Blandford Colour Series

Balloons and Airships

Lennart Ege

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It is nearly two hundred years since man first left the ground and travelled through the air in a vehicle of his own design. His aerial carriage was only a frail, paper-covered craft with a burning brazier at its base to provide the hot air that raised it from the ground; but from such humble beginnings stemmed the inspiration that has since carried him out to worlds beyond his own.

After hot air came hydrogen as the lifting medium, and after the free balloon came the airship, which could be powered and steered in flight. In 80 well-chosen examples this volume illustrates two centuries of progress in lighter-than-air flight, from the Montgolfier brothers' original 'cloud in a paper bag' of 1783 to its present-day counterpart flown by sportsmen in many parts of the world.

In between lie the famous, the infamous and the almost unknown: great pioneer names like Lebaudy, Charles and Parseval; the giant Zeppelin airships that operated the world's first airline services in 1910–14 before their military brethren, those 'monsters of the purple twilight', rained terror on London in the First World War; the great Italian polar airships of the 1920s; the balloon bombs launched by Japan against the United States in World War 2; headline-makers like the Hindenburg and R 101; the unsung but highly successful blimps of the US Navy; and many more.

The illustrations are by Otto Frello and the book is edited by Kenneth Munson, author of the Pocket Encyclopaedia of Aircraft series.

The Pocket Encyclopaedia
of World Aircraft in Colour

BALLOONS AND AIRSHIPS

1783–1973

by
LENNART EGE

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from translation prepared by
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PREFACE

The 'World Aircraft in Color' series would be incomplete without a book dealing with balloons and airships. This latest title in the series is therefore essential to the series and deals with a fascinating subject.

Eighty different types of balloons and airships from 1783 up to the present day are illustrated and described in this book, which presents an authentic cavalcade of the development of balloons and airships down through the years. It is not claimed to be a comprehensive selection. Twice that number could easily have been included, but the author has endeavoured to present in part those balloons and airships which represent definite steps in the development of aeronautics generally and in part those which left their indelible impressions in that field. For the latter reason this book includes some LTA (Lighter-Than-Air) types that previous publications dealing with this subject have not described at great length. It should be obvious that a book on airships will to a great extent be dominated by two names which even today are synonymous with this type of aircraft: Zeppelin and Goodyear.

This selection has been made, and the text written, by the Danish aviation historian Lennart Ege; the color plates are the work of artist Otto Frello. The compilation of this book would have been a more difficult task if the Library of the Danish Air Force, headed by librarian S. Aa. Jeppesen and located in Værløse, had not made available its vast collection of rare volumes and series of old periodicals on this subject to both author and artist. We are also especially indebted to Mr C. Schönwälder, an engineer now residing in Copenhagen, who received his training on, and became a crew member of, the passenger airships *Viktoria Luise*, *Hansa* and *Sachsen* and the first German naval airships L 1, L 2 and L 3. He willingly contributed authoritative, first-hand observations and information on their appearance, equipment and fates. Further valuable assistance, both with regard to the selection of the aircraft to be dealt with

and in supplying data about them, was rendered by: Colonel Rougevin-Baville of the Musée de l'Air in Paris; Lieutenant-Commander W. J. Tuck at the Science Museum in London; managing director Diplom Kaufmann Peter Förster and library manager Dr Ernst H. Berninger, of the Deutsches Museum in Munich; assistant director E. W. Robischon at the National Air and Space Museum, Smithsonian Institution, Washington, D.C.; Lyle Schwilling, manager of Goodyear Aerospace Corporation, Akron, Ohio; curator Olav Wetting, of the Norwegian Technical Museum in Oslo; flight instructor Johannes Thinesen, Jakobsberg, Sweden; aviation historian Erik Hildesheim, Copenhagen, and Mrs Milly Ege, Espergærde, Denmark. The work of translation and revision necessary for the English edition was undertaken by Mr Erik Hildesheim, an experienced aviation engineer and aviator who has flown with balloons and airships, and who is well known as a writer in Europe and U.S.A. The editor of the English edition is Mr Kenneth Munson, a specialist writer on aircraft and the author of the other titles in this series.

BALLOONS AND AIRSHIPS

Throughout all periods of our civilisation, Man has concerned himself with leaving terra firma and rising into the air. Even thousands of years ago our ancestors, while roaming about wearily, would stop for a moment occasionally and glance skywards in contemplation of the birds who flew about unhindered and seemingly without effort.

There are innumerable tales and myths dealing with flying gods and human beings in various shapes. Best known is undoubtedly the classical legend from Greece which deals with the young Icarus, who escaped from imprisonment by means of wings, the feathers of which were fastened with wax. In his exuberant joy over his recovered freedom, Icarus climbed too high and the heat from the sun melted the wax in his wings, causing him to plunge to his death in the waters which until recent years were named the Icarian Sea. There are reports of a Chinese emperor, Shun, who more than four thousand years ago also escaped from his prison by fashioning himself a pair of bird's wings. A contemporary compatriot of his, Hik-Tse, became renowned primarily for his sky travels. Among the Canadian Cree Indians reports are spread of one of their tribe who flew in feather garbs. Even the Incas in Peru had their Ayar-Utso who sprouted bird's wings. In *A Thousand and One Nights*, one tale concerns a mechanical flying horse – certainly a variation of the well-known flying carpet! In our own latitudes there is the story about Wayland the Smith whose brother, Egil, procured him a 'flygil' (flight tunic) made from feathers procured from vultures. The Finns have their own unique Ilmarinen, who simply created a Fire Bird. In Denmark the thunder god Thor flashes across the sky in fierce competition with all sorts of winged wonders or monsters. Numerous generations have reported boom and uproar, smoke and steam, but nothing definite enough to fix as the date of Man's first, genuine flight. Yet all these visions are no more imaginary than the 'weightless' sky chariots that only a few years ago invaded our newspapers, radio and television sets as a

foretaste of the strange contraptions that will carry coming generations into outer space.

In our search for something of any substance, we came across a French source which tells of a missionary who once found, in archives in Peking, a report of the way the civilised nations of the east solved the problem of aerial navigation by means of balloons, centuries before the Europeans. And herewith we approach the substance of the problem: there never has been a true flying human being and there will never be one. Man is defeated by the fact that the weight of the human body is out of proportion to its muscular strength. However ingenious the flying machine schemes may be, they all have one defect in common: their lack of a mechanical power source. Down through the years many designs have been tried out. With some of these contraptions jumps have been made from roofs and towers; they usually ended disastrously.

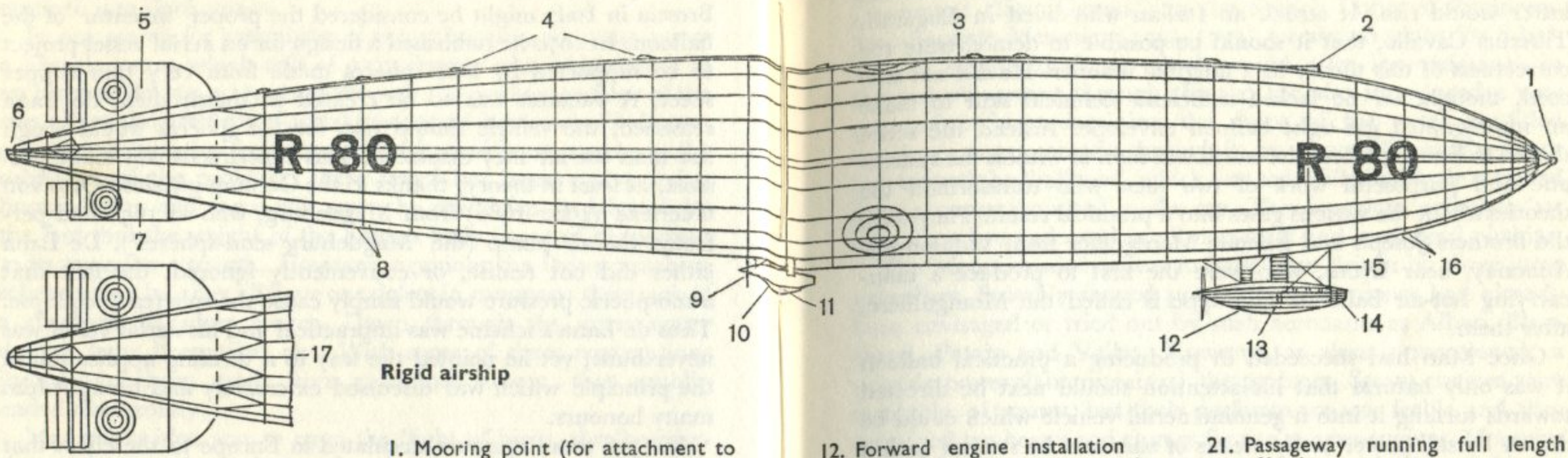
Man's first idea was to copy the flight of birds, the 'heavier-than-air' principle. It had to be abandoned for a while and at the beginning of the seventeenth century a new conception came about: air travel had to be tackled on the 'lighter-than-air' basis. The French author Jean-Savinien Cyrano de Bergerac (1619–1655) was one of the first to realise this possibility. Around 1650 he wrote some fiction novels about travels to the moon and the sun. This prophetic Frenchman worked out these trips by means of a girdle to which were fastened bottles filled with dew. As the sunbeams heated the bottles their content became lighter, so the wearer of the girdle climbed skywards. Adjustment of the altitude was very simple: one bottle – or more – was simply smashed. This method worked, in theory at least, because he was on the right track even though he failed fully to realise the scope of his idea: the finding of a substance lighter than air. For argument's sake he even mentioned some lightweight tanks that climbed when smoke was produced inside them. If the author had carried his thought a bit further, and had provided a hole in the bottom of his tanks, right then and there we should have had our first conception of the hot-air balloon.

The Italian scientist Galileo (1564–1642) had already proved, early in the seventeenth century, that air has weight. He first weighed some air-filled bottles, then the same ones again after the air had been evacuated from them.

The Jesuit Father Francesco de Lana-Terzi (1631–1687) from Brescia in Italy might be considered the proper 'inventor' of the balloon. In 1670 he published a design for an aerial vessel project to be supported by four spheres made from very thin copper sheet. A vacuum was to be created in them; then, de Lana reasoned, the vehicle should rise, for the spheres would weigh less than the air they displaced. This experiment was made possible, at least in theory, thanks to the German physicist Otto von Guericke (1602–1686) from Magdeburg, who in 1650 had perfected the air pump (the 'Magdeburg semi-spheres'). De Lana either did not realise, or conveniently ignored, the fact that atmospheric pressure would simply cause the spheres to collapse. Thus de Lana's scheme was impractical and his aerial vessel was never built; yet he pointed the way to a thrilling application of the principle which was discussed extensively and brought him many honours.

In 1736 some rumours circulated in Europe to the effect that a Brazilian clergyman, Father Bartolomeu de Gusmão, had ascended in an 'airship'. This was an exaggeration. Many years earlier, however, Gusmão had submitted his ideas on lighter-than-air flight to the Portuguese king, Johan V, who became enthusiastic and gave him financial support. After some unsuccessful experiments, Gusmão successfully demonstrated a model hot-air balloon before the Portuguese court on 8 August 1709 – the first demonstration of its kind in history. It involved a light wooden framework covered with paper below which a fire was kept burning. The later rumours referred to a more ambitious design called the Passarola (Great Bird), which is thought to have been a passenger-carrying nacelle intended to be raised aloft by a large hot-air balloon. There is no record that the Passarola ever flew, but there is a remarkable similarity between its carriage and that of a heavier-than-air convertiplane designed more than a century later by Sir George Cayley.

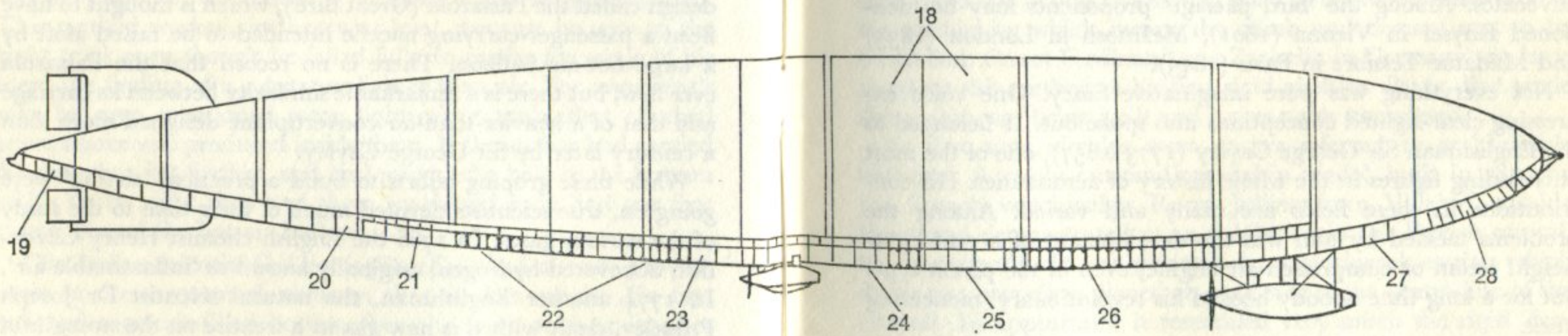
While these groping efforts to build a practical 'airship' were going on, true scientists devoted much of their time to the study of the various gases. In 1766 the English chemist Henry Cavendish discovered hydrogen, originally known as 'inflammable air'. In 1774 another Englishman, the natural scientist Dr Joseph Priestley, dealt with this new gas in a treatise on the strength of which Dr Joseph Black (1728–1799) in Edinburgh conceived the



Rigid airship

ANATOMY OF THE AIRSHIP

1. Mooring point (for attachment to mooring mast)
2. Gunner's platform with speaking tube to keel
3. Exterior catwalk
4. Valves
5. Upper fixed tail fin with rudder
6. Tail gunner/observer's seat
7. Lower fixed tail fin with rudder
8. Water ballast release
9. Propeller on rear engine car
10. Silencer
11. Combined buffer and flotation bag
12. Forward engine installation
13. Door and platform for parachute jumper
14. Bridge
15. Stairway to airship hull
16. Water ballast release
17. Plan view showing fixed horizontal tail surfaces and elevators
18. Gas cells (total of 15)
19. Connecting passageway from keel to rear observer/gunner's position
20. Water ballast (for emergency release)
21. Passageway running full length of keel
22. Fuel tanks
23. Water ballast for use in manoeuvring the airship
24. Crew accommodation
25. Officers' mess and cabins
26. Water ballast for use in manoeuvring the airship
27. Water ballast (for emergency release)
28. Passageway for entry from mooring mast to all sections of airship



idea that when confined within a sufficiently light cover the latter would rise. It struck an Italian who lived in England, Tiberius Cavallo, that it should be possible to demonstrate the correctness of this theory in a tangible manner. He did not succeed, though, for he lacked sufficient technical skill to make an impregnated gas-tight balloon envelope. Instead the scene shifted to France, where the world was soon to witness the systematic and purposeful work of two men who transformed the theories about the various gases into a practical result. They were the brothers Joseph and Étienne Montgolfier from Vidalon-les-Annonay, near Lyons, who were the first to produce a man-carrying hot-air balloon. This type is called the Montgolfière, after them.

Once Man had succeeded in producing a practical balloon it was only natural that his attention should next be directed towards turning it into a genuine aerial vehicle which could be driven by sail power or by means of oars and be steered with a rudder. It was soon realised that, to render a balloon dirigible (steerable) at all, it must advance at a higher speed than the air surrounding it. No suitable means of propulsion being available, the last years of the eighteenth century brought forward a great number of weird propositions. They comprised schemes employing airscrews or complete driving wheels operated by brawny men or even by horses. Other suggested means of propulsion included hot-air or steam jet propulsion. Even the idea of employing trained birds as draught animals was advanced in all seriousness. Here eagles were the first choice, but even pigeons had their advocates. Among the 'bird passage' proponents may be mentioned Kayser in Vienna (1801), McIntosh in London (1835) and Madame Tessiore in Paris (1845).

Not everything was pure imaginative fancy. One voice expressing clear-sighted conceptions also spoke out. It belonged to the Englishman Sir George Cayley (1773–1857), one of the most outstanding figures in the whole history of aeronautics. His contributions in these fields are many and varied. Among the problems tackled by him was the development of a real lightweight steam or compressed-air engine, even of the piston type. But for a long time nobody heeded his revolutionary, pioneering work.

Though Cayley remained the ignored 'lonely swallow',

common sense soon began to prevail, and as early as 1784 a Lieutenant (later General) in the French Corps of Engineers, Jean-Baptiste Meusnier (1754–1793), presented plans for a balloon of elongated shape which would offer less resistance in forward movement through the air. He also introduced a new conception for maintaining the shape of the outer gas-filled envelope, as gas escaped through it, by means of a smaller inner bag termed the 'ballonet', which was to be filled with air supplied from a pump mounted in the car. This ingenious principle has ever since been adopted in all non-rigid and semi-rigid airships.

The Meusnier airship was to have been driven by three large propellers. Suitably shaped propellers or airscrews had already been envisaged or tried out by such aeronauts as Alban, Blanchard, Potain and Vallet. However, as already mentioned, a suitable powerplant remained the problem. Steam engines were available, of course, but their performance was feeble and they remained too heavy and clumsy for use as aero-engines. Meusnier calculated that 80 men should be needed to drive his airship by hand at the necessary speed to render the rudder effective. This would mean an airship of such large size as to make it impractical. Yet Meusnier will be remembered forever as the one who really conceived the successful dirigible airship form.

The first serious attempt to build a dirigible airship was made by two Swiss, John Pauly and Durs Egg, living in England. In 1816–17 these two men produced an airship with an envelope of dolphin shape, made from gold-beater's skin and provided with a ballonet. One interesting detail of their airship layout was a sand-filled box acting as a sliding scale in the longitudinal axis of the airship by which means the climb and descent was to be controlled. Count Ferdinand von Zeppelin in Germany was later to adopt this method in his first rigid airships. Pauly died while the airship was being built and it was never completed.

At that time airships were always referred to as 'dirigible balloons'. A really outstanding airship model, built in 1850 by the French watchmaker Pierre Jullien from Villejuif, outside Paris, and demonstrated at an exhibition in the French capital, flew excellently. It was powered by a clockwork engine which drove two propellers placed on each side of the centre-line of the aircraft. In appearance it resembled very much the rigid Zeppelin airship of fifty years later. A full-size Jullien airship was

said to have been built in 1852, but if so its power-plant and fate are unknown. However, the results achieved with the Jullien airship model proved an inspiration to the French engineer Henri Giffard, who did succeed in producing a small and light steam engine and thereby truly inaugurated the airship era.

The varied story of the development of the balloon and the airship, with its abundant triumphs and failures, is told in the type descriptions in the text that follow and is also illustrated in the colour plates. It becomes evident that no balloon ascent was ever a routine matter, nor ever will be. And every time an airship climbs skywards, be it in times of war or peace, the reigning atmosphere on board is akin to that of the pioneering days.

The balloon has not become an anachronism; indeed it is still 'going strong' today. At first, balloons were used as an exhibition stunt at public displays. Later, they served scientists as research vehicles; were employed as instruments of war; and, more happily, have become the attractive mounts of keen sportsmen. By an odd chain of development ballooning, which began with the hot-air type, has now traversed the full circle until today a modern version of the same type is used alongside the gas-filled variety.

The future course of the airship is slightly more complicated to plot. Admittedly, small non-rigid airships, mainly of Goodyear manufacture, are still to be seen used for advertising in the skies of Europe and America; and as recently as March 1972 a 192·5 ft (58·7m) long Goodyear advertising and TV airship named *Europa* was built in the historical Cardington airship shed in Bedfordshire. However, no really large passenger airship of the rigid type has now been built for more than thirty years. It is also a fact that the term 'Zeppelin' has become synonymous with the concept of all large airships, and from as long ago as World War I some still associate these giant air monsters with a new and terrible form of warfare or with massive disasters. If large airships are ever to stage a comeback—and they still have their advocates as well as their antagonists—it will most likely be as pure cargo carriers.

Some of the present advocates of airship revival include voices from out of the past, so to speak. They number, among others, the former American airship commander, Admiral Charles E.

Rosendahl, and Captain Max Pruss, the last master of LZ 129 *Hindenburg*. The last moving spirit of the Zeppelin yards, Dr Hugo Eckener (who died in 1954 at the age of 86) was, on the other hand, somewhat less optimistic. But at Goodyear there are still leading officials with implicit faith in large passenger-carrying airships. Yet they all realise that if the airship is to compete with the modern jet airliner at all it will be on the score of the convenience that the former offers. In this hurried age of fast air travel there still are people left who prefer restful travel at a more leisurely pace.

It is principally circles in Great Britain and Russia that now propose the revival of airship travel. The Soviet Union has always needed to transport large quantities of cargo over great distances. In both countries much has been written, and discussions have been held, of both the advantages and disadvantages of cargo airships. The belief is that they must be able to carry useful loads of between 500 and 1,000 tons if there is to be any justification for them at all.

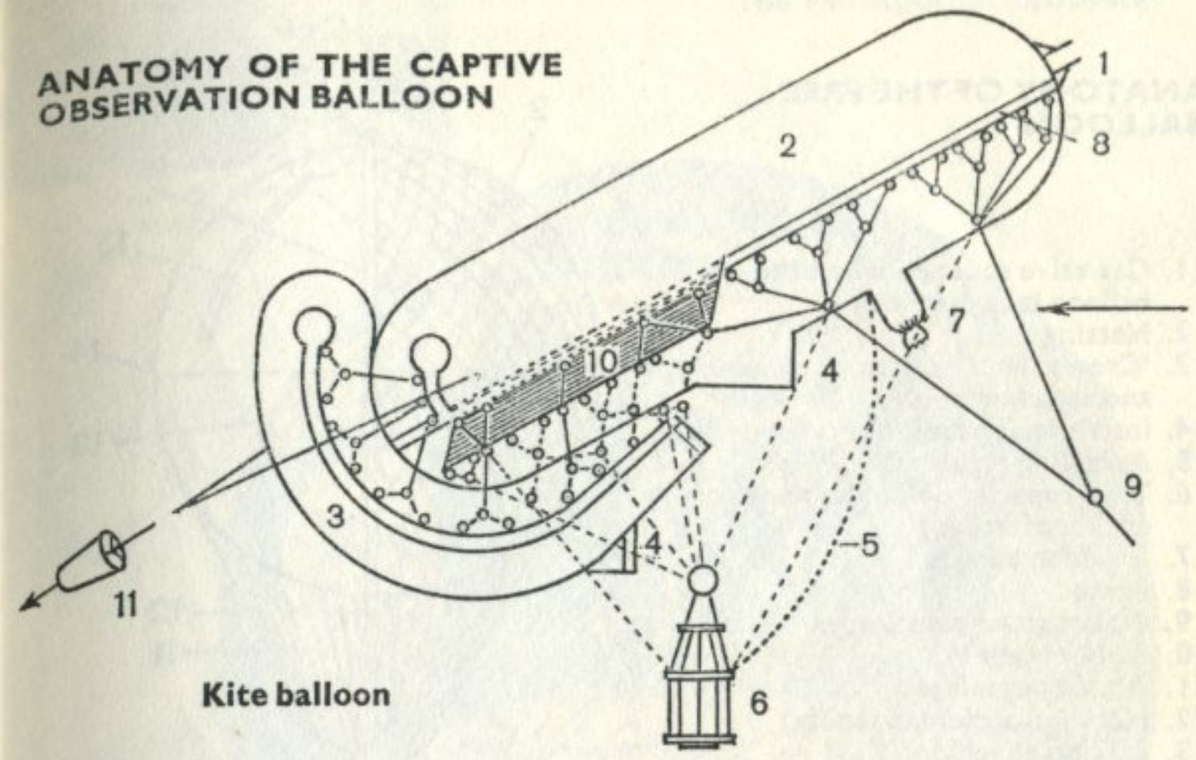
The advantages of the modern airship may be listed as follows: its frame can today be made of plastics materials, and the gas cells will be filled with helium. Today this element is available in much larger quantities than formerly; and, what is still more important, is now available outside the United States, which no longer enjoys a monopoly of the gas. Conventional petrol and diesel engines or atomic power could be used as powerplants, when coupled to electric generators that provide the current for the electric motors which drive the propellers, they would have a lower noise level. Because only very low starting and landing speeds are involved, air contamination is also held to a minimum. These qualities, combined with an almost limitless flight duration, likewise spell increased safety. Finally, now that passengers, if carried, will travel for pleasure and sightseeing at low levels, they can enjoy comfort to a degree hitherto unknown and unavailable in heavier-than-air craft. Such vessels will move about with unrestricted ease, at greater safety, throughout their air voyage.

