.

Unlike the Wright machine the speed of the motor is under the control of the pilot by means of foot pedals.

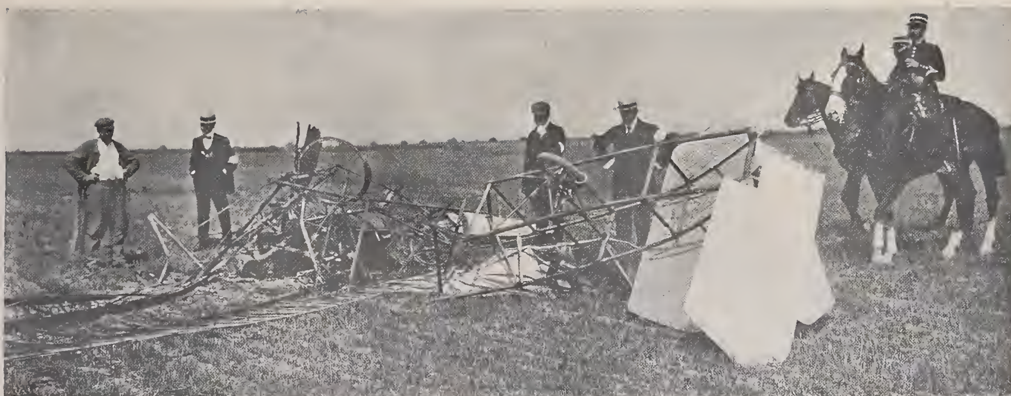
The motor, which weighs complete with radiator, magneto and pumps 192 pounds, is of the Herring-Curtiss type, and drives a wooden propeller 6 feet in diameter at 1300 revolutions per minute, developing 25 H. P.

The framework is principally Oregon spruce and bamboo, and the total weight of the whole machine, including Mr. Glenn Curtiss, is only 550 pounds. Assuming that his weight is 130 pounds, we may take it that the machine itself weighs 420 pounds. The total lifting surface is less than 300 square feet and so we see that this small machine has to lift less than two pounds per square foot of surface.

In addition to the extraordinary speed of 48 miles an hour which this biplane developed when making the 20 kilometre flight which enabled Mr. Curtiss to win the Gordon Bennett Cup, the machine is noticeable from the fact that it rises off the ground with an infinitely shorter run than any other type of aeroplane. This may doubtless be accounted for by its extreme lightness and the rapidity with which it gathers speed.

I will now give a brief description of a "Blériot" monoplane, and though this type of machine has undergone several slight changes since M. Louis Blériot, its designer and inventor, built "No. 1," I think if I select "No. XI," in which he made his historic flight across the Straits of Dover, it will serve to give a clear idea of the general principles of the majority.

The main carrying surface is formed by two wings



All That Was Left of Blériot's Monoplane, Burned at Rheims.

Face page 226.

BLÉRIOT'S CROSS-COUNTRY FLIGHT.

Face page 227.

fixed to a central longitudinal body, the framework of both wings and body consisting of ash and poplar covered on both sides with "Continental" fabric (much similar to the balloon fabric of this name described in an earlier chapter). The span of the main wings measures 25½ feet and their surface 150 square feet. At the rear of the body—only the front portion of which is covered with fabric—is the horizontal tail-plane 6 feet wide and 3 feet deep, with movable wing-tips on either side. When turning in the air the machine is made to "bank" over by warping the back edges of the main planes, on somewhat the same principle as the Wright warping. Behind the tail-piece is fixed a vertical rudder which is turned to the right or left by a pedal controlled by the pilot's foot. The length of the body fore and aft and including this vertical rudder is 26½ feet; the total sustaining surface is 168 square feet; the weight (including Mr. Blériot, and petrol for two hours) is 670 pounds. It will thus be seen that this monoplane supports about four pounds per square foot of surface. The motor, which is placed in the nose or the bow of the body, drives a tractor propeller which is coupled direct to the shaft right in front. Although various types of motors have been experimented with, M. Blériot seems to have given preference to a three-cylinder Anzani, which develops from 22 to 25 H. P. at 1500 revolutions per minute, and weighs 150 lbs. The propeller used on the occasion of the cross-Channel flight was two-bladed and made of wood, as designed by Lucien Chauvière, the blades being 6.85 feet from tip to tip.

The whole machine is mounted on a chassis which runs on two bicycle wheels, whilst beneath the tail another small supporting wheel is fitted.