To deal with the unavoidable drawbacks as well (which can never be entirely eliminated from passenger accommodation or cargo facilities), it must be pointed out that the modern airship must necessarily be of large dimensions; lengths of about 1,475 ft

(450 m) have been mentioned. A giant hull of that nature is not meant for high altitude flying, and hence will be exposed to the unstable weather conditions in the lower regions, such as strong headwinds and ice formation. This in turn influences the question of economical service which, above all, remains the deciding factor. Thus the experts at present must investigate whether it is cheaper overall to transport heavy and bulky stores in airships rather than in surface vessels or aeroplanes. Optimistic calculations favour the airship, but something else must also be considered – and that is whether it will prove a paying proposition to develop and build new airships unless they can be turned out in substantial numbers. Both the advocates and the adversaries of the airship have advanced long rows of dry figures and financial calculations in support of their points of view. Their findings really fall beyond the scope of this book, but may be studied in trade journals and technical volumes.

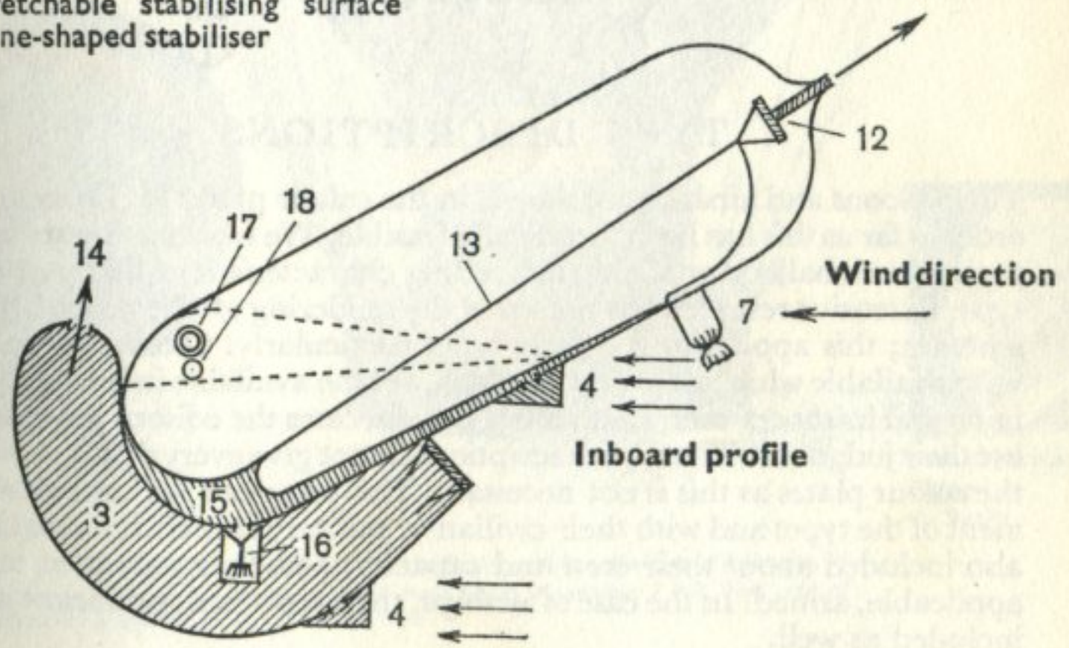
One point is not in dispute. It would be a great pity if people of today should be deprived of the magnificent sight which impressed former generations so much: to witness one of the 'Queens of the Sky' soar by across cities and countryside, unperturbed by noisy and smoke-trailing jet aeroplanes hurrying by. Let us hope also that the hitherto unhappy associations of the word 'Zeppelin' may also disappear along with that terminology.

ANATOMY OF THE CAPTIVE OBSERVATION BALLOON



Kite balloon

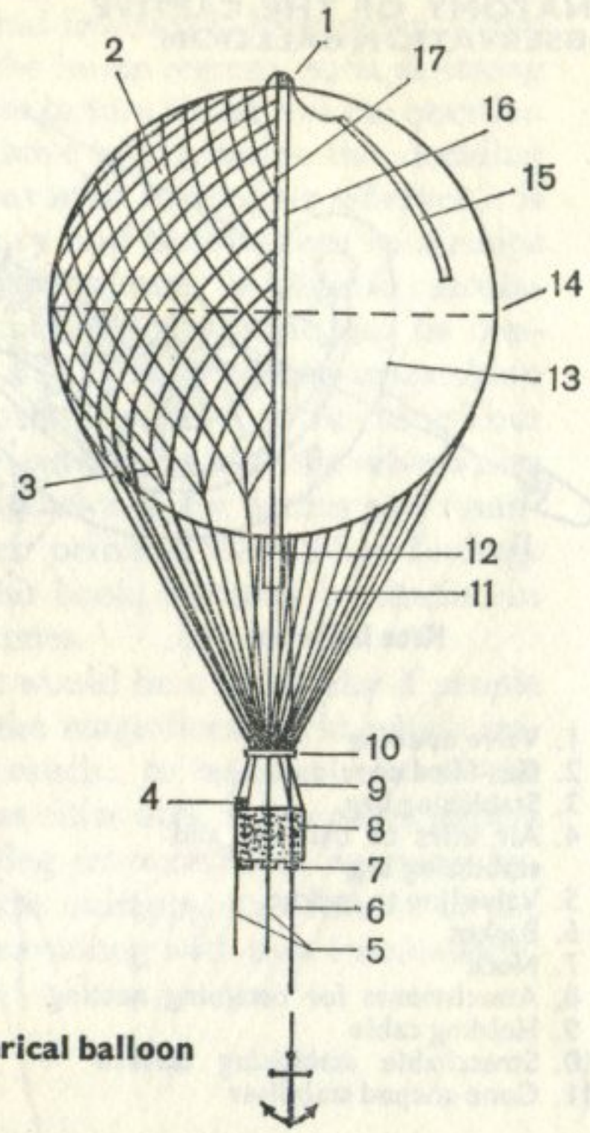
1. Valve opening
2. Gas-filled envelope
3. Stabilising bag
4. Air inlet to ballonet and stabilising bag
5. Valve line to basket
6. Basket
7. Neck
8. Attachments for retaining netting
9. Holding cable
10. Stretchable stabilising surface
11. Cone-shaped stabiliser
12. Main valve
13. Valve line inside balloon envelope: when pulled, gas is discharged
14. Ballonet outlet opening
15. Air-filled ballonet
16. Air passageway to stabilising bag
17. Gas outlet opening
18. Air outlet opening



Inboard profile

ANATOMY OF THE FREE BALLOON

1. Gas valve (opened when the balloon is to descend)
2. Netting
3. 'Crows feet' junction of netting and attachment lines
4. Instrument panel
5. Arresting ropes
6. Trail-rope (in olden days with an anchor attached)
7. Wooden boards
8. Basket
9. Basket attachment ropes
10. Basket hoop
11. Attachment lines
12. Neck gas outlet (appendix)
13. Balloon envelope
14. Equator (diameter) of spherical balloon
15. Ripping panel
16. Attached line for pulling away ripping panel
17. Line pulled to open gas valve on top of balloon envelope



Spherical balloon

TYPE DESCRIPTIONS

The balloons and airships are shown in the colour plates in chronological order as far as this has been technically feasible. We have further striven to present each balloon or airship in a setting characteristic of that particular type. Extensive research has preceded the rendering of the various colour schemes; this applies to the early types particularly. Often, few sources were available which date that far back, yet the available information has in several instances been conflicting. In such cases the editors have had to use their judgment. The type descriptions do not give every detail shown in the colour plates as this is not necessary. The text deals with the development of the types and with their civilian or military career. Information is also included about their crew and capacity, how they were used and, if applicable, armed. In the case of airships, their technical specifications are included as well.

Joseph and Étienne Montgolfier

Jean-François Pilâtre de Rozier

1 The world's first aeronauts, Pilâtre de Rozier and the Marquis d'Arlandes, in their ascent from La Muette outside Paris on 21 November 1783. This type of balloon is referred to as a 'Montgolfière'.

Left: The hot-air balloon of the Montgolfier brothers carried the first air passengers (a sheep, a duck and a cock) in a basket.

2 Jacques Alexandre Charles and Marie-Noël Robert make the second manned balloon ascent, from the Tuileries Gardens in Paris, on 2 December 1783 and (*below*) land near Nesles. The balloon was filled with hydrogen; this type is called a 'Charlière' after its inventor.

Jacques Alexandre César Charles

3 Lunardi's second balloon ascends from the Moorfields parade ground on the northern outskirts of London on 13 May 1785.

Left: Lunardi's first balloon.

Vincenzo Lunardi

Blanchard and Jeffries

Jean-Pierre Blanchard

John Jeffries

4 Blanchard and Dr Jeffries make the first successful, though dangerous, air crossing of the English Channel from Dover to Calais on 7 January 1785.

de Rozier and Romain

5 Pilâtre de Rozier and Pierre Romain take off on their fatal first attempt to cross the English Channel by air from Boulogne-sur-Mer on 15 June 1785. They became the first to lose their lives by this means of travelling through the air. *Right:* Their combined hot-air and hydrogen balloon catches fire and plunges to the ground.

L'Entreprenant

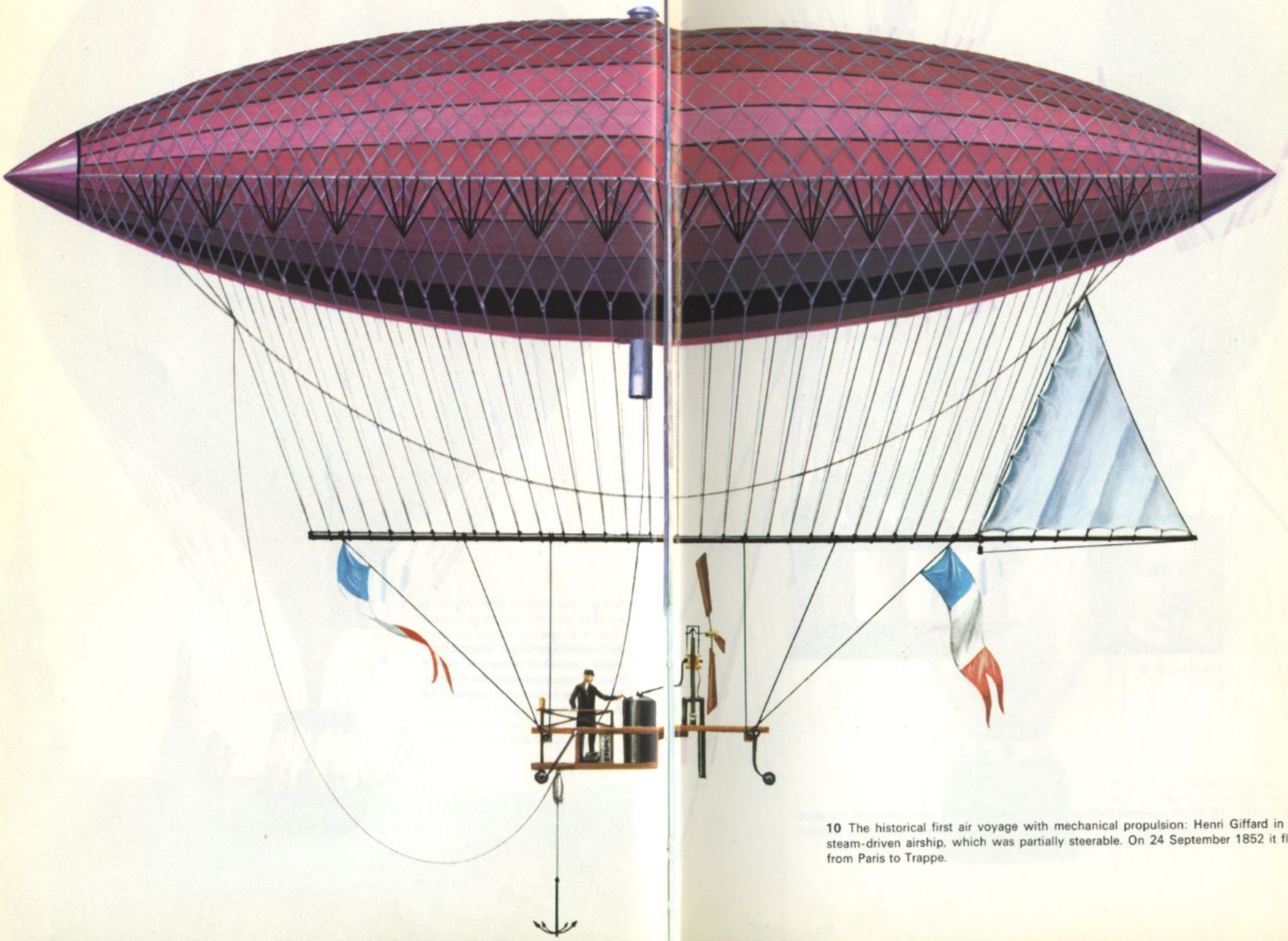
6 The balloon *L'Entreprenant* became the first aerial reconnaissance vehicle on record. It was sent aloft as a captive balloon observation post during the battle at Fleurus on 26 June 1794. The balloon basket was manned by Captain Jean Marie Joseph Coutelle, C.O. of the French Army Balloon Corps, and General Moriot as observer.

Garnerin

7 André Jacques Garnerin ascends by balloon with his parachute attached which he releases to descend in the car. *Above:* one of the unmanned balloons that Garnerin released on the occasion of the coronation of Napoleon Bonaparte in the cathedral of Notre Dame in Paris on 2 December 1804.

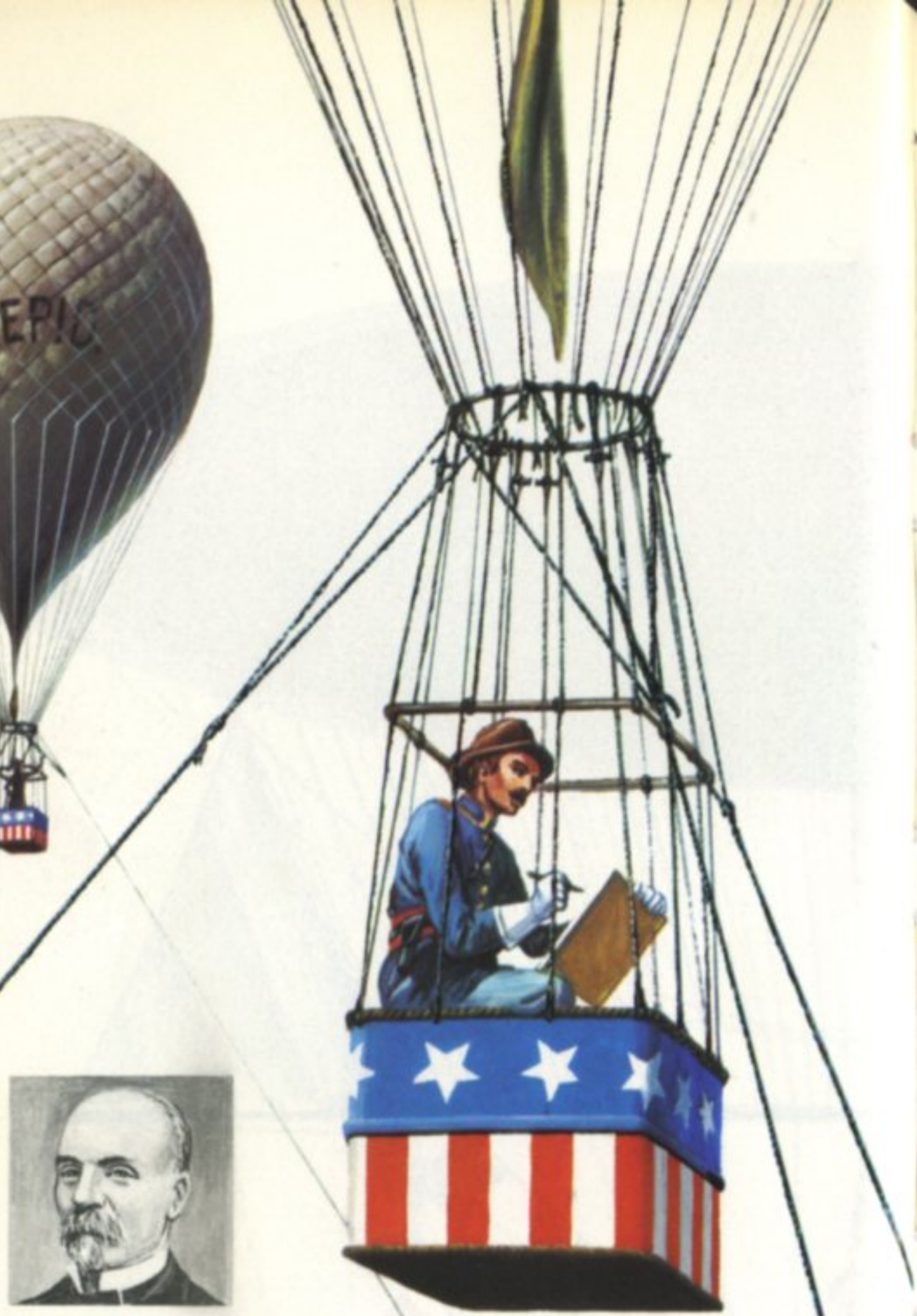
8 Johan Peter Colding was the first Danish aeronaut. Here he ascends from the parade ground of Rosenborg castle in Copenhagen on 10 November 1811. By royal command, in 1808 Colding experimented with air mail, sending letters to King Frederick VI by unmanned balloons between the islands of Funen and Zealand across the Great Belt.

9 Charles Green's gas-filled balloon *Royal Vauxhall* (later re-named *Nassau*) made a renowned trip from London to Nassau in Germany on 7-8 November 1836.



10 The historical first air voyage with mechanical propulsion: Henri Giffard in his steam-driven airship, which was partially steerable. On 24 September 1852 it flew from Paris to Trappe.

Lowe



Thaddeus S. C. Lowe

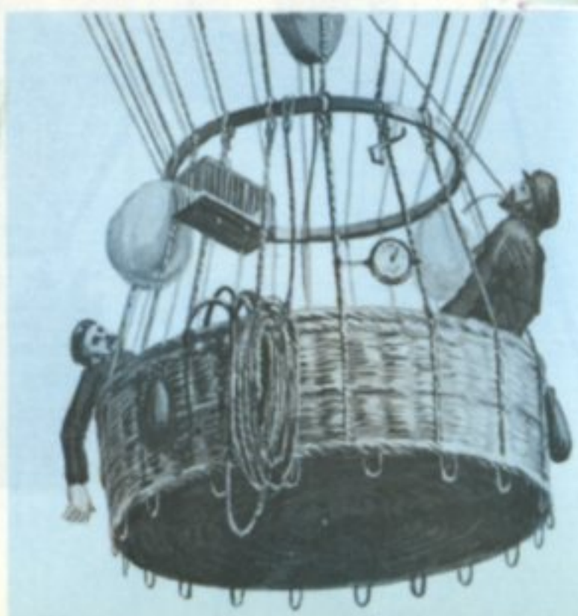
11 Lowe's captive balloon *Intrepid* making aerial observations in the skies above Maryland on 8 December 1861. The observer in the car is Colonel W. F. Small of the Federal Armies, sketching the enemy positions.

Le Géant

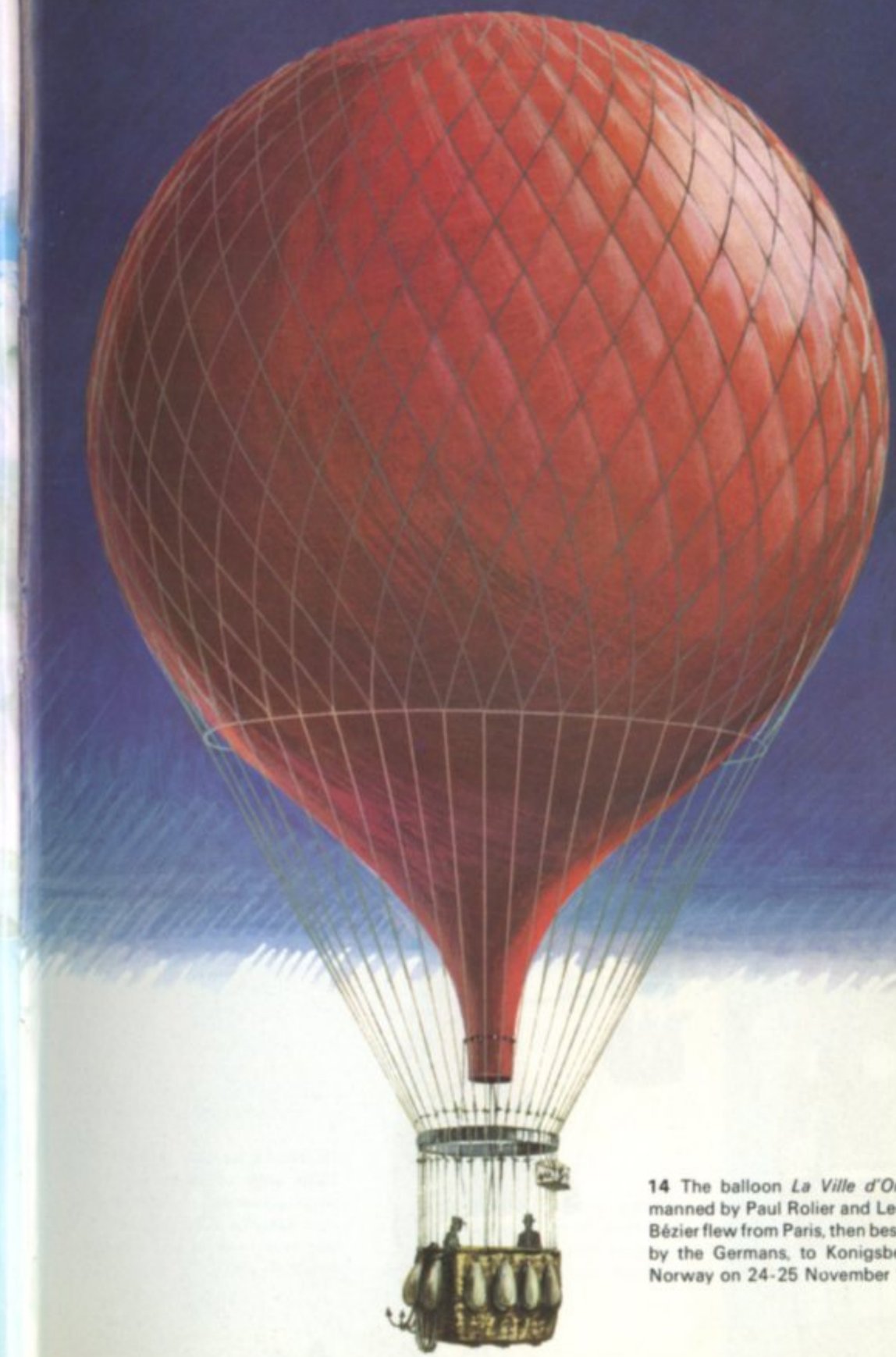
12 The huge balloon *Le Géant* of 1863. It belonged to the French photographer Nadar, whose real name was Gaspard Félix Tournachon.