The pilot sits in the body of his machine level with the back edge of the main planes and behind the motor. I should specially mention that the two wings or main planes can be detached from, or fitted to the body in a few minutes—an excellent feature of great practical utility when it may be desired to either transport the machine from one place to another, or to house in it a limited space.

The last machine of which I will attempt to give a brief description is the "Antoinette," made famous by a young aviator named Hubert Latham, who had only commenced the practice of flying a very little time ere his achievements brought him and the machine he used into great prominence.

The Antoinette monoplane is the design and invention of M. Levavasseur, a gentleman of somewhat corpulent and shaggy appearance, but genial to a degree, and ever ready to give advice or explain technical details to anyone interested in the science of mechanical flight.

By comparison with the tiny Blériot machine, the Antoinette is quite a "big bird," or rather, it should be described, I think, as resembling a dragon fly.

It has a long canoe-shaped body, the front part of which projects beyond the main plane and supports an 8-cylinder Antoinette motor, which drives a two-bladed aluminium propeller with steel strengthening strips running down the centre of each blade. The wings, which have a considerable curve from front to rear, measure about 42 feet from tip to tip, and the wooden framework of which they are composed is covered top and bottom by a varnished fabric. The front edge of the wings is about 4 inches deep, increasing gradually to the highest point, about one-third from the front, to

Blériot's Cross-Country Flight. Racing a Train.

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Fournier's Wrecked Biplane at Rheims.

Face page 229.

11 inches, whence it gradually reduces to about 1 inch along the back edge. The surface of these planes is approximately 324 square feet.

The pilot's seat, which resembles a comfortable office padded leather armchair with a semi-circular back, is placed in the body immediately behind the line of the main plane. At the stern of the body is fixed a horizontal tail-piece, behind which again is a movable horizontal plane or rudder, whilst above the rear horizontal plane is a triangular-shaped vertical plane, attached to the back of which is a triangular vertical rudder.

To the outer extreme of each main plane is attached at the rear a small hinged wing, or aileron, for maintaining lateral stability, and which work in conjunction, one up and one down, with the stern vertical rudder when the pilot desires to alter his course to the right or left. The radiators of the motor run lengthways along the outside of the body from the bow to just behind the pilot's seat on each side.

When on the ground the machine is supported on a chassis which has two strong bicycle wheels placed side by side, and a rigid skid or runner projecting forwards, to the end of which is attached a small solid wooden wheel. Underneath the outer extreme of each wing is fixed a wooden skid or runner to protect the wings should the machine land somewhat sideways and either wing tip run along the ground.

The above is a brief description of "Antoinette IV" in which M. Latham made his first attempt to cross the Channel. "Antoinette VII," in which the second attempt was made, differs from the other by having the rear part of the wings made to "flex" gradually from the centre outwards, one bending down as the other bends up and *vice versa*, by which contortion of the wings a similar effect is produced when turning from right to left horizontally as gained in the machine described above by the hinged ailerons.

M. Latham informed me that, if anything, he gave a slight preference to the flexing wings, and it was on a machine of this type that he made his longest flight at Rheims when he covered a distance of 96 miles.

A noticeable feature of the Antoinette machine is the apparent ease with which it is driven, for I have often seen M. Latham sailing steadily through the air as if running on railway lines, with neither hand touching the controlling wheels.

I should perhaps explain that on each side of his seat is placed a large wheel, the one on the left controlling the rear horizontal rudder; that on the right, in one machine controlling the ailerons, and in the other flexing the wings. The vertical stern rudder is moved to right or left by pressing the right or left pedal on which the pilot's feet rest, and which are connected to the rudder by wires running from a bar lever attached low down in the chassis.

X

Flying the Channel

In the year 1785 M. Blanchard and Dr. Jeffries performed the historical feat of travelling in a balloon from England to France across the Channel, as related in a former chapter.

In 1875 Captain Webb, who subsequently lost his life in the rapids of Niagara, succeeded in swimming across the Channel, a feat which has never since been successfully performed, though so many attempts have been made.

Just as was the case with balloons, it was only two or three years after the problem of human flight by mechanical means had been solved that M. Louis Blériot astonished the entire civilised world by his successful trip in the monoplane "Bleriot XI," on which he flew during the early morning of Sunday, July 25th, 1909, from the hamlet of Baraques, near Calais, to Northfall Meadow on the east side of Dover Castle.

A prize of £1000 had been offered by the proprietors of the English newspaper, *The Daily Mail,* for the first aviator to succeed in accomplishing this feat, and the young Frenchman, 26 years of age, M. Hubert Latham, who had suddenly leapt into fame by performing some extraordinary flights in an Antoinette aeroplane, was the first man to decide to try and win this prize.

A temporary shelter in the form of a gigantic tent was erected for his machine alongside the old Channel Tunnel Works at Sangatte on the French coast midway between Calais and Cape Blanc Nez.

After many days of weary waiting for a lull in the wind, which blows with persistence and considerable velocity along this part of the coast, M. Latham made his pioneer effort to fly across to England on Monday, 19th July, 1909.

From the deck of a Calais tug lying about four miles out to sea from Sangatte I watched him start from the ground through a telescope. Soaring to a considerable altitude over the land he circled round and came towards us, gradually attaining a height of not less than 900 feet above the water.

Looking in the distance like a great dragon-fly, he approached us with tremendous speed, and, passing high over our heads, appeared certain to reach the English shore within half an hour from the start.

Bad luck, however, dogged this plucky pioneer, for after he had travelled some seven or eight miles from Sangatte his motor suddenly stopped, through the breaking of a small piece of wire which worked its way into a vital part of the engine (as was subsequently discovered) and he was obliged to descend to the water by a series of long glides. His machine eventually took the sea with scarcely a splash noticeable, and floated on the surface like a great seagull with outstretched wings until we arrived near him in the tug.

His customary sang-froid had not deserted him for a moment, for he sat in the canoe-like body of his machine placidly smoking and waiting for a boat to be sent alongside to pick him up and take him on board. He did not, however, quit his aerial craft until he had securely fastened ropes to two of the strongest main parts of the machine, so that the latter could be taken in tow and held alongside the tug.

THE FIRST CROSS-CHANNEL ATTEMPT: LATHAM'S "ANTOINETTE" ALONGSIDE THE TUG.

Face page 232.

Thus ended the first attempt to fly the Channel, and although the result was unsuccessful it should always be remembered that Hubert Latham was the man who had sufficient pluck to lead the way in an enterprise which seemed as dangerous as it was novel, and who risked his life *on the assumption* that his machine would float, as it did, if through any mishap he was obliged to descend before reaching England's shores.

Immediately after this experience, M. Blériot forwarded his entry for the £1000 prize to the donors, and a day or two afterwards arrived with his tiny monoplane at Baraques.

Considering that he was suffering great pain and inconvenience from the fact of his left foot and ankle having been recently burnt by an explosion of petrol, M. Blériot showed determination and pluck which cannot be too highly praised in deciding at such a time to follow Latham's lead and attempt to fly the Channel. All the same, I can never forget that the supposed risk had greatly diminished by the fact of Latham's safe descent in mid-channel, and to the latter I personally shall always attribute a large portion of the honour and glory attaching to the first shore to shore flight.

On the Sunday morning above referred to I arrived at Baraques soon after 3 A. M. and found M. Leblanc, who is M. Blériot's principal aide and great friend, directing the mechanics in taking the aeroplane out of its shelter on to the large adjoining tract of land. Quickly and deftly the preliminaries were got through. M. Blériot hobbled after his machine on crutches, and, after watching the engine tested for a few moments, was lifted to his seat and promptly gave the word to let go. For several minutes he charmed the hundreds of spectators who had already assembled by flying round in two great circles, and then alighted as gently as a bird near the spot from which he had started.

"In ten minutes I start for England," he declared, and true to his word after a short interval he once more started the motor; the propeller revolved, the machine ran forward about a hundred yards, and then rose in the air.

For about half a mile he flew over the ground parallel to the coast line on the edge of which are a succession of sand hills some sixty feet high, and on the summit of one of these I had taken up a position with several friends. M. Blériot circled sharply towards the sea and passing almost above us at a height of perhaps 100 feet, he headed straight for Dover and flew away over the sea, frantically cheered by all spectators.

The sun was just rising behind us, but was not high enough to make the white cliffs of Dover show up as they did half an hour later, so that after keeping him in view through my glass for eleven minutes, until his machine appeared like a tiny bird in the far distant mist of the early morning, I lost sight of him, and then made a dash with others for a motor-car which quickly took me over the intervening three miles to Sangatte. Here, just beside M. Latham's tent, was a high pole temporarily erected for the purpose of sending and receiving messages by wireless telegraphy, the other station being at Dover. We knew that by this means we should obtain the first intelligence of M. Blériot's arrival in England should he succeed in getting there, and we had not long to wait before the news was flashed across that he had safely landed near Dover Castle.