Coxwell

13 Henry Tracy Coxwell's balloon *Sylph* of 1848. *Below:* Coxwell's and Glaisher's near-disaster during an altitude ascent with the balloon *Mammoth* on 5 September 1862.



La Ville d'Orléans



14 The balloon *La Ville d'Orléans* manned by Paul Rolier and Leonard Bézier flew from Paris, then besieged by the Germans, to Konigsberg in Norway on 24-25 November 1870.

Wise

John Wise

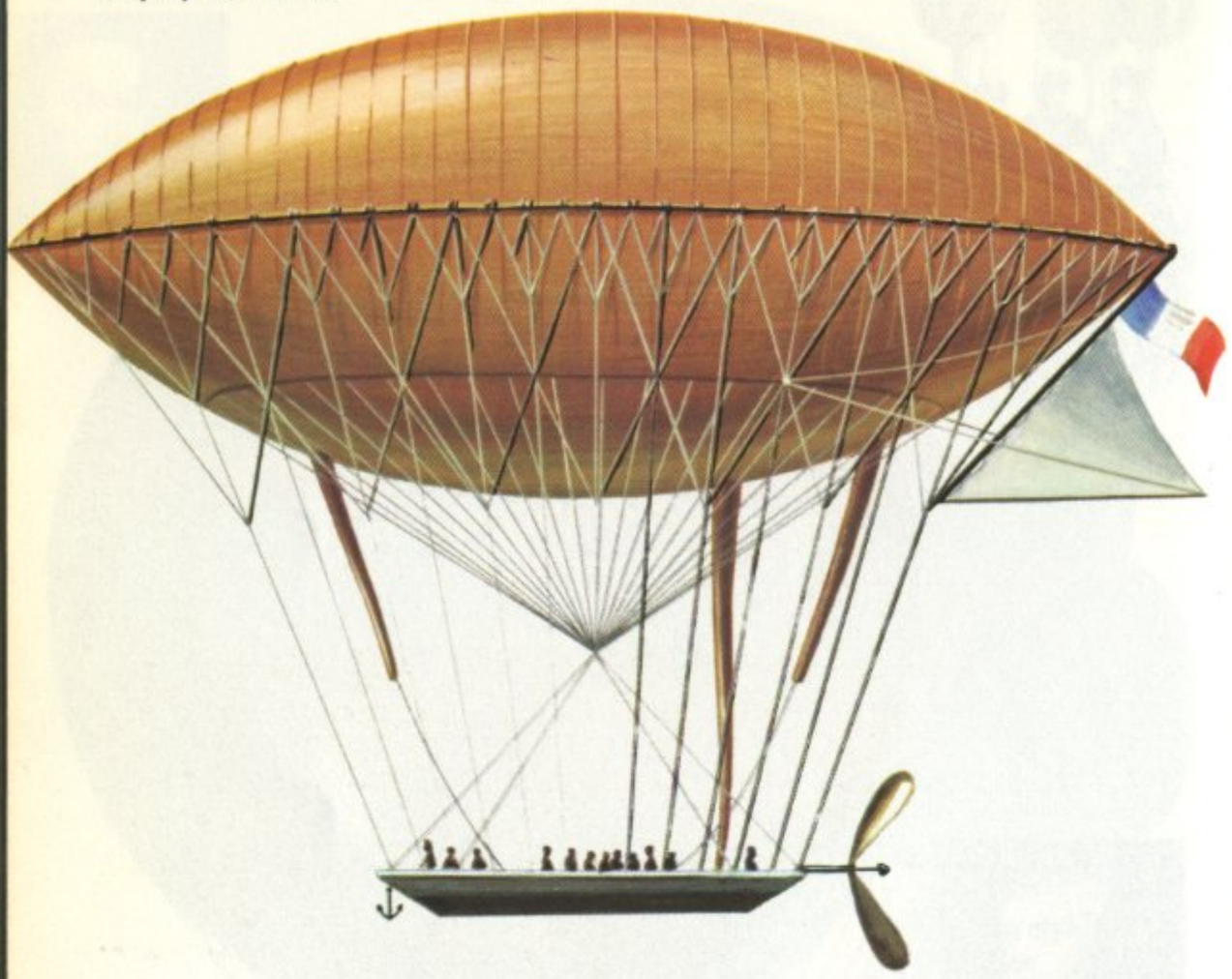
15 Wise's balloon *Atlantic* of 1859, with which he planned an aerial crossing of the Atlantic from America to Europe. *Left:* A sectional view of the cleverly designed car.

Tissandier

Gaston Tissandier

16 Tissandier's balloon *Zénith* before and after the disaster on 15 April 1875. In the basket, below the three bags filled with oxygen, are Tissandier, Crocé-Spinelli and Sivel, of whom the last two lost their lives from lack of oxygen.

Dupuy de Lôme

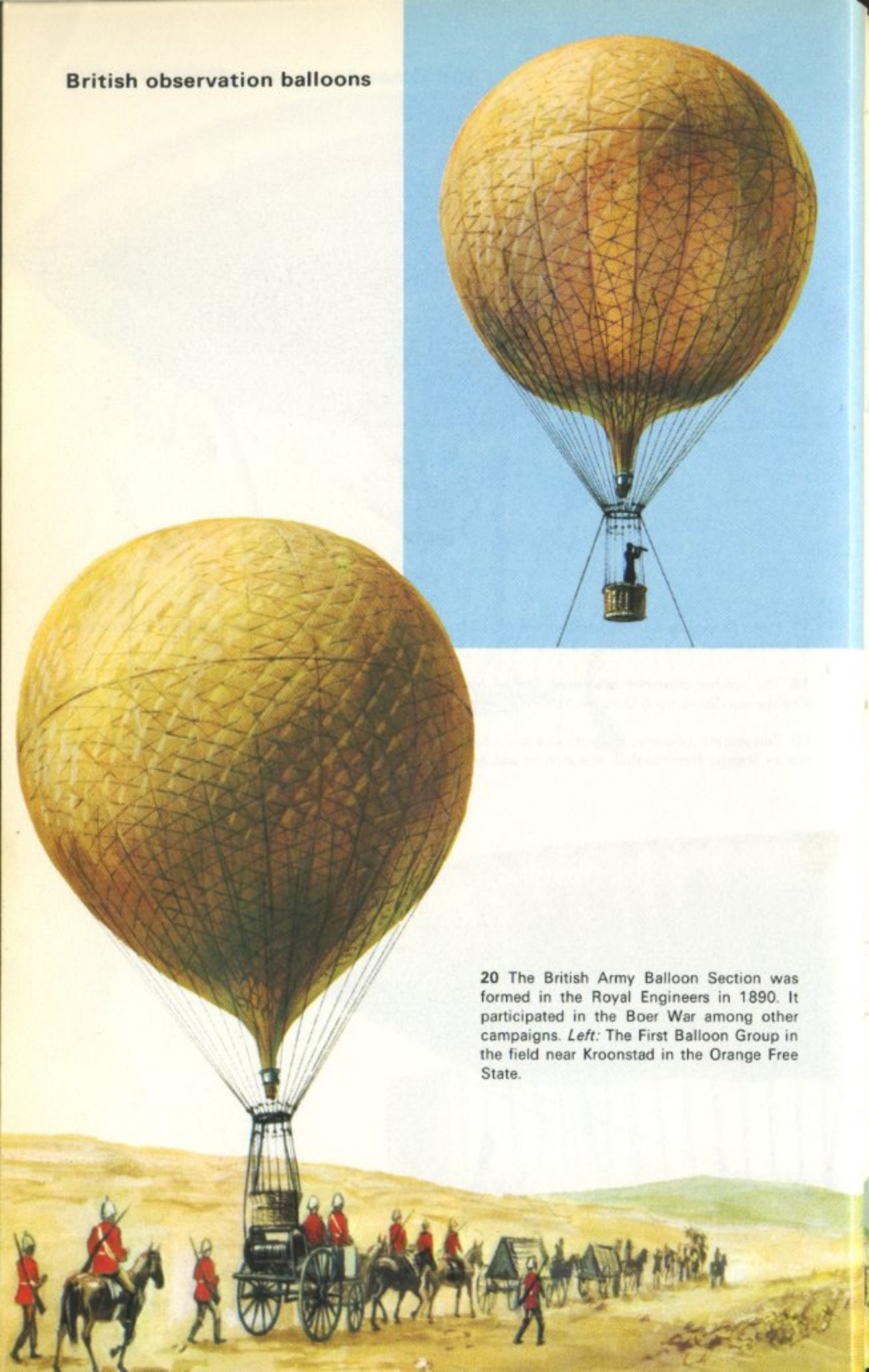


The Tissandier brothers and La France

17 Henri Dupuy de Lôme's hand-driven dirigible airship during its trial trip from Fort Neuf in Vincennes to Mondécourt on 2 February 1872.

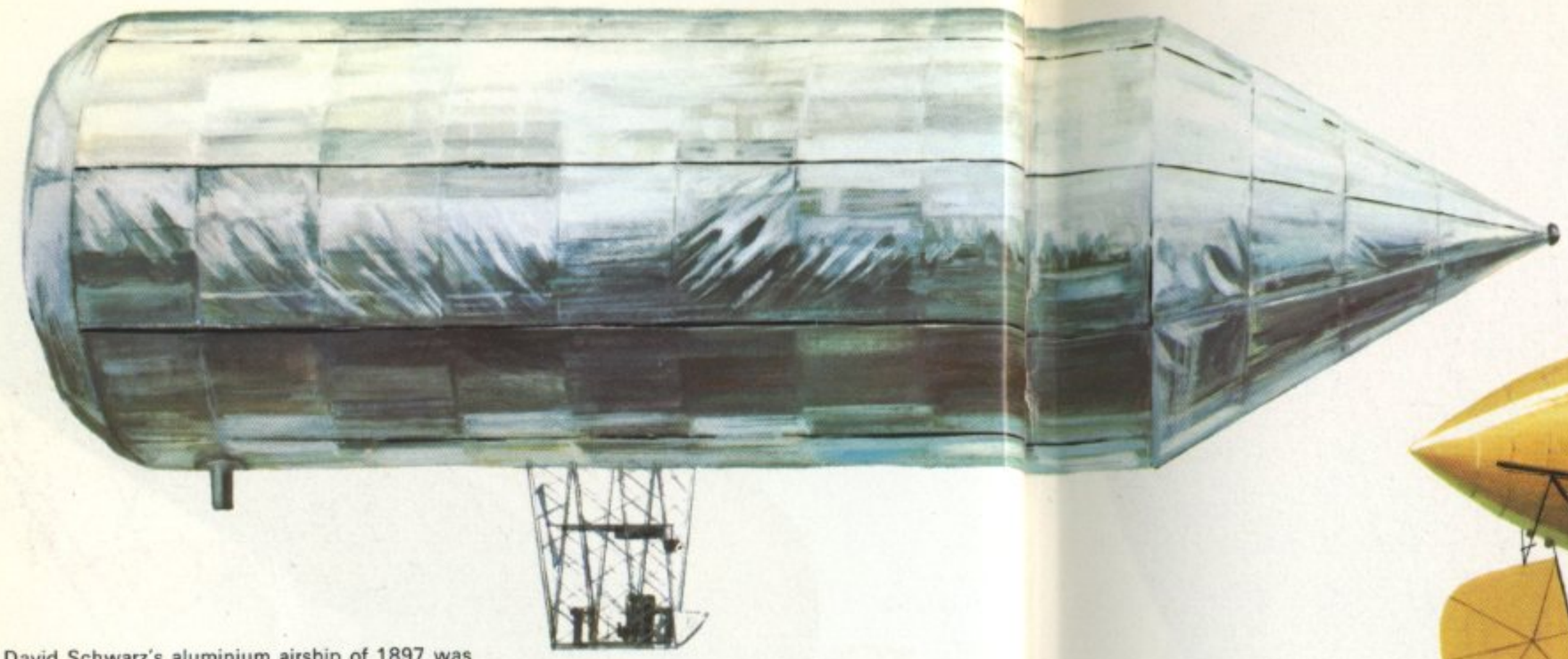
18 The electric-powered airship of Gaston and Albert Tissandier during its trial flight from Auteuil to Croissy-sur-Seine on 8 October 1883.

19 The electric-powered dirigible airship *La France* designed by Charles Renard and Arthur Krebs during the air voyage from Chalais-Meudon to and across Paris on 23 September 1885.

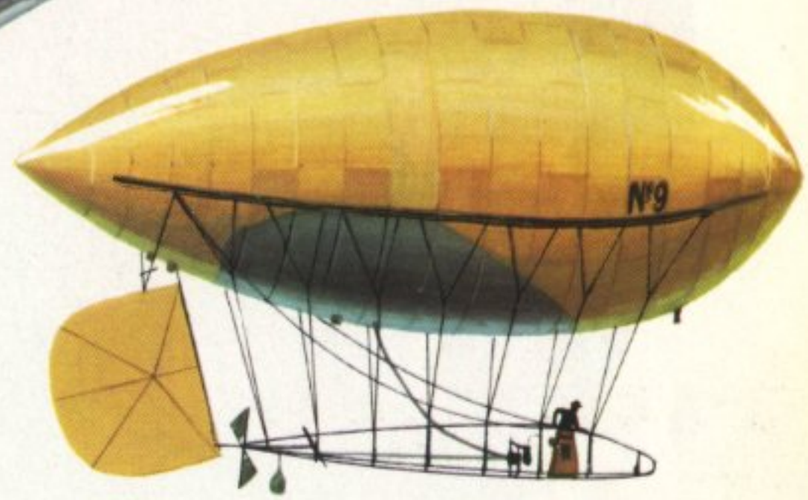


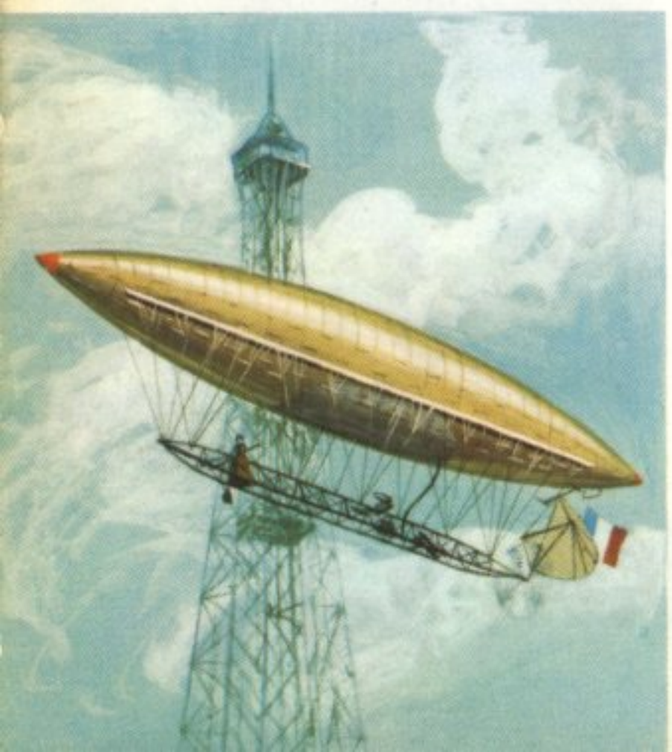
20 The British Army Balloon Section was formed in the Royal Engineers in 1890. It participated in the Boer War among other campaigns. *Left:* The First Balloon Group in the field near Kroonstad in the Orange Free State.

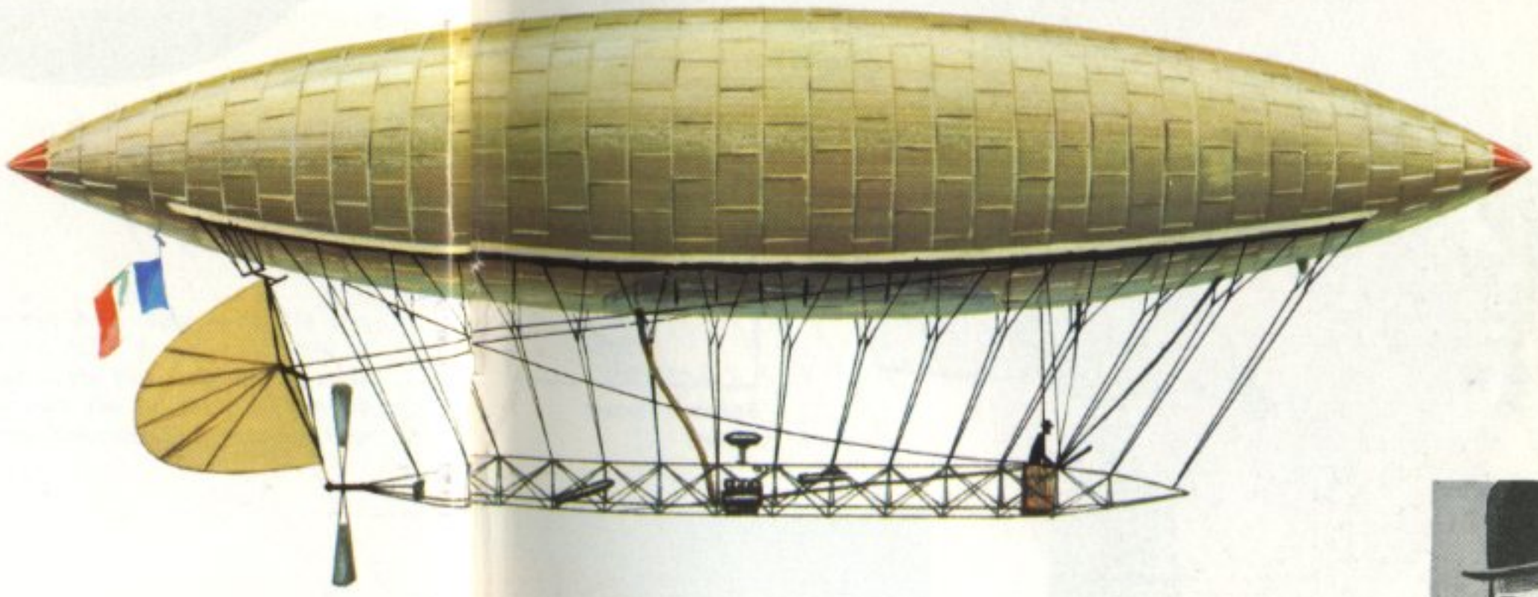
21 The Parseval-Sigsfeld kite-type observation balloon of the German Army, introduced in 1898. They were used in great numbers during the First World War.



22 David Schwarz's aluminium airship of 1897 was a technical advancement for its day. It was wrecked due to poor handling on its trial trip at Schöneberg near Berlin.



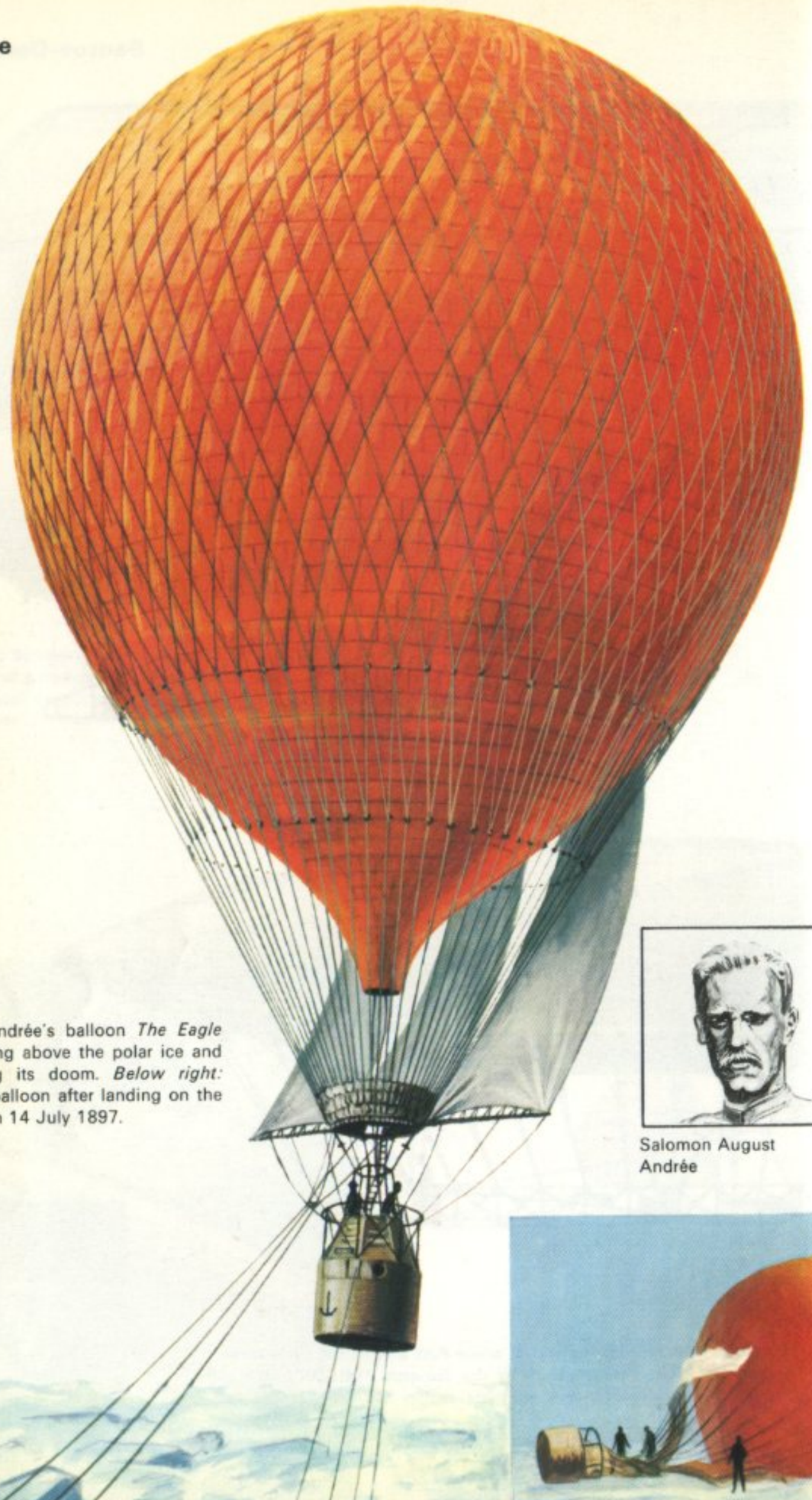




23 Santos-Dumont's airship 'No. 6' which flew around the Eiffel Tower on 19 October 1901, thereby winning the Deutsch 100,000 francs prize. *Above:* Santos-Dumont's small dirigible airship 'No. 9'

Alberto
Santos-Dumont

Eagle



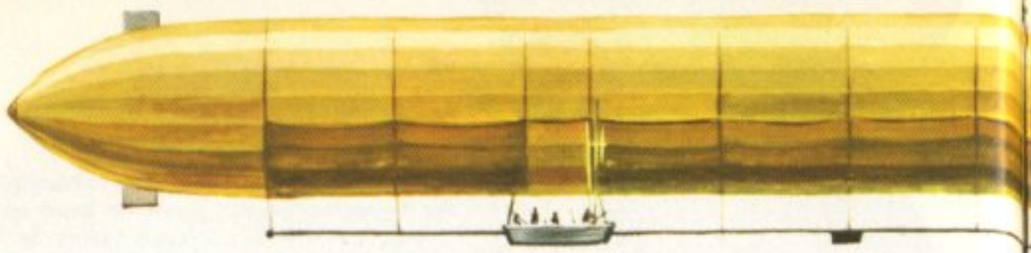
24 Andrée's balloon *The Eagle* floating above the polar ice and facing its doom. *Below right:* The balloon after landing on the ice on 14 July 1897.

Salomon August Andrée

Prussia

25 The giant balloon *Preussen* (Prussia) being filled at the Tempelhof parade ground in Berlin on 31 July 1901. It was only partially inflated before its release on this altitude ascent made by Arthur Berson and Reinhard Süring. The picture at top left shows that as the balloon gained altitude the expanding gas filled the envelope fully.

Zeppelin LZ 1

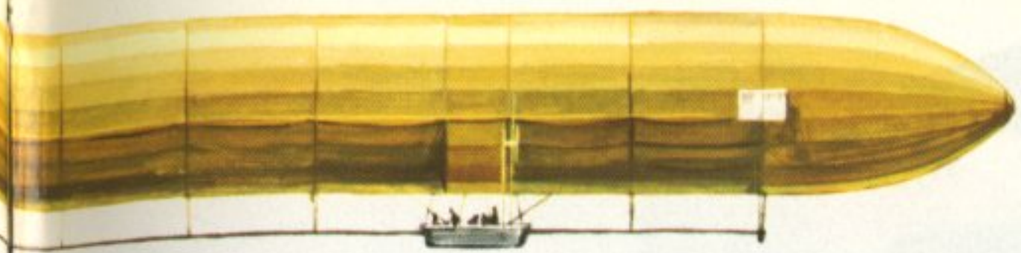


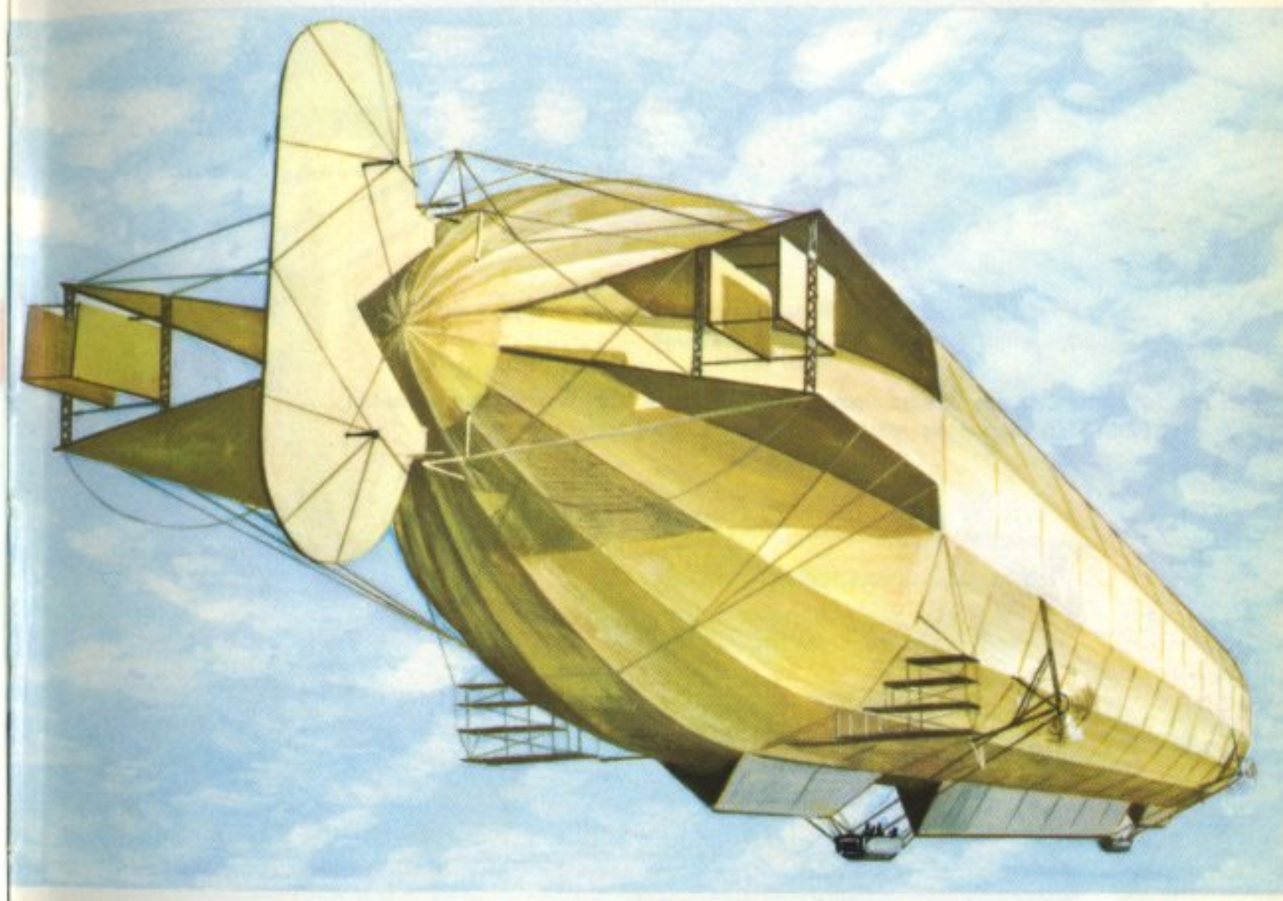
Ferdinand
von Zeppelin

26 Zeppelin LZ 1 was the world's first rigid dirigible airship. It arose from Lake Constance near Friedrichshafen on its maiden air voyage on 2 July 1900. Note the 'sliding balance', for horizontal trimming of the airship, on the rail which extends beneath the hull for almost its full length.

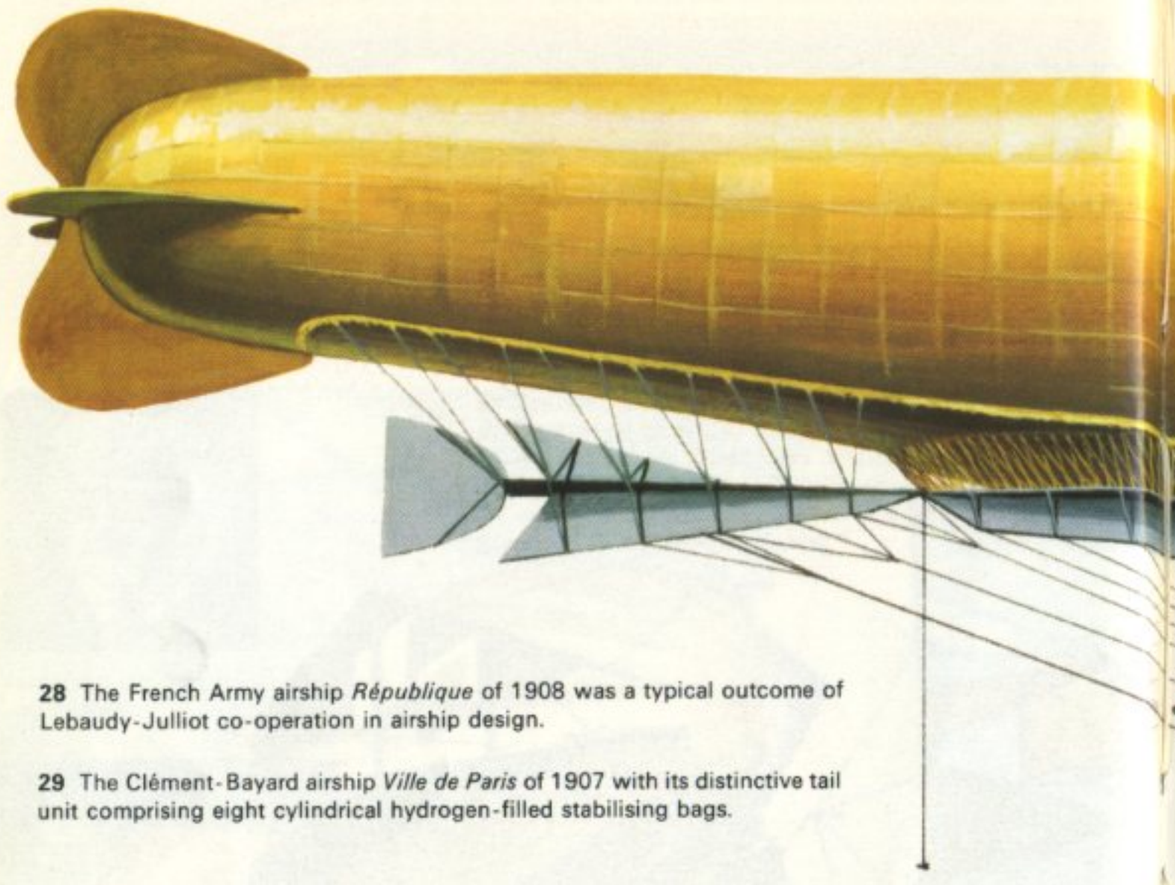
27 *Below and left:* Zeppelin LZ 7 *Deutschland* (Germany) of 1910, the first commercial airship, which carried a total of 220 passengers before it was wrecked over the Teutoburger forest near Osnabrück during a storm on 28 June the same year. *Right:* Zeppelin LZ 5 (Z II). This rear view shows the multiple rudders and elevators as well as the chain-driven propellers.

Zeppelin LZ 7



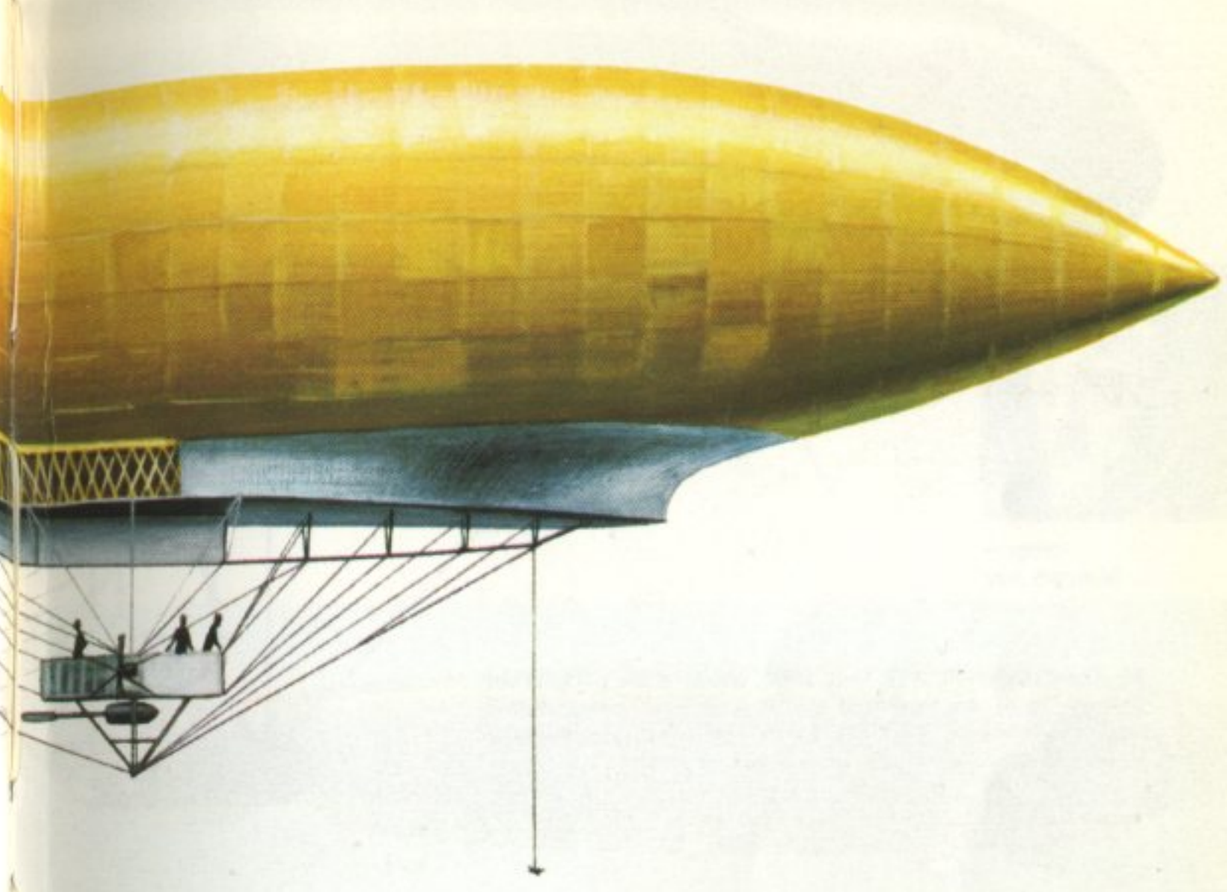


République

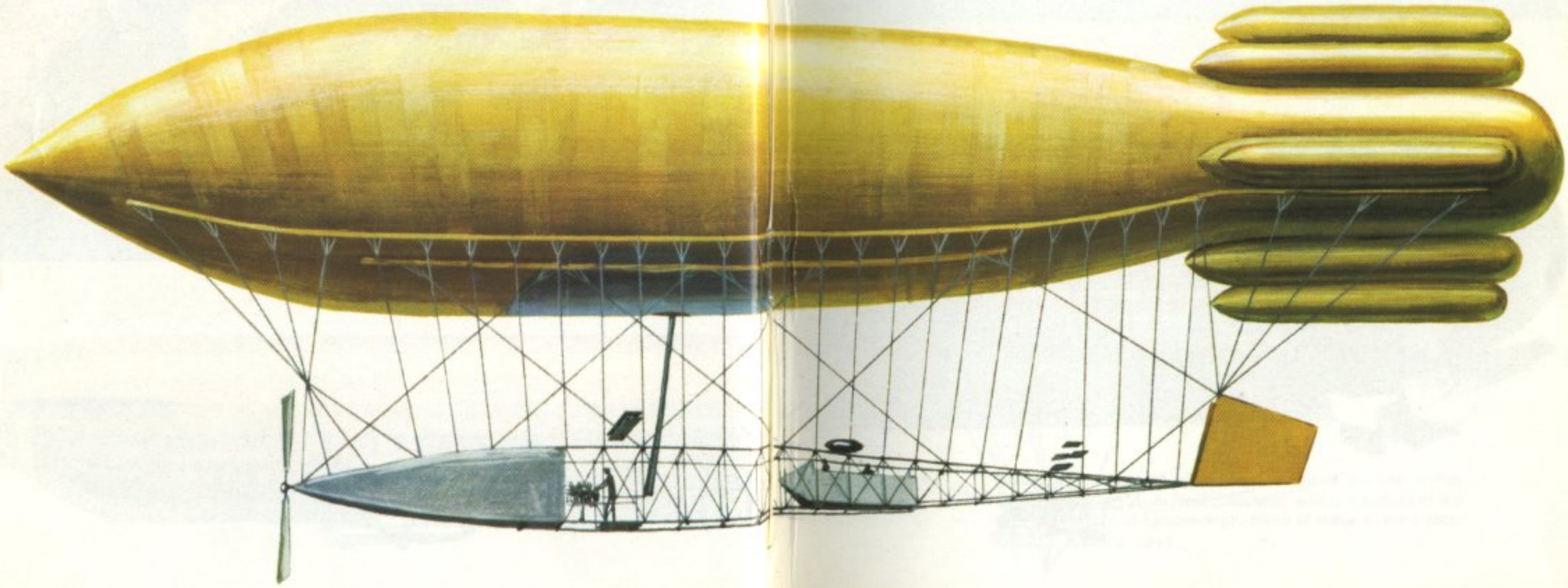


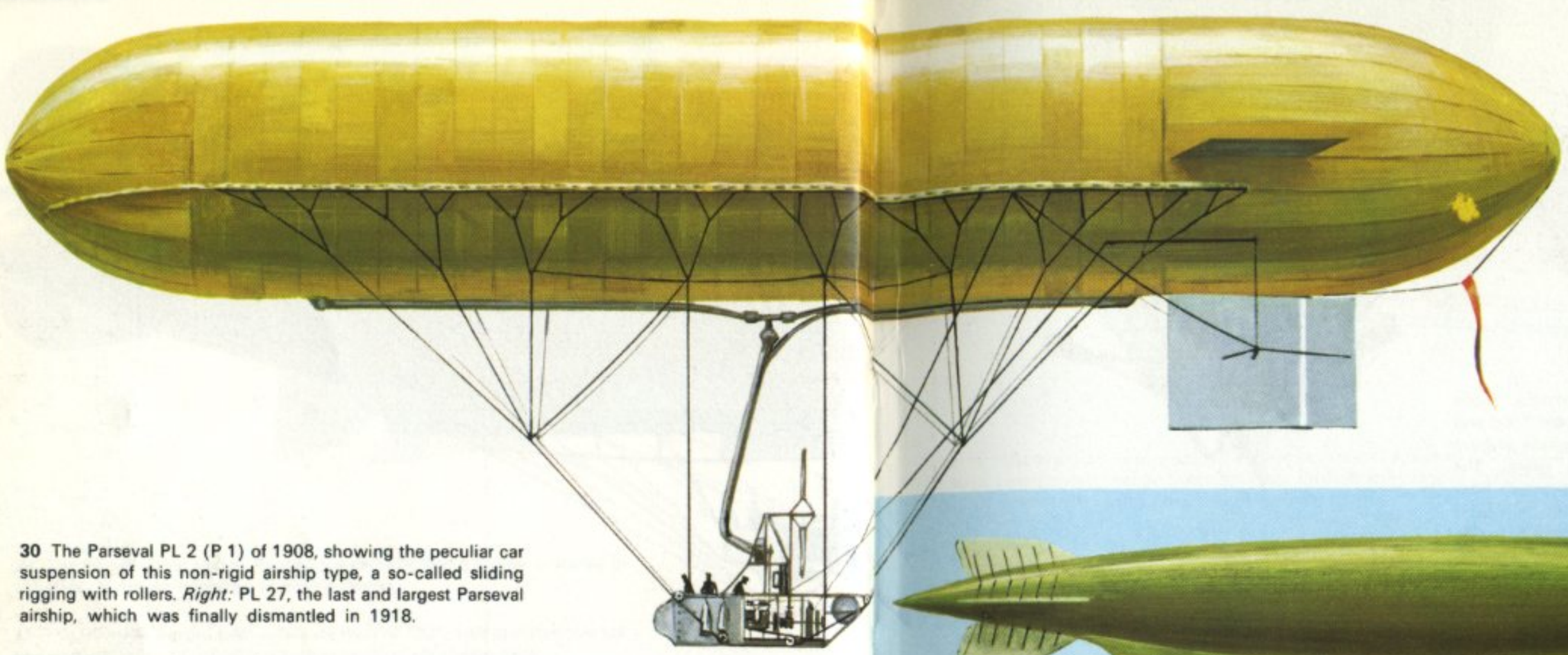
28 The French Army airship *République* of 1908 was a typical outcome of Lebaudy-Julliot co-operation in airship design.

Ville de Paris



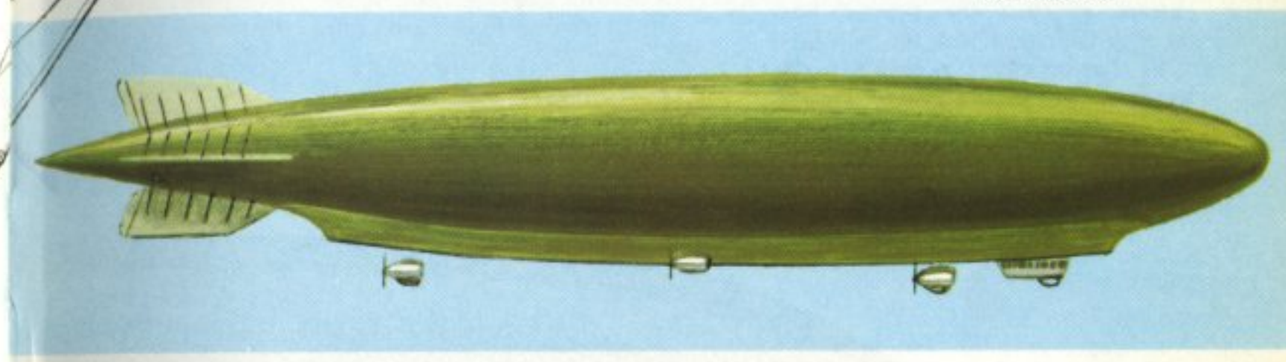
29 The Clément-Bayard airship *Ville de Paris* of 1907 with its distinctive tail unit comprising eight cylindrical hydrogen-filled stabilising bags.

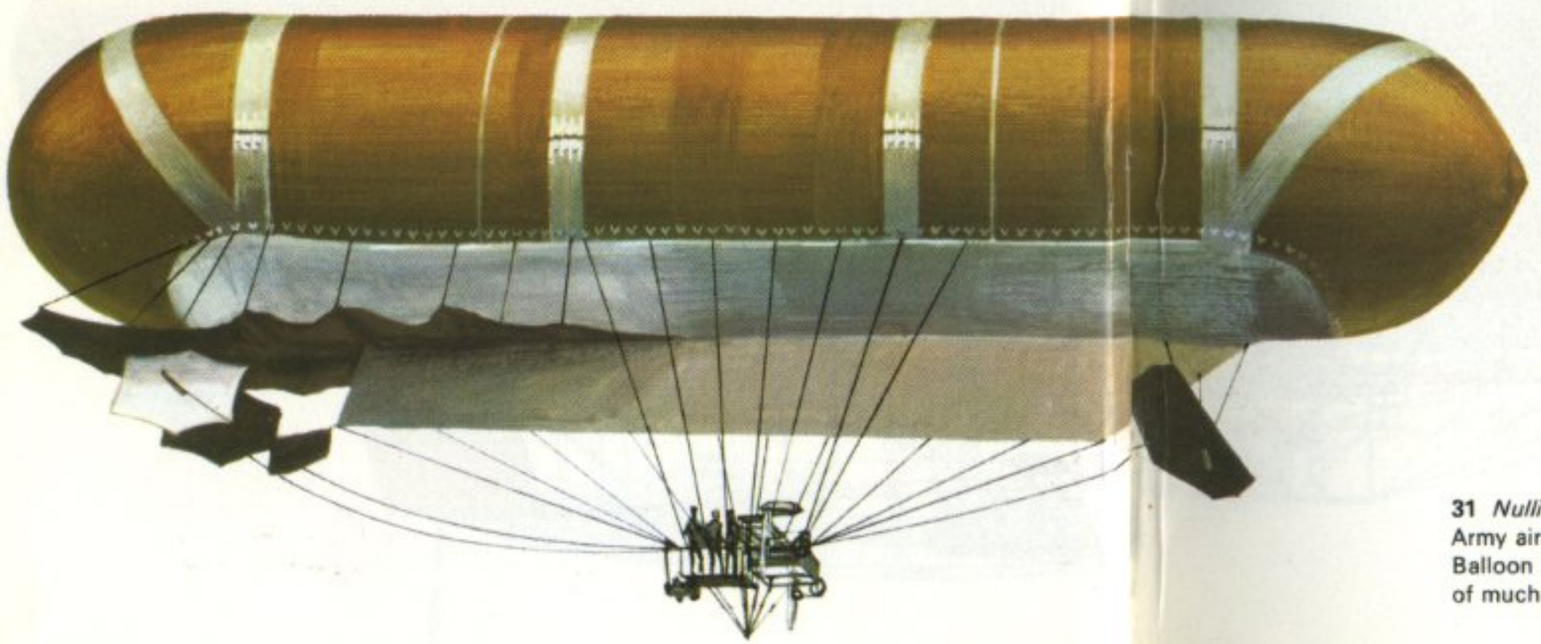




August
von Parseval

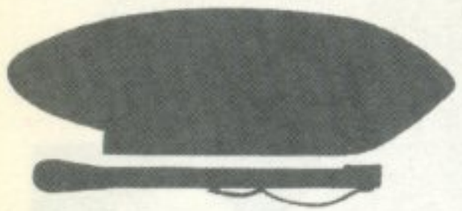
30 The Parseval PL 2 (P 1) of 1908, showing the peculiar car suspension of this non-rigid airship type, a so-called sliding rigging with rollers. *Right:* PL 27, the last and largest Parseval airship, which was finally dismantled in 1918.