I shall never forget the cheering which followed this announcement, or the beaming faces of M. Leblanc and

Blériot Leaving the French Coast for England.

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The First Lady to Fly in England: Mrs. Cody Ready to Fly with Her Husband.

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his mechanics, who naturally felt special personal pride at the success of their chief and his monoplane in thus achieving a feat which must mark an epoch in history to be handed down through succeeding generations for all time.

Meanwhile what of M. Latham? During the morning I had frequently turned my telescope from Baraques towards Sangatte, and was astonished that I could see no sign of life or movement at the latter place, but soon after my arrival there M. Latham himself appeared and told me how, through a friend's mistake, he had not been called in time to take advantage of the prevailing calm weather and make a start.

Though naturally suffering terrible disappointment at being thus robbed of a chance to be the first man across, like a good sportsman he joined in the cheering which greeted the news of his rival's success, and then at once desired that his machine might be prepared with all possible despatch, so that he might at all events try to emulate M. Blériot's performance as speedily as possible.

Further disappointment was, however, in store, for the mechanics took so long in making ready and in dragging the machine up the hill to the point most suitable for a start, that the wind, which had been steadily rising, was now blowing at a velocity of at least 25 miles per hour, and the directors of the Antoinette Company wisely and quite rightly refused their permission for M. Latham to attempt to start, anxious though he was to be allowed to do so.

Another favourable opportunity did not occur for two days, but after midnight on Monday I noticed the wind was gradually abating and considered that favourable conditions were likely to prevail before sunrise. Accordingly, acting upon a promise I had made to M. Latham, I started for Sangatte in a motor-car accompanied by friends, and arriving there at 3.30 A. M., quickly awoke most of the occupants of the little wooden hotel, and M. Latham's mechanics promptly began to make preparations for an early flight. At the last moment we woke the aviator himself, who lost no time in getting dressed and hurrying up the hill to see if all was ready. The aeroplane was not the same that had descended in the water the week before, this latter having been almost entirely destroyed by injudicious handling whilst being towed ashore at Calais. The new machine was of slightly different design, the wings being arranged for flexion and having no ailerons like the other one. With the idea of a preliminary trial to see how the new design worked, M. Latham made a circular flight over the land for a distance of about five miles, during which he rose to a height of approximately 600 feet. In coming to ground he was caught by a sudden side gust of wind which drove the head of his machine against some rising ground, bending the propeller blades, and doing some damage to the chassis. This mishap spelled delay for some hours, and it was not until six o'clock in the evening that all was ready for a fresh start.

This time I had obtained a passage on one of the French torpedo vessels which were told off to accompany the aviator on his journey, and were disposed across the Channel at intervals of two miles from Sangatte.

Through glasses we could see the white wings of the aeroplane on the hillside, and we were able to gauge the exact moment when it left the ground. After a short turn inland M. Latham came straight out to sea, and flying about 200 feet high passed the torpedo boats one

Latham's Second Cross-Channel Attempt. (From the French Destroyer "Escopette").

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after another with extraordinary speed, considering we had all headed for Dover and were travelling in that direction as hard as we could go at about 24 knots an hour. Flying as straight and as steadily as a train running on rails, as he passed our vessel he looked down on us and waved with both hands. It seemed certain that nothing could deprive him of success this time, but in flying as in other things the old adage—"There's many a slip 'twixt cup and lip"—applies very frequently.

When only about 1½ miles from Dover his engine stopped, and he was obliged to come down in the water without reaching his goal. One after another the French torpedo boats arrived on the scene and we saw M. Latham picked up by the steam pinnace of an English warship and thence transferred to the French destroyer, *Escopette,* which had led us in our chase across the Channel.

So practically ended the story of the three first efforts made within a week to fly across the Straits of Dover, and everyone who witnessed all or any of these extraordinary attempts is never likely to forget the circumstance or names of the two men who thus led the way in trying to achieve a feat which, five years ago, would have been considered merely a scheme or idea of a dreamer, if not of an absolute lunatic.