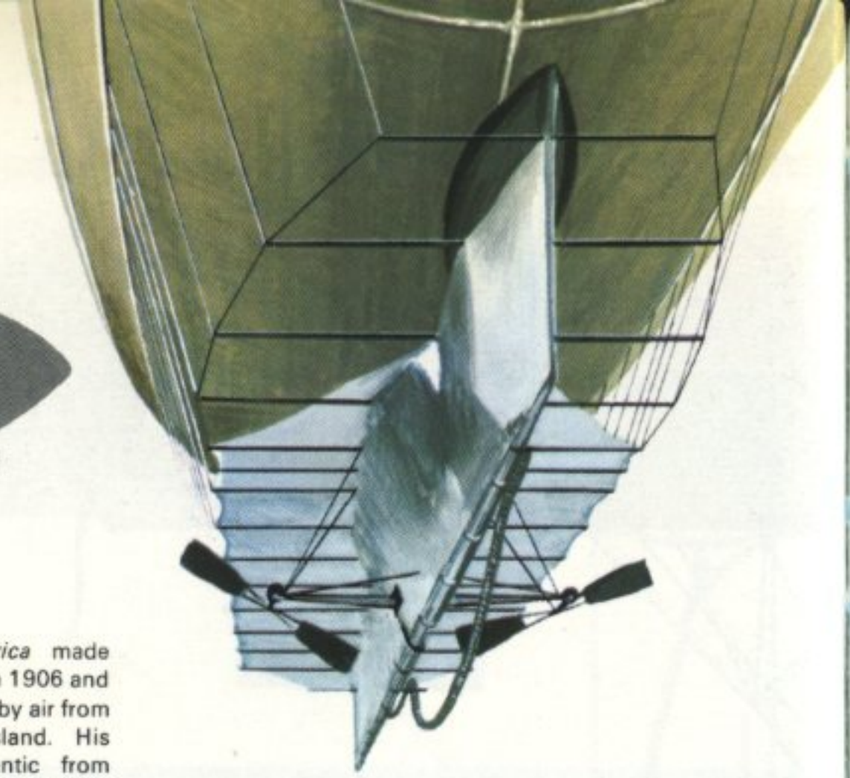




31 *Nulli Secundus II,* a modified version of the first British Army airship 'No. 1' or *Nulli Secundus* which was built at the Balloon Factory at Farnborough. None of these airships were of much practical value.

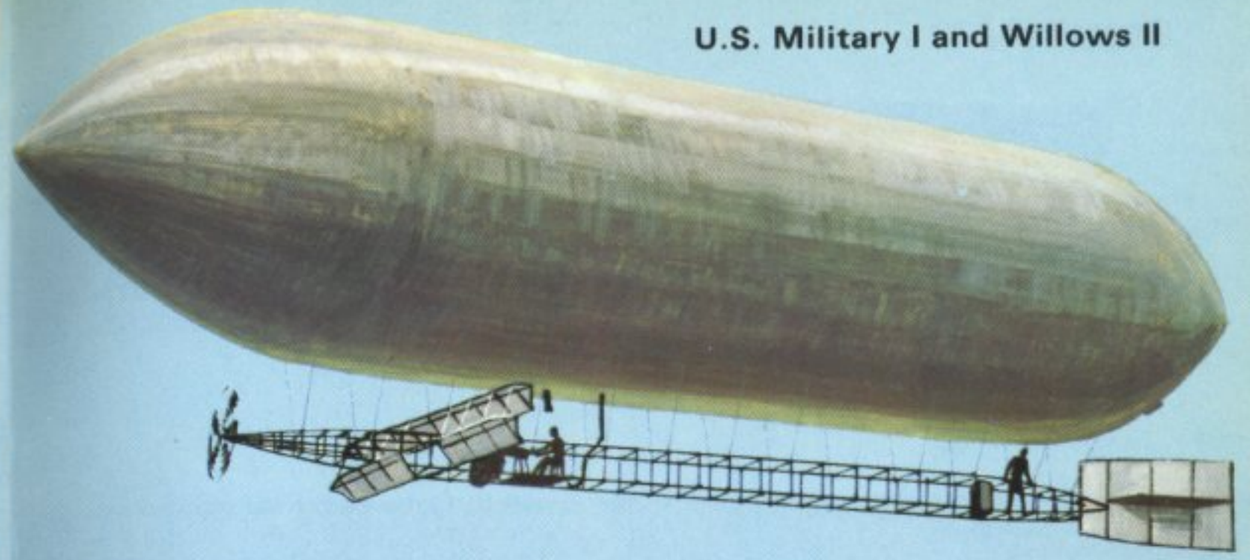
America



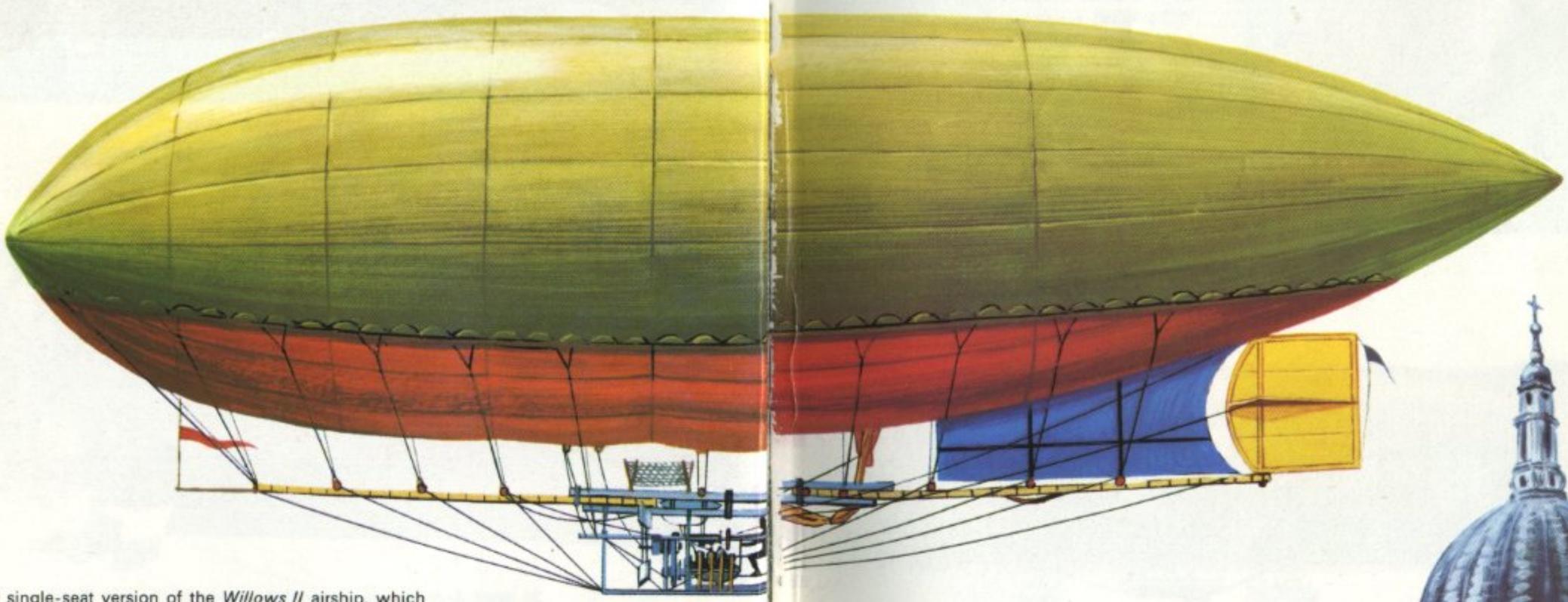


32 Walter Wellman's *America* made several vain attempts between 1906 and 1909 to reach the North Pole by air from a base on Spitsbergen island. His attempt to cross the Atlantic from America to Europe with this airship in 1910 likewise ended in failure; it was forced down at sea, but a steamer rescued the crew.

U.S. Military I and Willows II



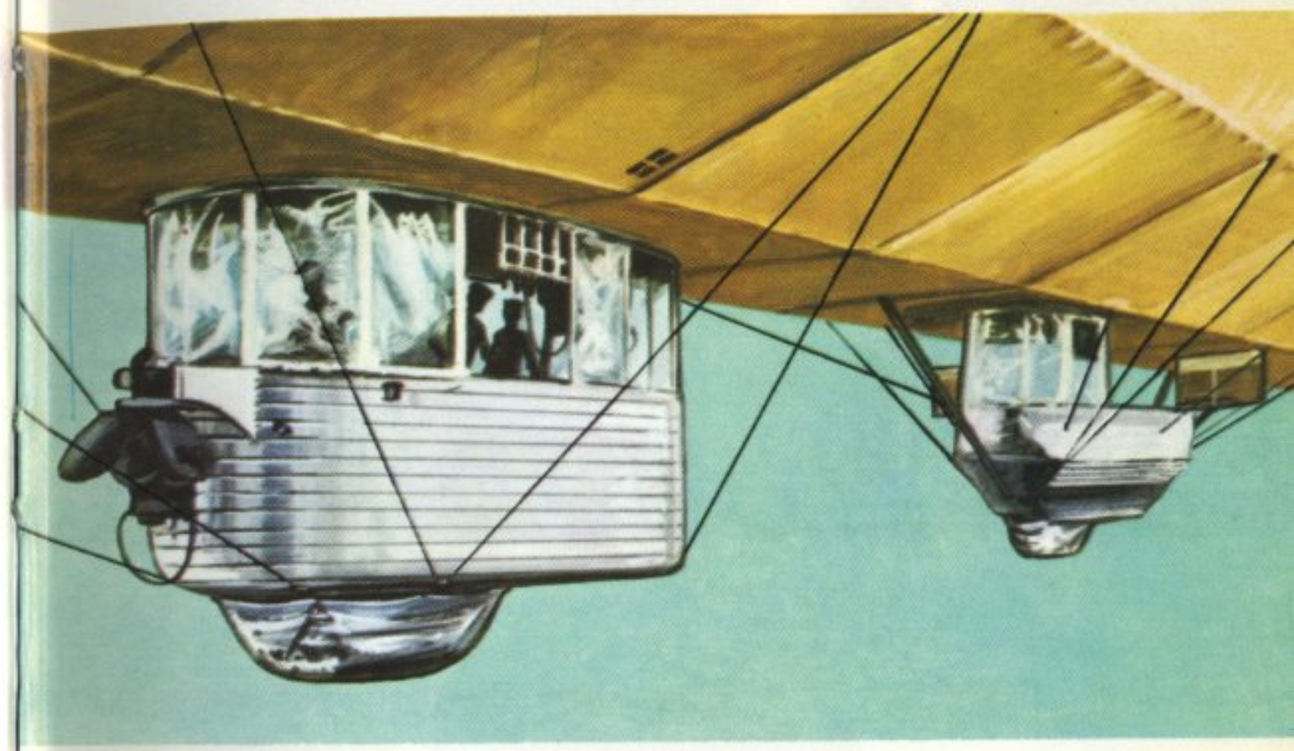
33 In 1908 the U.S. Army acquired its first airship and assigned it to the Signal Corps. The contract for it was awarded to Thomas Scott Baldwin, then an experienced balloonist and parachute jumper. The designation of this airship was *U.S. Military I*.



34 The 1909 single-seat version of the *Willows II* airship, which the following year flew from Cardiff to London. Later in 1910 a modified version of this airship, now named *City of Cardiff I*, made a vain attempt to reach Paris by air from England.

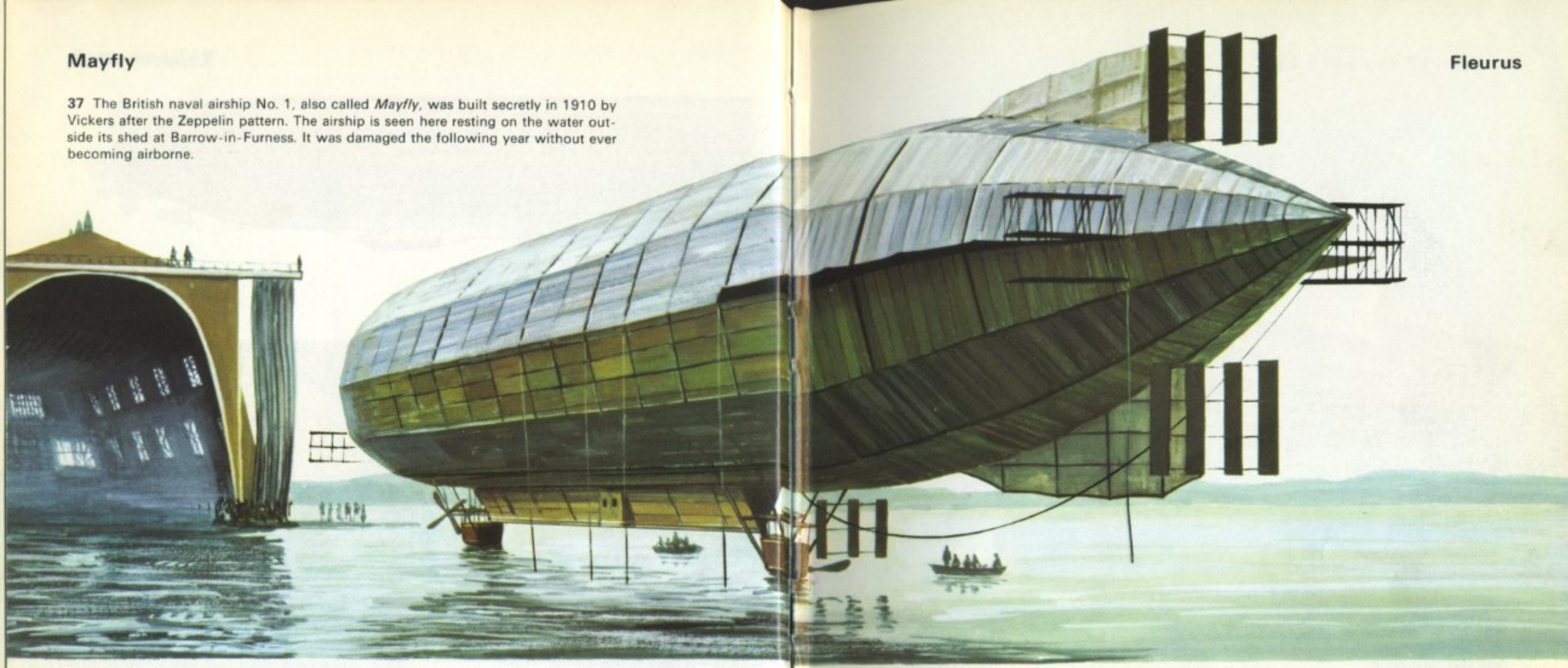
35 LZ 13, the commercial Zeppelin airship *Hansa* of 1912, which made 399 successful passenger trips before the outbreak of World War 1. In the autumn of 1914 this airship was taken over by the German Army and later transferred to the German Navy; both used it as a training vessel for turning out new crews to man the military airships. *Hansa* was retired and dismantled in 1916. *Left: Hansa* arrives in the Danish capital from Hamburg on 19 September 1912; this was the first voyage abroad undertaken by any commerical airship.

36 The naval Zeppelin airship L2 (LZ18) incorporated a number of specific innovations which German naval engineers considered would improve this airship design. They included a covered interior passageway and fully- or partly-enclosed cars directly beneath the hull. Shortly after leaving the Johannisthal aerodrome near Berlin on its acceptance flight on 17 October 1913 the airship exploded and plunged to the ground on fire. The entire crew and all the naval acceptance officers on board were killed. *Right:* The front control car and the centre engine car.

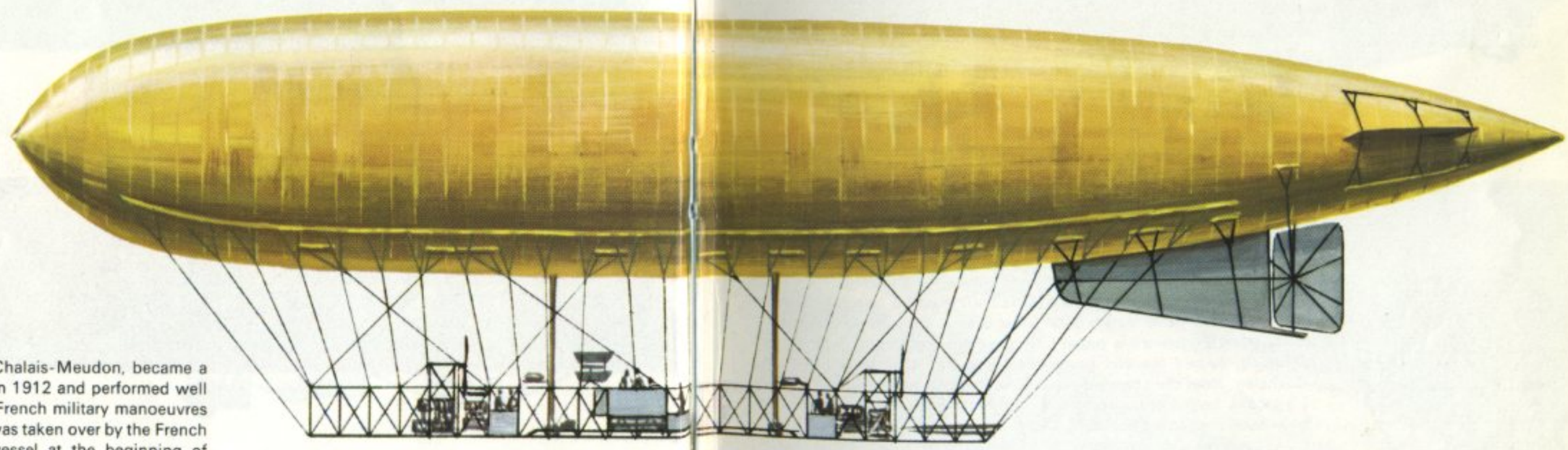


Mayfly

37 The British naval airship No. 1, also called *Mayfly*, was built secretly in 1910 by Vickers after the Zeppelin pattern. The airship is seen here resting on the water outside its shed at Barrow-in-Furness. It was damaged the following year without ever becoming airborne.

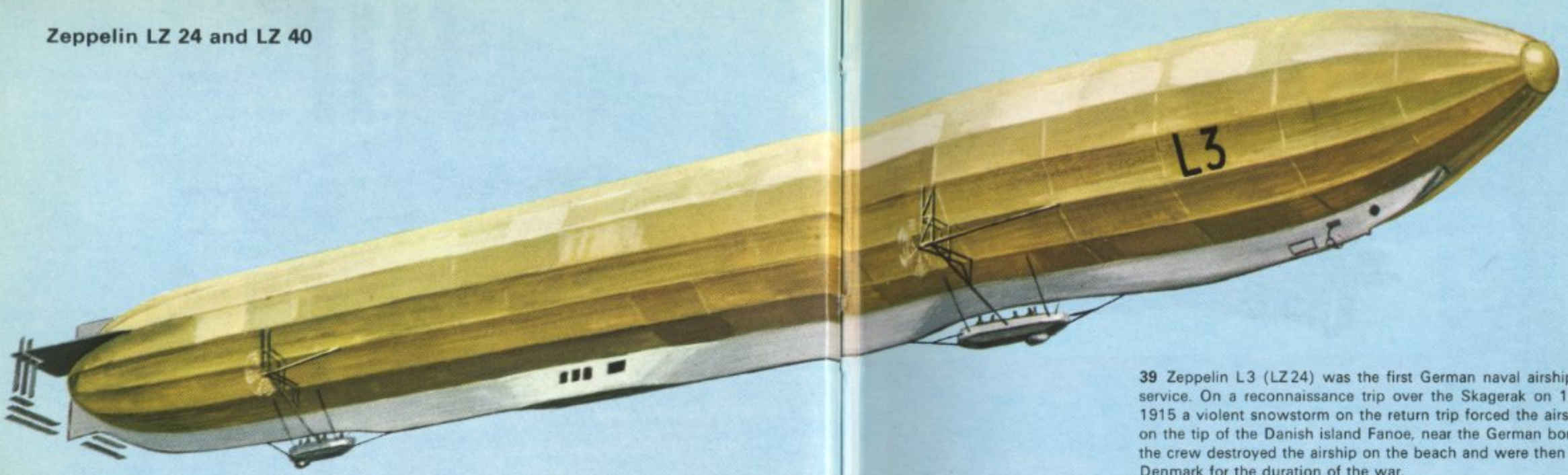


Fleurus

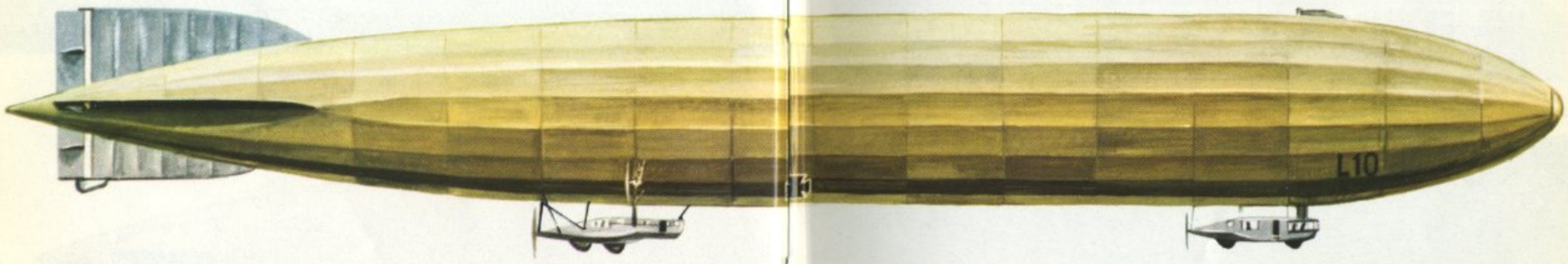


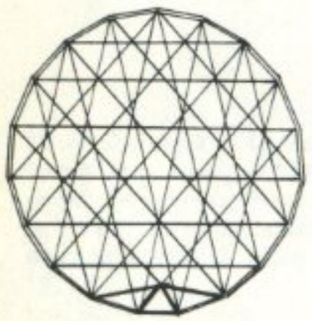
38 *Fleurus*, built at Chalais-Meudon, became a French Army airship in 1912 and performed well during the extensive French military manoeuvres in 1913. This airship was taken over by the French Navy as a training vessel at the beginning of 1917.

Zeppelin LZ 24 and LZ 40

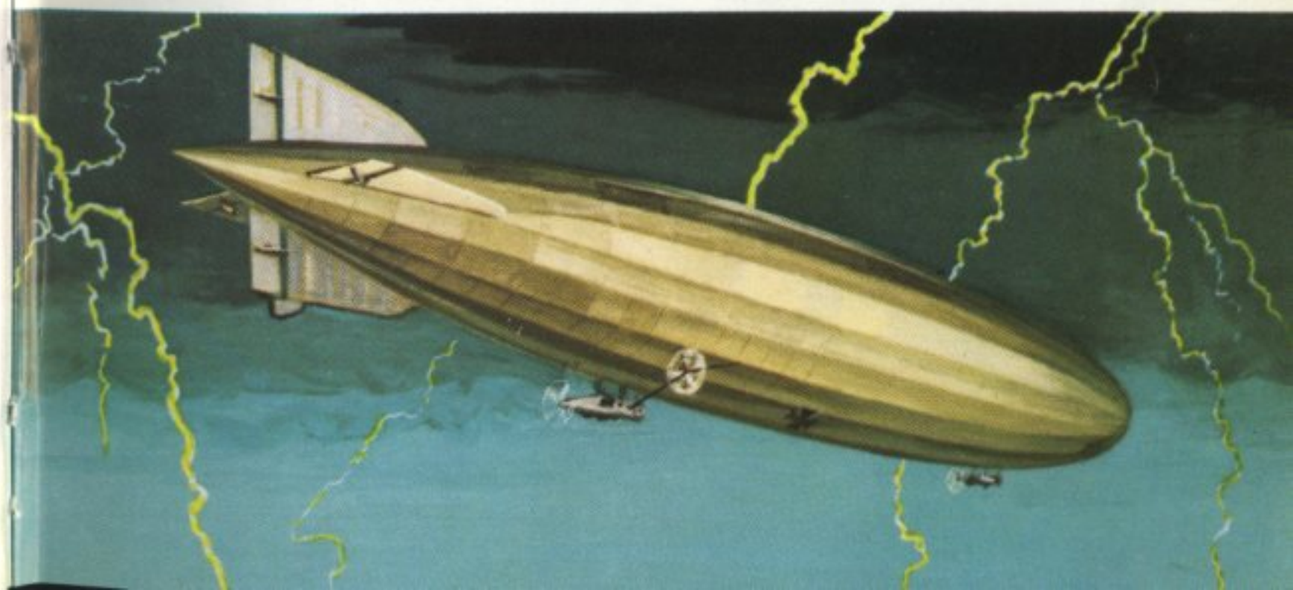


39 Zeppelin L3 (LZ24) was the first German naval airship on active service. On a reconnaissance trip over the Skagerak on 17 February 1915 a violent snowstorm on the return trip forced the airship to land on the tip of the Danish island Fanoe, near the German border, where the crew destroyed the airship on the beach and were then interned in Denmark for the duration of the war.

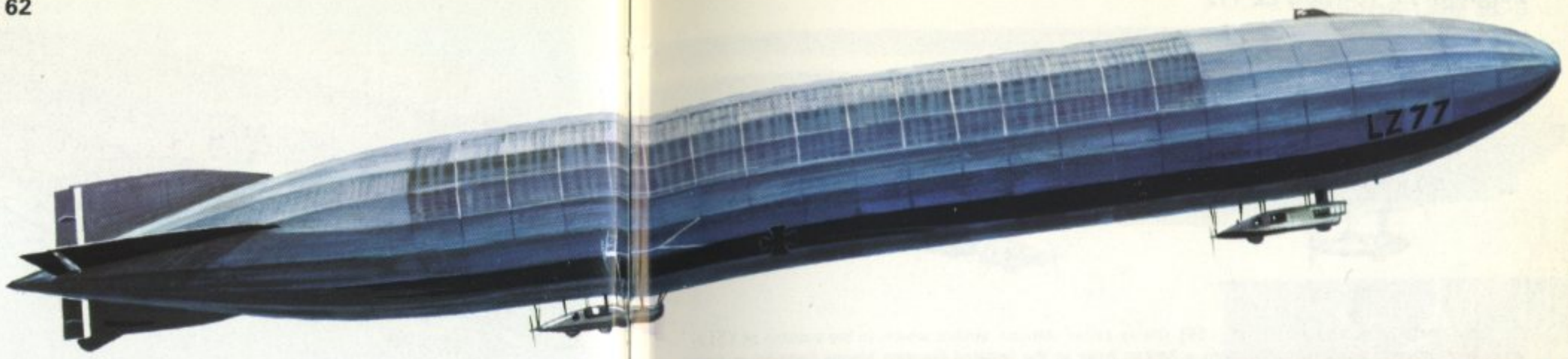


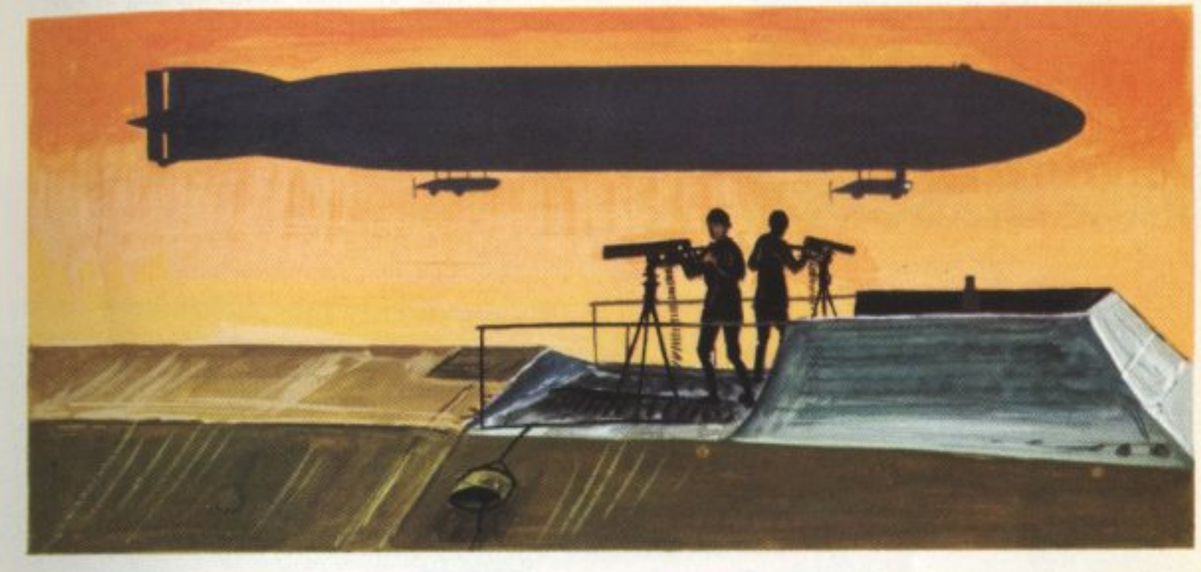


40 The naval Zeppelin airship L10 (LZ40) made a total of 28 war flights, including five raids against Great Britain. On 3 September 1915 it valved hydrogen while passing through a thunderstorm, was hit by lightning, caught fire and plunged burning into the North Sea near Cuxhafen. Note the changed tail unit and engine cars since the earlier L3 model. *Left:* a cross-section of an interior girder frame, one of the bulkheads supporting the gas cells.



Zeppelin LZ 47 and LZ 62



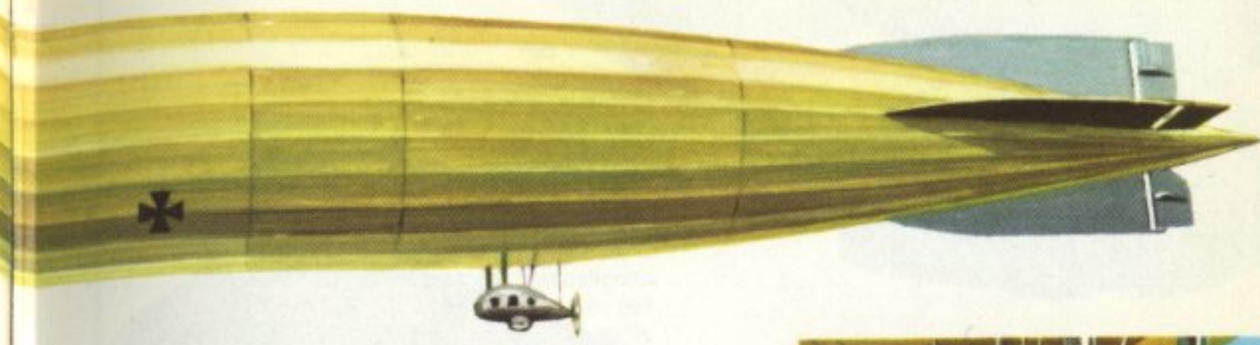


41 The German Army airship Zeppelin LZ77 (LZ47) in the camouflage painting applied to safeguard the airship against attacks over enemy territory on moonlight nights. *Left:* The interior passageway in LZ77. *Right:* The gunners' platform on top of the airship hull where two 8-mm Maxim machine-guns were mounted as a defence against attacking aeroplanes.

42 The naval airship L30 (LZ62) was the first of the so-called 'Super-Zeppelins', with a volume of 1,949,373 cu ft (55,200 cu m), and had a more streamlined hull. L30 participated in nine raids on Great Britain before being laid up at the Seerappen base near Königsberg on the Baltic Sea in August 1917. Here the airship was dismantled in 1920 at Belgian request.

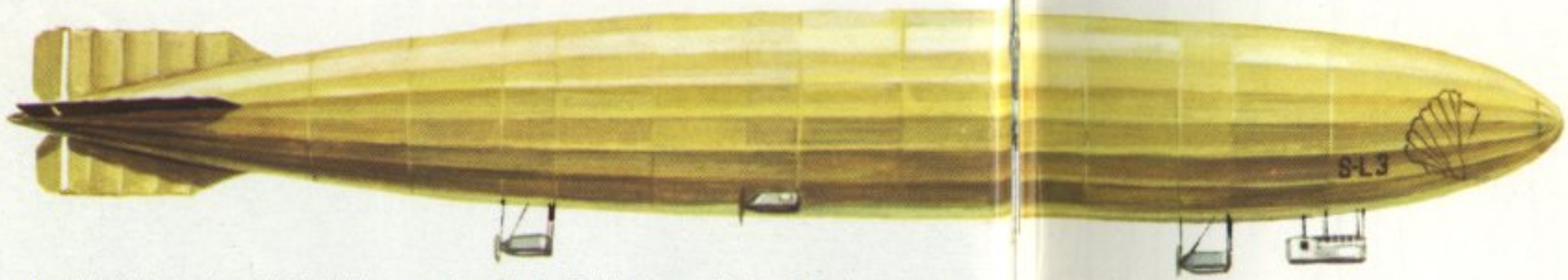
Zeppelin LZ 104 and LZ 112

Schütte-Lanz SL-3



43 The naval airship Zeppelin LZ104 (L59), the so-called 'African' airship which, in the autumn of 1917, was commissioned to fly supplies from a Balkan base to the isolated German troops fighting in East Africa under the command of General von Lettow-Vorbeck. *Right:* the control car of L59.

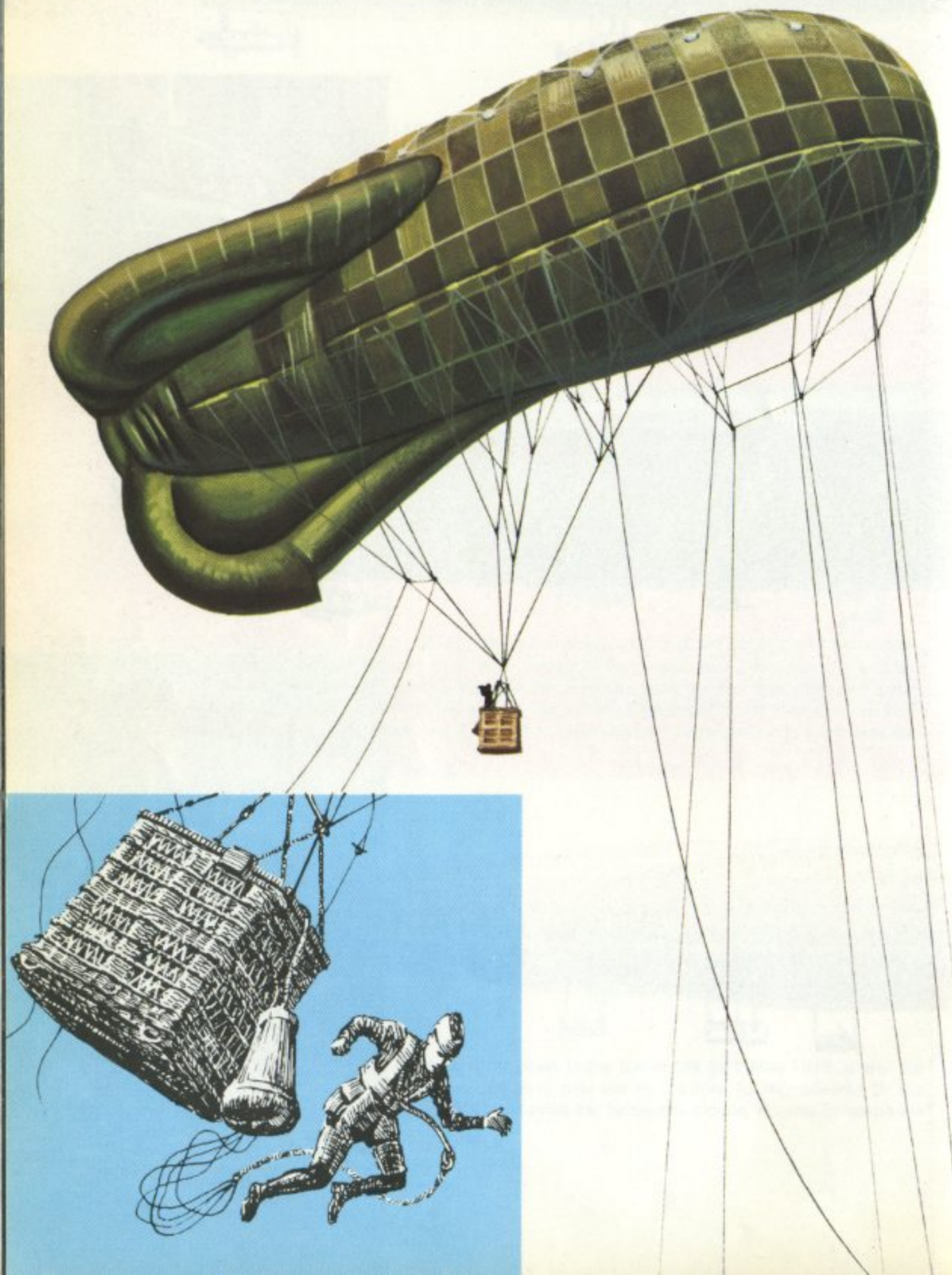
44 With the naval airship Zeppelin L70 (LZ112) and a few sister vessels of the same class the Zeppelin yard in Friedrichshafen attained the peak in military airship performance. But fate dealt this airship a cruel blow, for the Commander and driving spirit of the German naval airship fleet, Frigate-Captain Strasser, was on board L70 himself on this last airship raid against England of World War 1 on the night of 6 August 1918, when it met its match in a British D.H.4 biplane south-east of London and was shot down in flames in the English Channel.



45 The naval airship Schütte-Lanz SL3, which went down in the Baltic Sea on 1 May 1916. It was the practice of the SL3, like other German airships operating over enemy territory, to stay covered by the clouds under the guidance of an observer lowered in a small car below the clouds. He was in telephone communication with the control car.

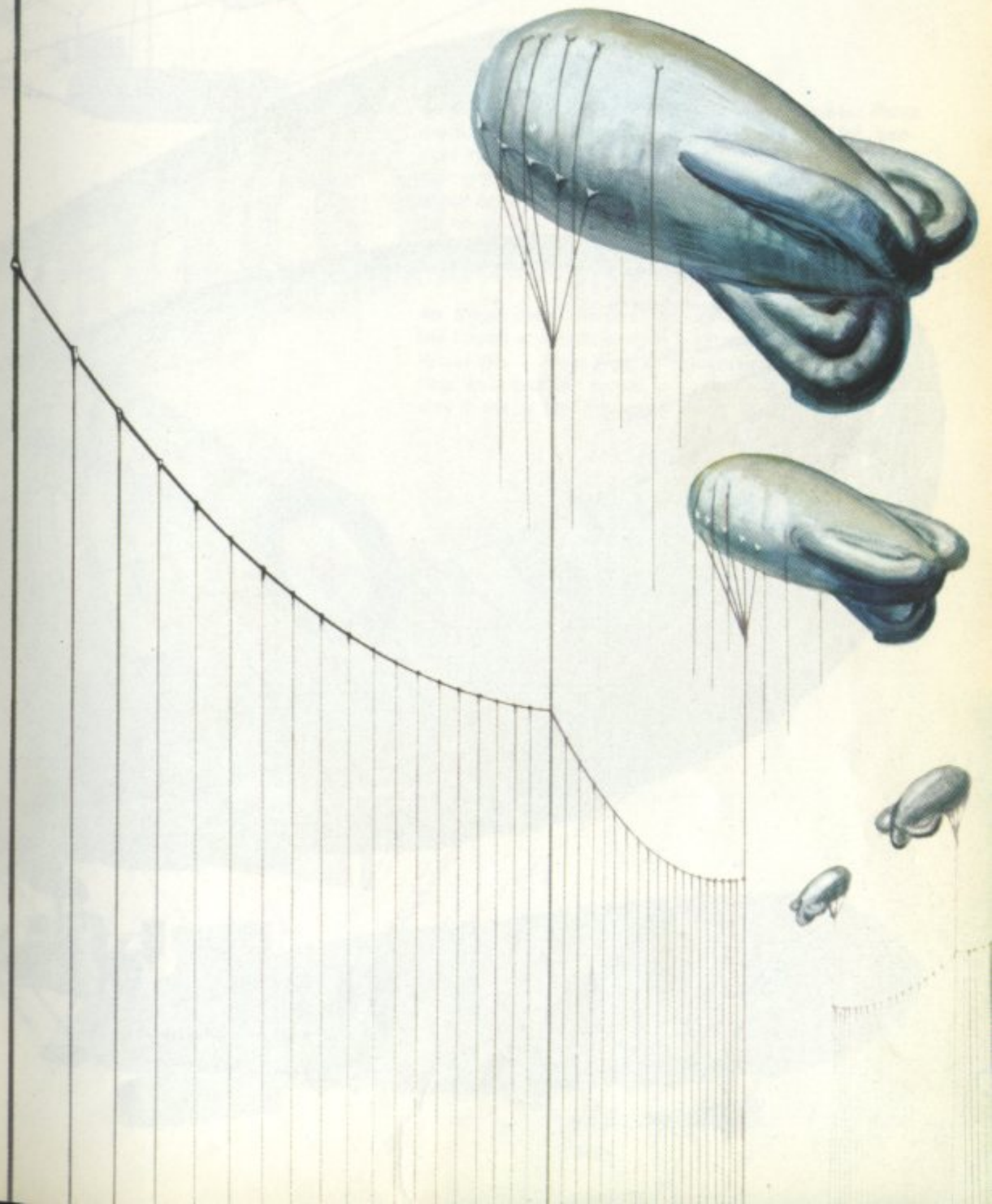
Caquot captive balloon

46 The French Caquot captive balloon appeared during World War 1 as an improvement on the German kite balloon style and was used extensively by the Allies. The observer was equipped with a parachute and jumped when his balloon was attacked by enemy aircraft.



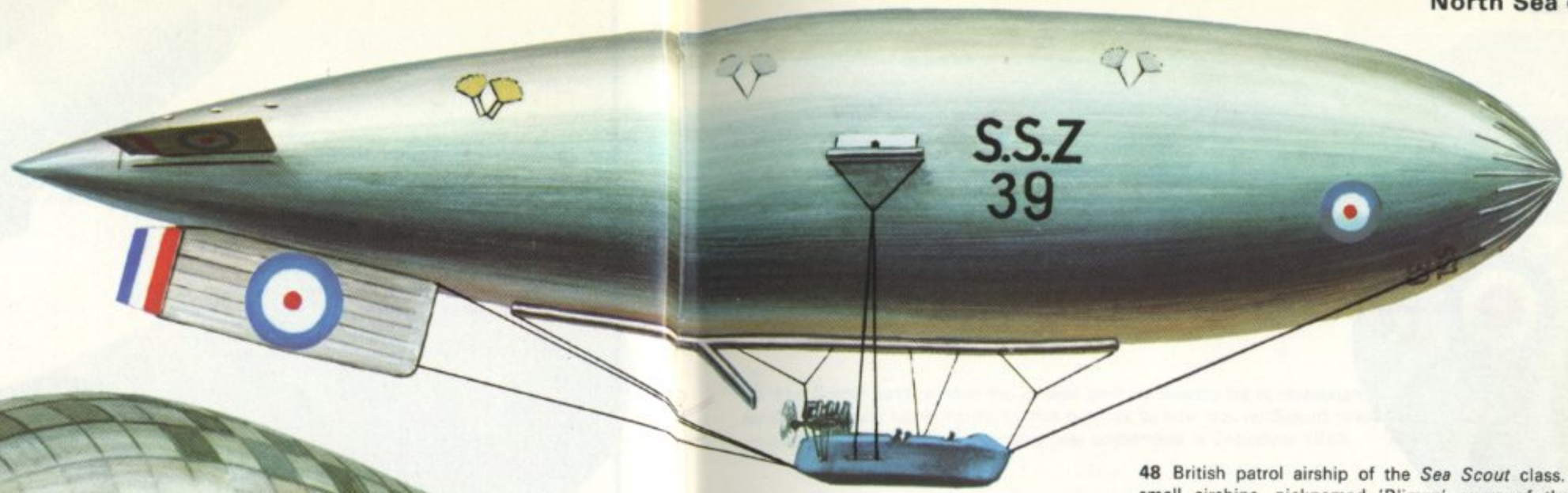
Barrage balloons

47 The Caquot type were also used as barrage balloons in both World Wars and changed little in appearance. The balloons shown here date from 1918; a barrage net comprising long, light, vertical cables is suspended underneath.