XI

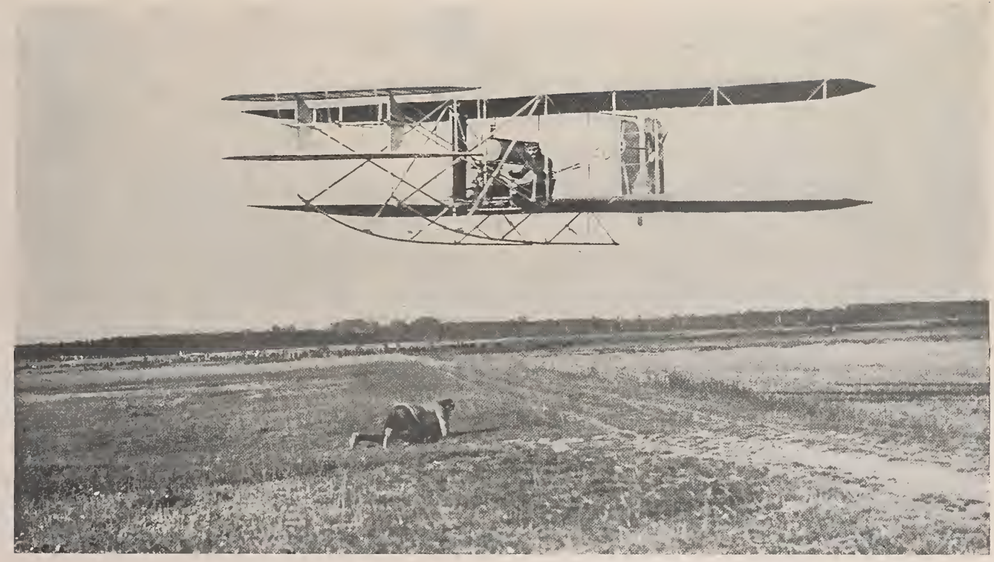
The First Aviation Meeting

I cannot close this little book without making reference to the great Rheims Aviation Week which was held on the plains of Betheny from August 22nd to 29th, 1909, and from which I have just returned to England.

No matter how often one has seen a single aeroplane flying through the air, the impression of nine machines mostly of totally different types passing before one simultaneously can never be forgotten, and will, I think, remain indelibly as a remarkable picture on the minds of all who witnessed this sight.

The most remarkable features of this remarkable week were, firstly, the series of manœuvres executed by M. Lefebvre on a Wright biplane in front of the grandstand just before dusk on the first day of the meeting. At this time he was not competing for any event, although he had just done an excellent three circuits of the track in the competition for the Prix de la Vitesse. Figures of three, figures of eight, upward dives and downward dives, a dash towards the stand when he passed over the heads of the numerous spectators in the enclosure, and then with a rapid turn flew out again over the open track, all performed with an ease and dexterity which took away one's breath and caused the thousands of people who were watching him to cheer and yell frantically in their delight at his extraordinary display.

Later in the week we saw for the first time what appeared to be a race between three machines. Going



Lefebvre Flying over a Spectator at Rheims.

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Aeronautical Exhibition in the Grand Palais, Paris, 1909.

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down the long stretch of the course to our left were two Farman biplanes flying practically neck and neck, but one somewhat higher than the other. Several hundred yards behind them, but flying infinitely higher, we suddenly noticed M. Latham in his Antoinette, the superior speed of which enabled him to overtake the other two just as they passed before the stands. With a downward swoop like a hawk chasing its prey he passed only a few feet above the biplanes, and then, using his horizontal rudder, quickly rose again to his former altitude and dashed ahead to make another circuit of the track.

On another occasion two airships, the "Colonel Renard" and "Godiac III," were manœuvring high in the air in front of the stands. Several aeroplanes in turn passed beneath them and then again came M. Latham travelling probably three times as fast as the dirigible balloons, but instead of passing below them as the others had done he darted in between the two great vessels and afforded a realistic idea of the possibilities of various types of aerial craft in the warfare of the future, much as depicted in the writings of Mr. H. G. Wells and by pictures in his book dealing with the subject.

I shall not attempt to describe further this Flying Week, for the newspapers have been full of the various doings, and I have no doubt that my young readers have read the accounts with considerable interest. Let it suffice for me to say that the ideas of future possibilities with airships and aeroplanes that I have attempted to express in earlier chapters have been greatly strengthened in my mind by all I saw at Betheny, and I consider it is only necessary for those who are sceptical on the subject of the conquest of the air, and its enormous bearing on the future of all civilised nations, to be present at a similar carnival in order to change their opinion entirely.

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