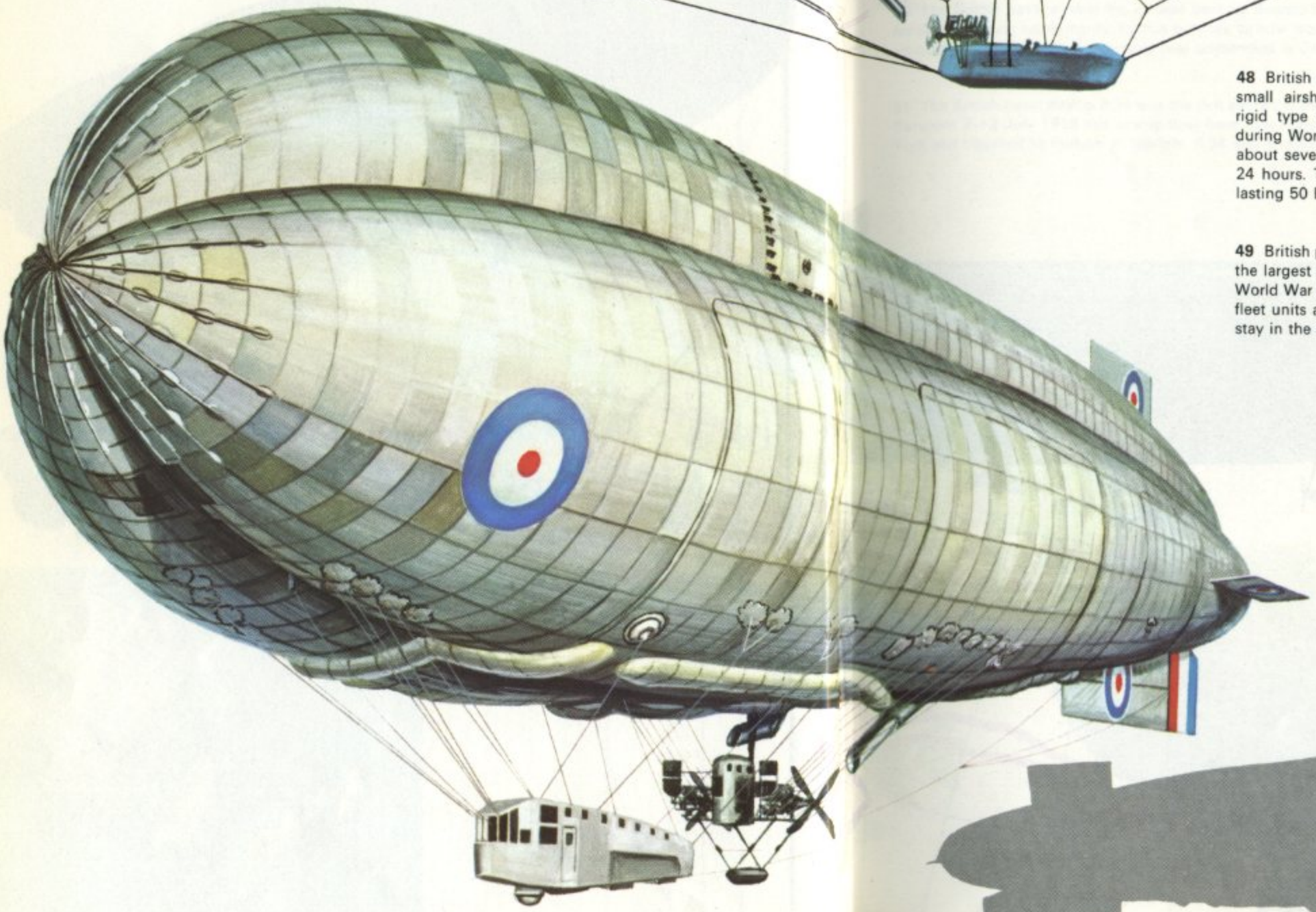
Sea Scout class

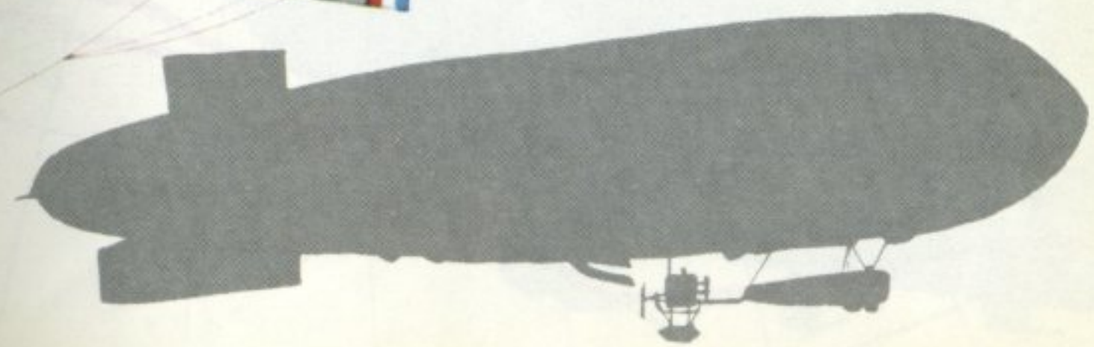
North Sea class

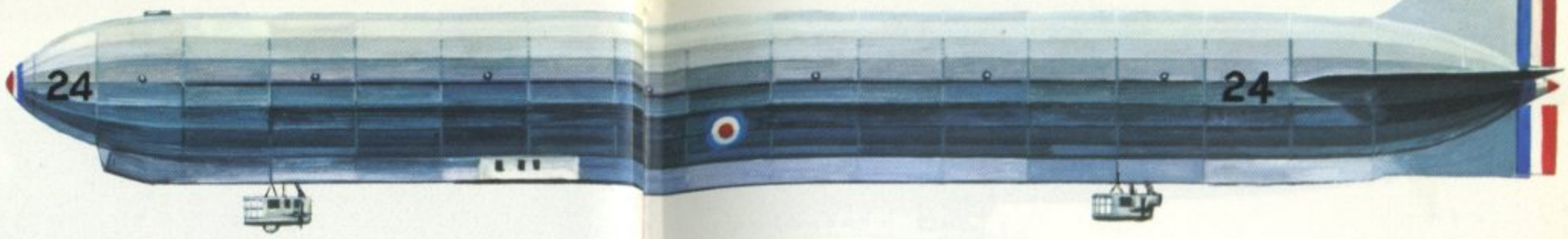


48 British patrol airship of the *Sea Scout* class. These small airships, nicknamed 'Blimps', were of the non-rigid type and performed extensive patrol work at sea during World War 1. They had a normal flight duration of about seven hours, but often stayed aloft for 12 or even 24 hours. The record was held by SSZ39 with a cruise lasting 50 hours.

49 British patrol airship of the *North Sea* class. They were the largest non-rigid airships built in Great Britain during World War 1. These airships co-operated with the various fleet units and also served as convoy escorts. They could stay in the air for 24 hours or more.

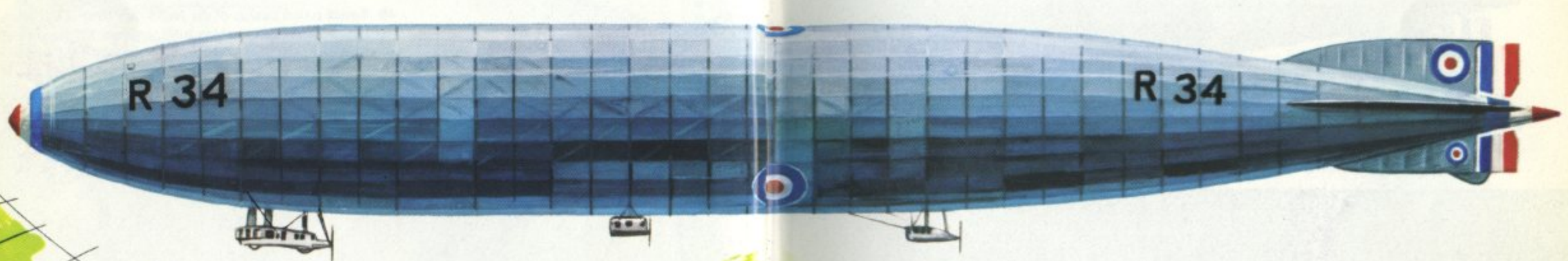


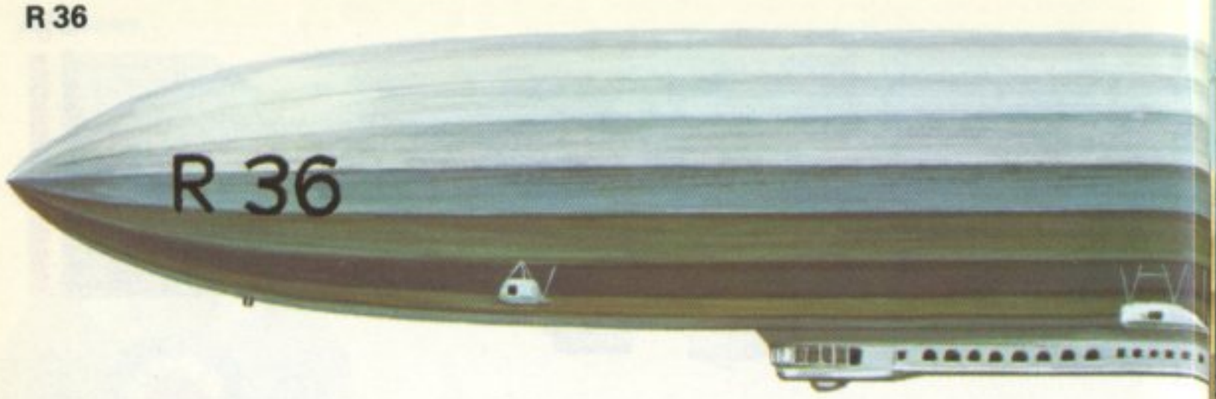




50 The British naval airship No. 24 was built by Beardmore at Inchinnan in 1917 and was used mainly for mooring mast experiments; for this purpose its bow was reinforced. It was relatively slow and was not an outstanding success. The airship was dismantled in December 1919.

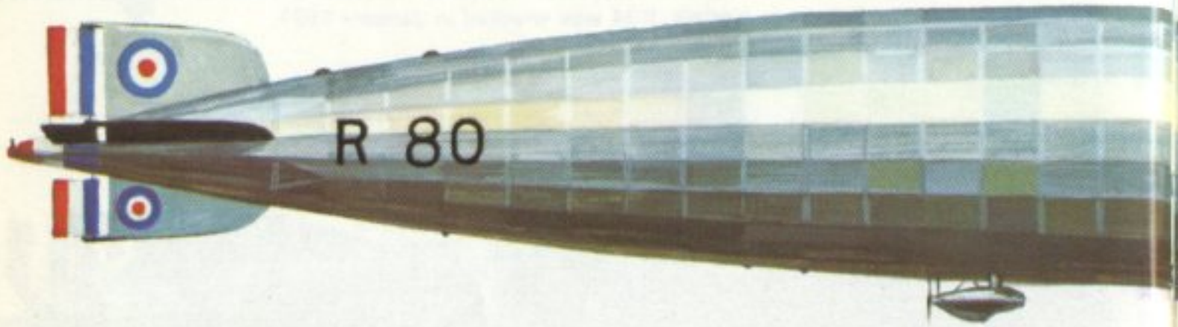
51 The British naval airship R 34 was the first aircraft in the world to cross the Atlantic in both directions. Between 2-13 July 1919 this airship flew from East Fortune on the Firth of Forth to Mineola near New York and returned to Pulham in Norfolk. R 34 was wrecked in January 1921.

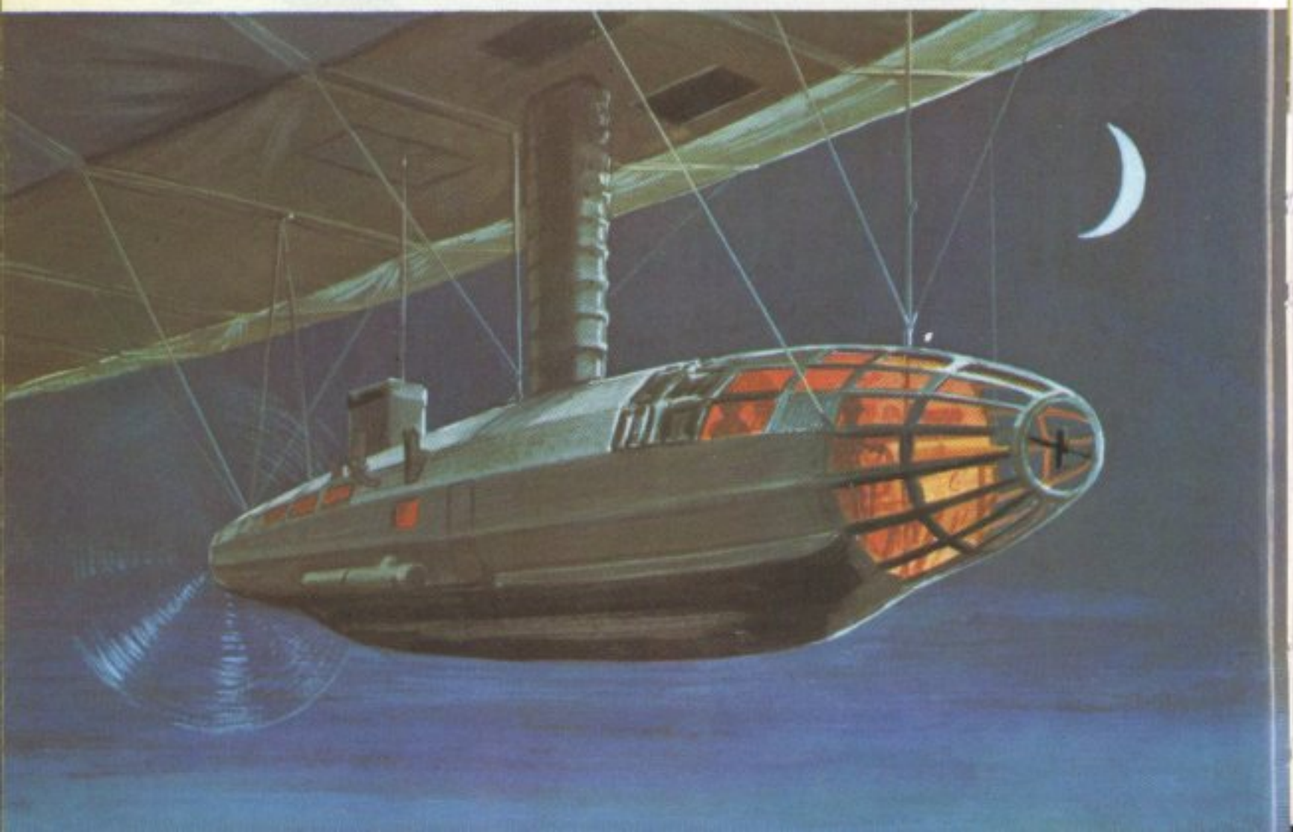




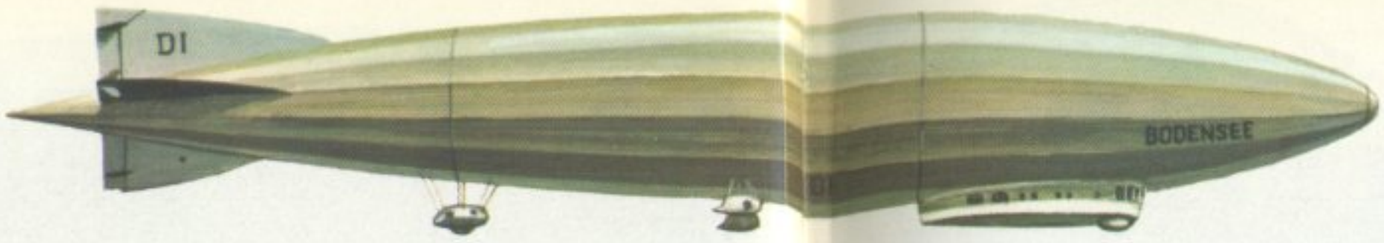
52 R 36 was the last rigid airship built to the order of the British Admiralty during World War 1. It was originally based upon the German Zeppelin L 48 (LZ 95), and although built to military specifications was equipped to carry passengers. It was planned to operate the airship between London and Cairo, but this route never materialised.

53 The Royal Air Force airship R 80 was the last of the rigid type designed in World War 1. After the cessation of hostilities neither the military nor civil authorities could decide how to utilise this airship, so it was dismantled in 1925 after accumulating a total flying time of only 73 hours. *Bottom left:* the combined control and engine car in R 80.

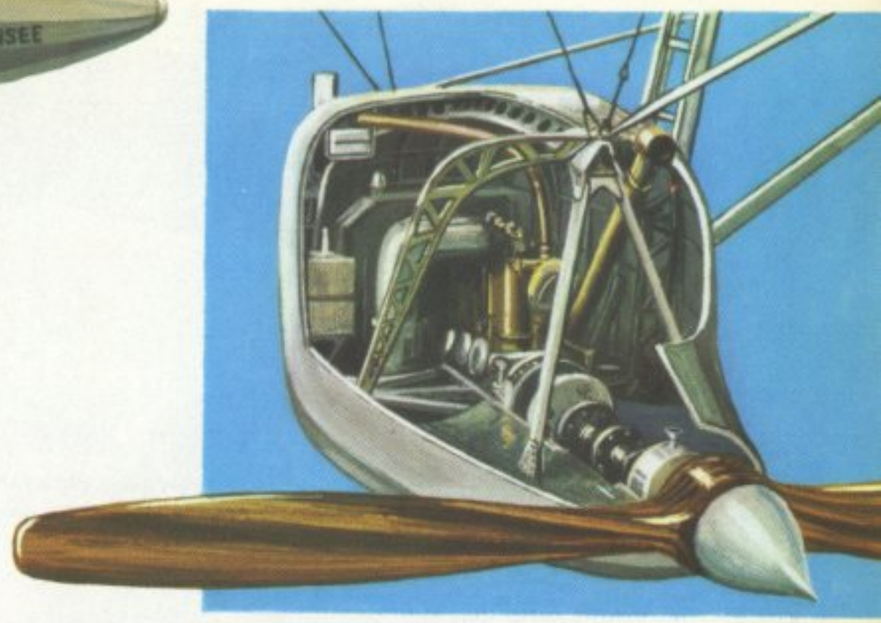




Zeppelin LZ 120

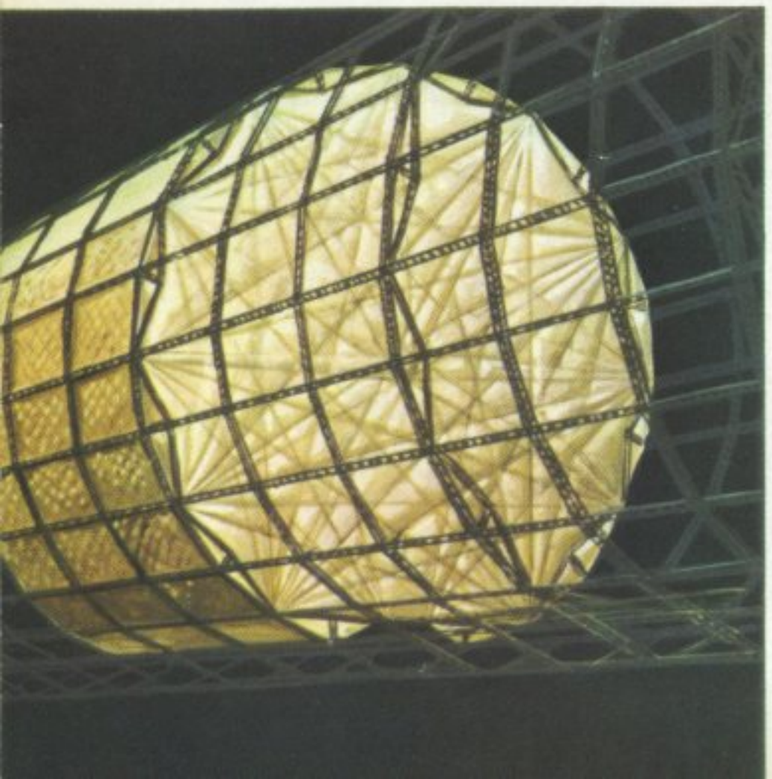


Zeppelin LZ 114

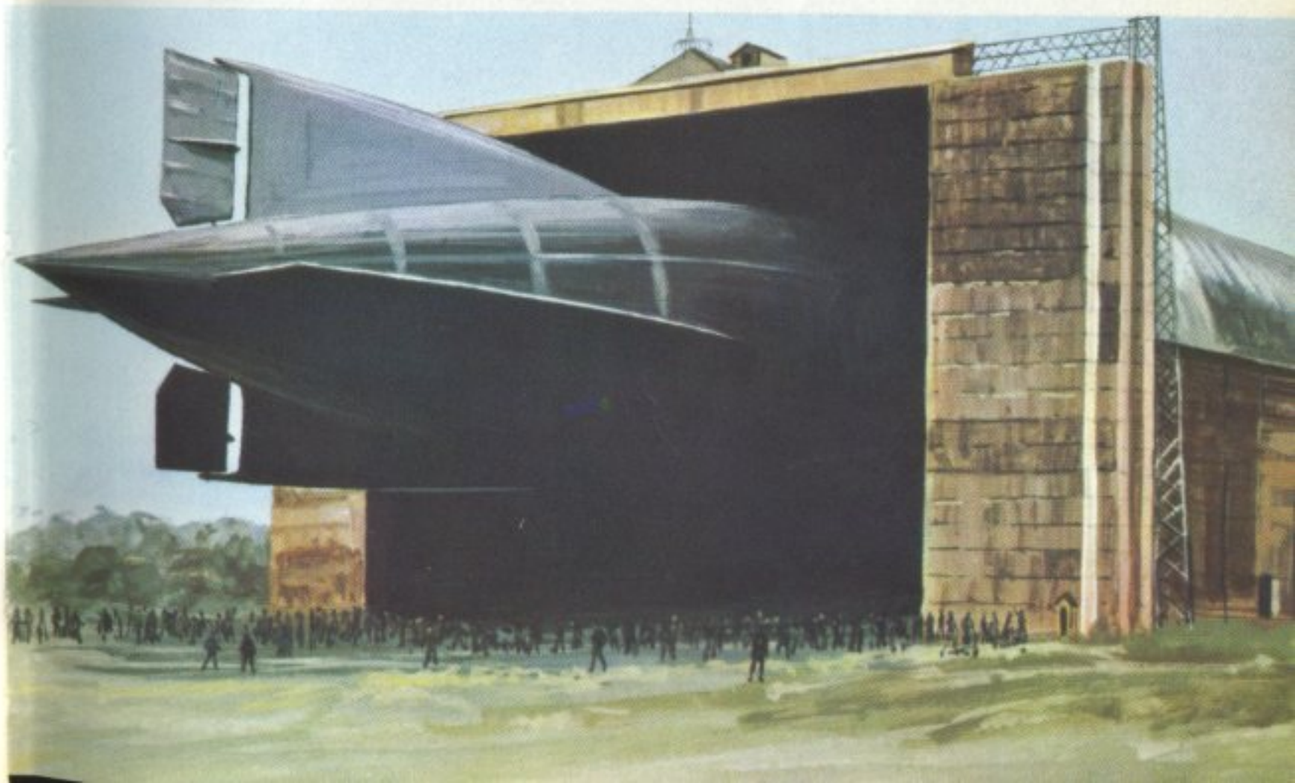


54 Zeppelin LZ120 *Bodensee*, the first small airship turned out by the yard at Friedrichshafen after World War 1. During the autumn of 1919 *Bodensee* maintained regular passenger services between Staaken, near Berlin, and Friedrichshafen on Lake Constance, making round trips on alternate days. In July 1921 this airship was turned over to Italy as part of the war reparations to that country and renamed *Esperia*. *Right:* Cutaway of one of the engine cars showing the stairs entering from the hull.

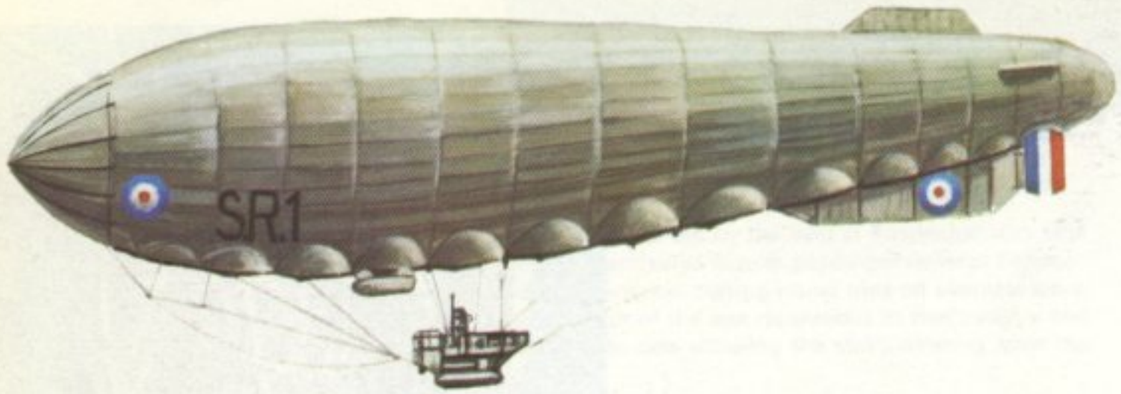
55 The German naval Zeppelin airship L 72 (LZ 114) survived the war and as part of the war reparations was turned over to France in July 1920, where it was named *Dixmude*. It carried out several long and successful flights, but disappeared without trace in December 1923, while on a Mediterranean cruise, with its full French naval crew of 52 men.
Left: a gas cell mounted in the still uncovered framework. *Right:* L 72 enters its shed at the Maubeuge base after being turned over to the French military authorities.



Hugo Eckener

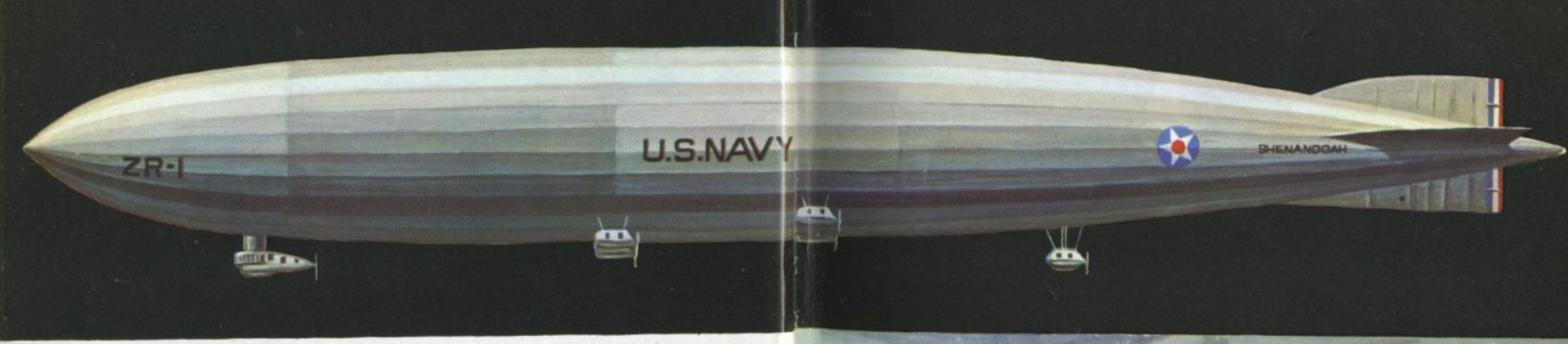


Italian M class



56 *Above:* S.R. 1, an Italian semi-rigid airship of the M class bought by the British Admiralty in 1918 for experimental purposes. *Right:* M-10, another semi-rigid airship of the same class, leaving its shed. Both the Italian Army and Navy used these airships extensively in World War 1. Note the gunner's platform forward on top of the hull.

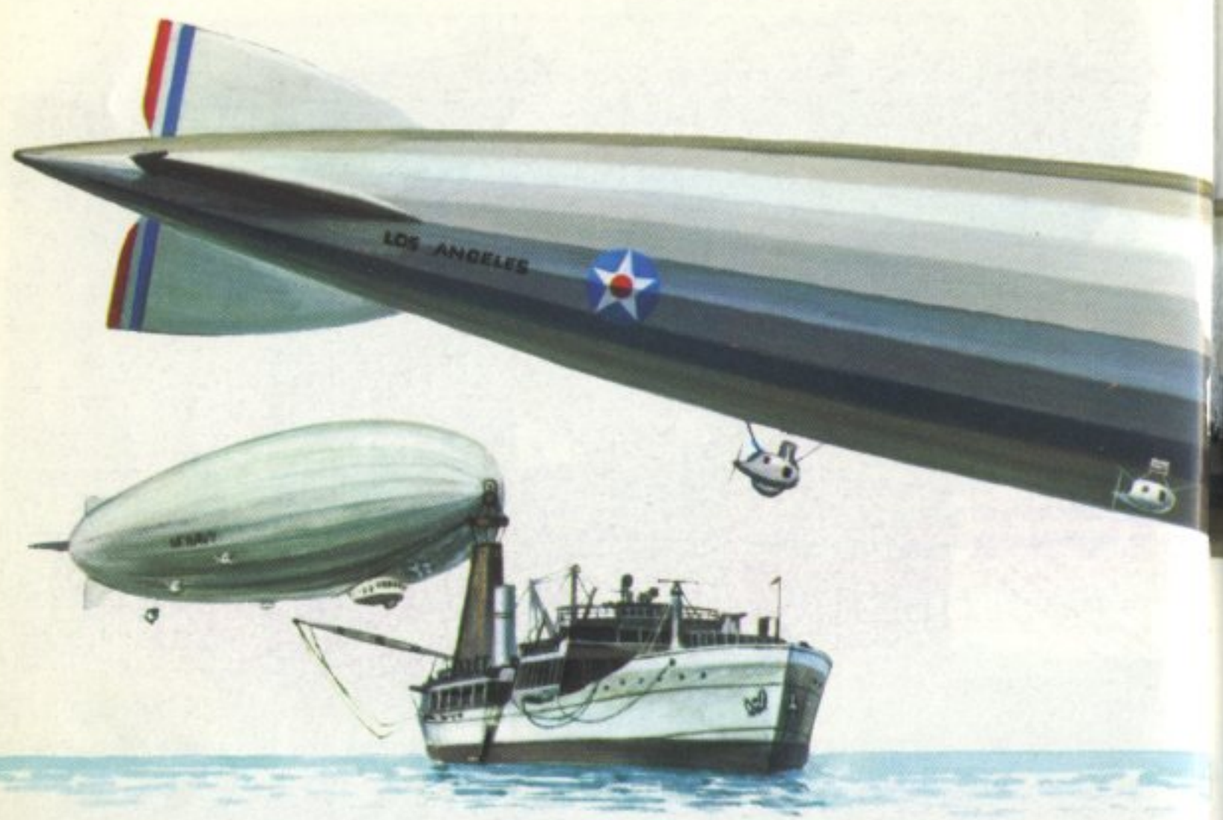
Shenandoah

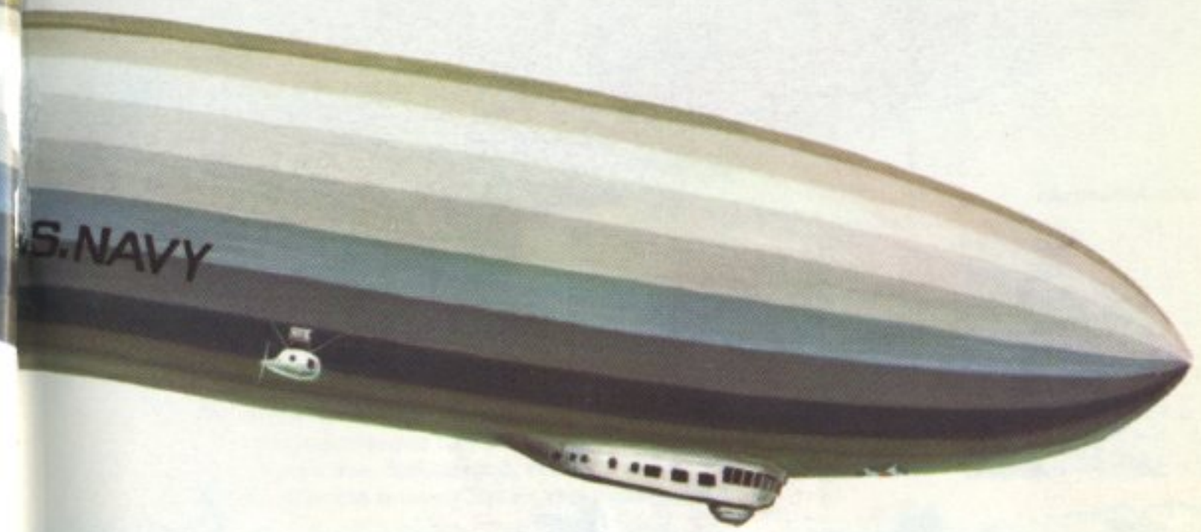


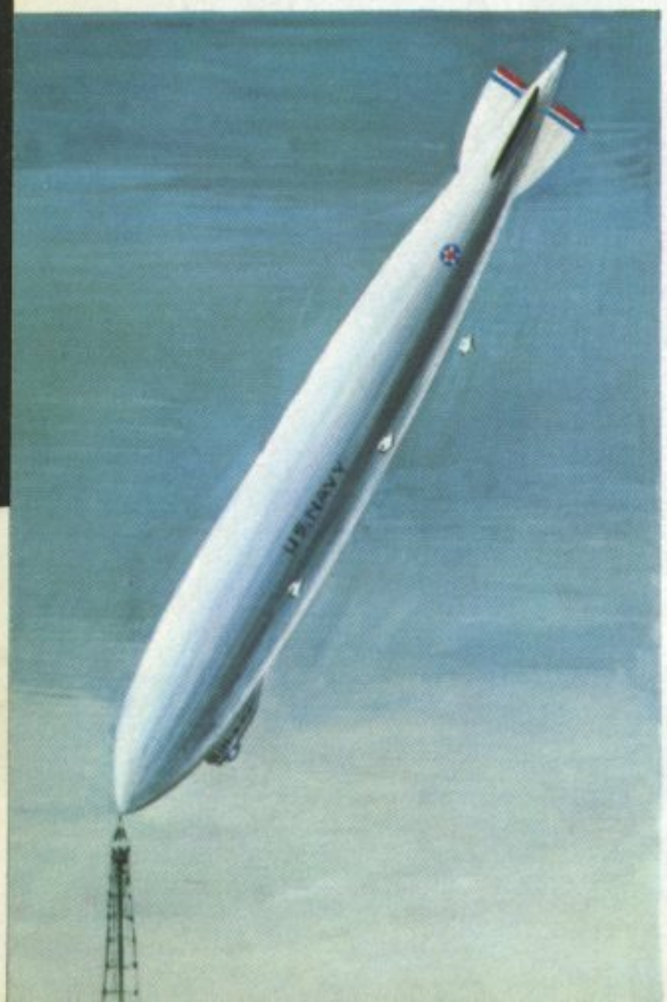
57 The U.S. Navy's airship ZR-1 *Shenandoah* was the first of the rigid type to be built in America and made its maiden voyage on 4 September 1923. During a cross-country flight on 3 September 1925 the airship was caught in a violent storm and a squall caused it to break into three parts. Fourteen crew members were killed in the wreckage at Byesville in Ohio, but those in the rear section (right) free-ballooned to a safe landing.

Los Angeles

58 Zeppelin LZ 126 was built at the Friedrichshafen airship yard for the U.S. Navy, designated ZR-3 named *Los Angeles* and flown across the Atlantic in October 1924 to the Lakehurst air station in New Jersey. *Los Angeles* was the peak airship achievement for its day and rendered many years of distinguished service. It was retired in 1932, though later it was recommissioned for a short period for experiments with 'hook-on' fighter biplanes. It was finally scrapped in 1939. *Bottom left:* A nose stand by ZR-3 on top of its mooring mast, resulting from a shift in both the direction and force of the wind one summer day in 1926. *Bottom centre:* Because of the fire hazard with hydrogen-filled airships, all control cars and engines were mounted outside the envelope. *Bottom right:* Centre gangway in the passenger section of *Los Angeles*.







Norge

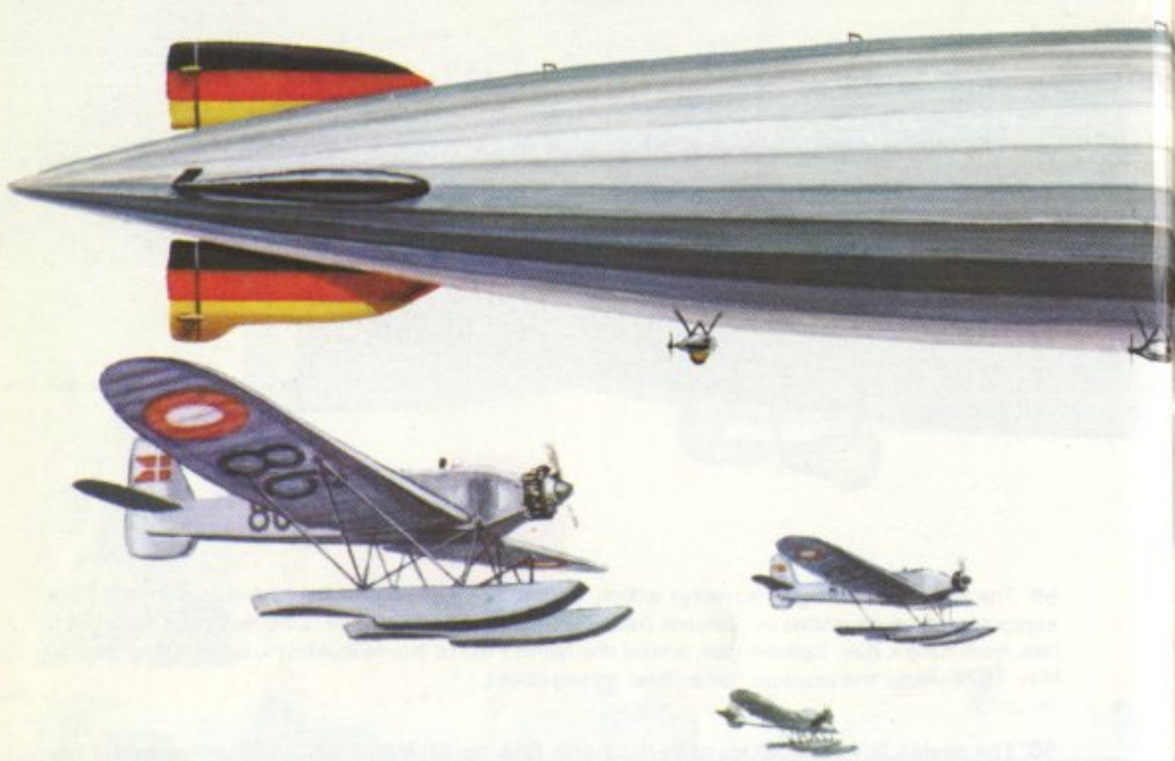
Italia

Roald Amundsen

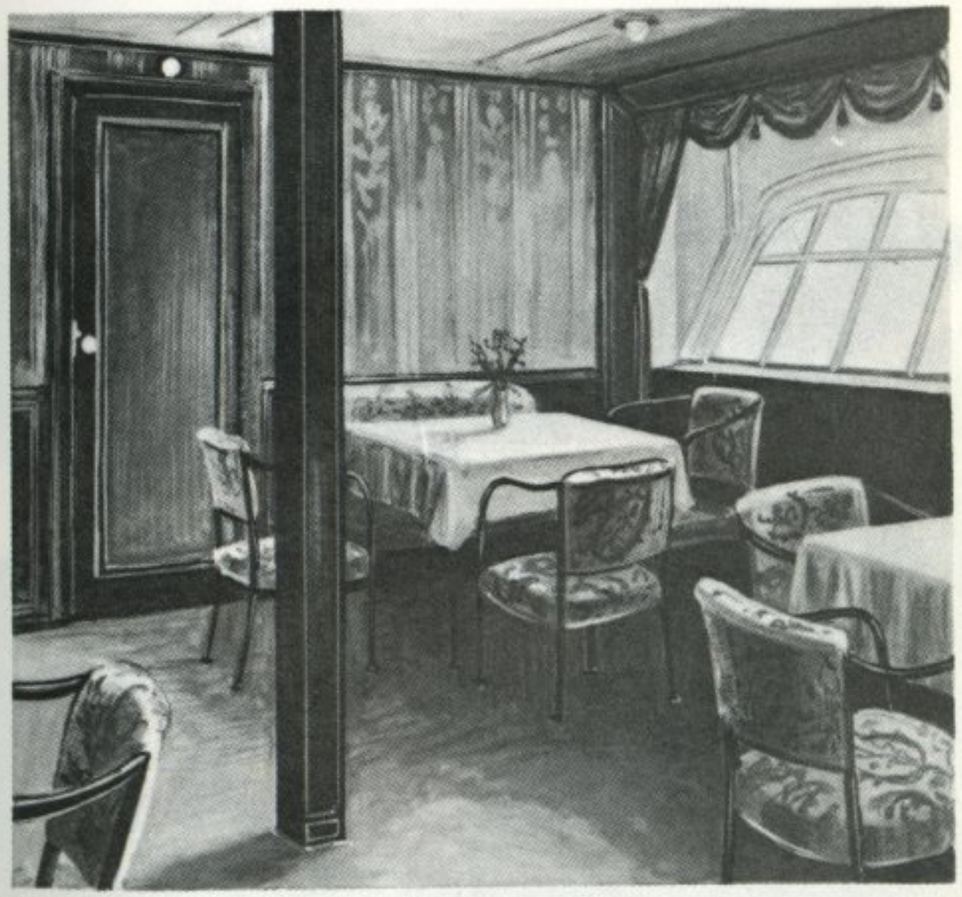
Umberto Nobile

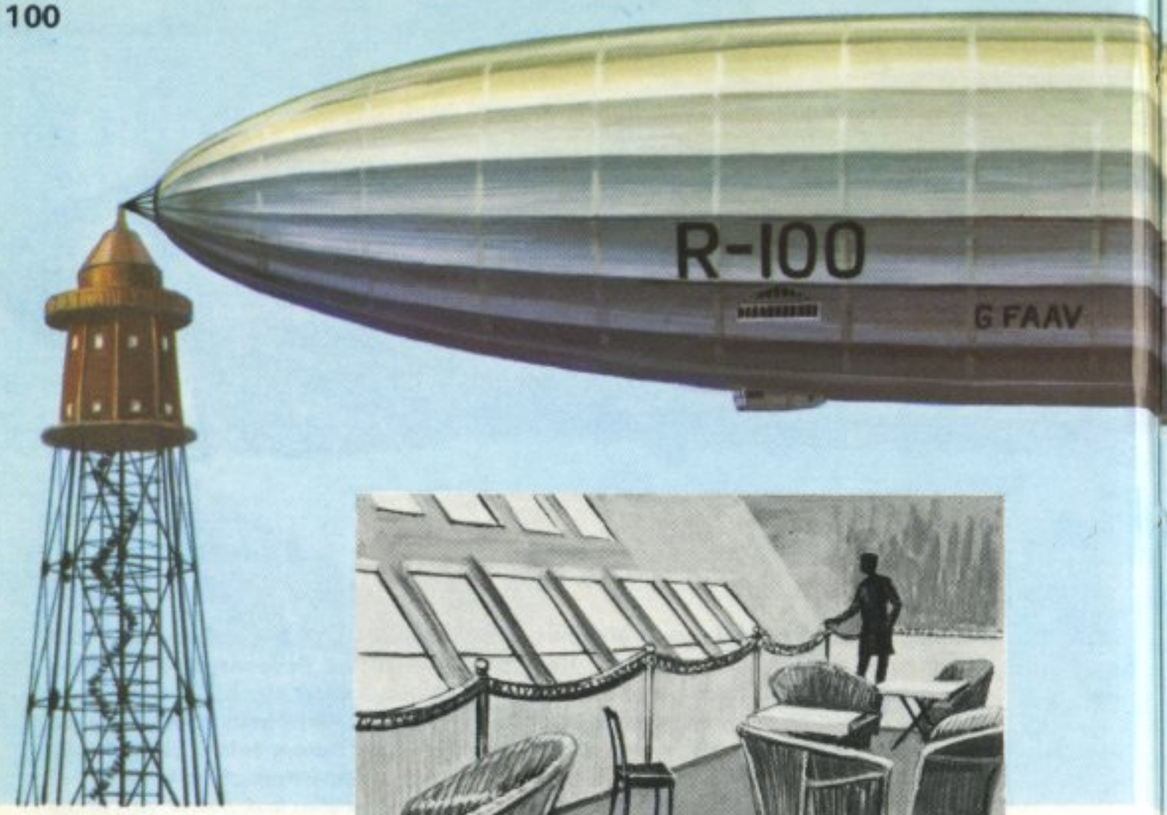
59 The airship N 1 *Norge* (Norway) which, under the leadership of Roald Amundsen, the Polar explorer, and commanded by Colonel (later General) Umberto Nobile, who designed the airship, flew from King's Bay, Spitsbergen, across the North Pole to Nome in Alaska, between 11 and 14 May 1926. Note the unusual Italian keel arrangement.

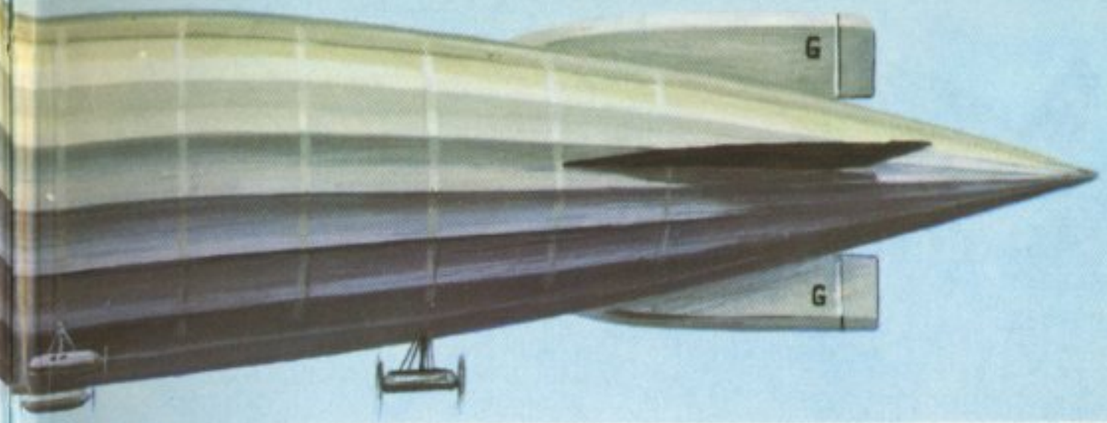
60 The airship N 4 *Italia* en route to the North Pole on 23 May 1928, commanded by General Nobile. On 25 May the airship collided with the ice and the control car was torn off. The rest of the ill-fated airship disappeared forever. *Left:* The survivors of the disaster in their red tent on the floating patch of ice.



61 Zeppelin LZ 127 *Graf Zeppelin* was the world's first truly efficient passenger airship and toured many parts of four continents. Here it is depicted over Copenhagen on 14 May 1931 escorted by a squadron of Danish naval seaplanes. A great number of passengers had been carried on many air voyages when this airship was retired in its home port shed at the Rhein-Main air base, where it still attracted many visitors before being finally dismantled in May 1940. *Below left:* The partly-assembled framework of the huge hull of LZ 127 during construction at the Zeppelin yard in Friedrichshafen and, *below*, part of the dining room.

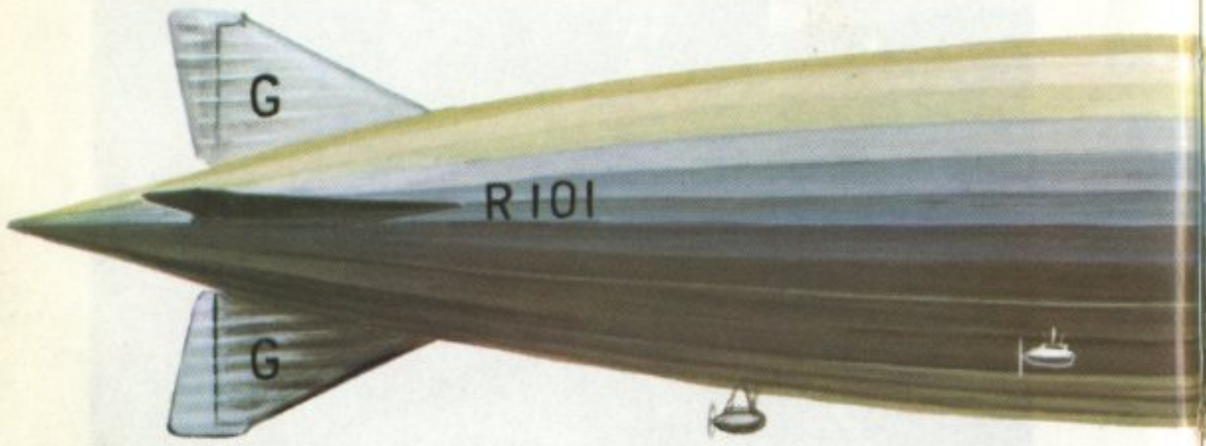




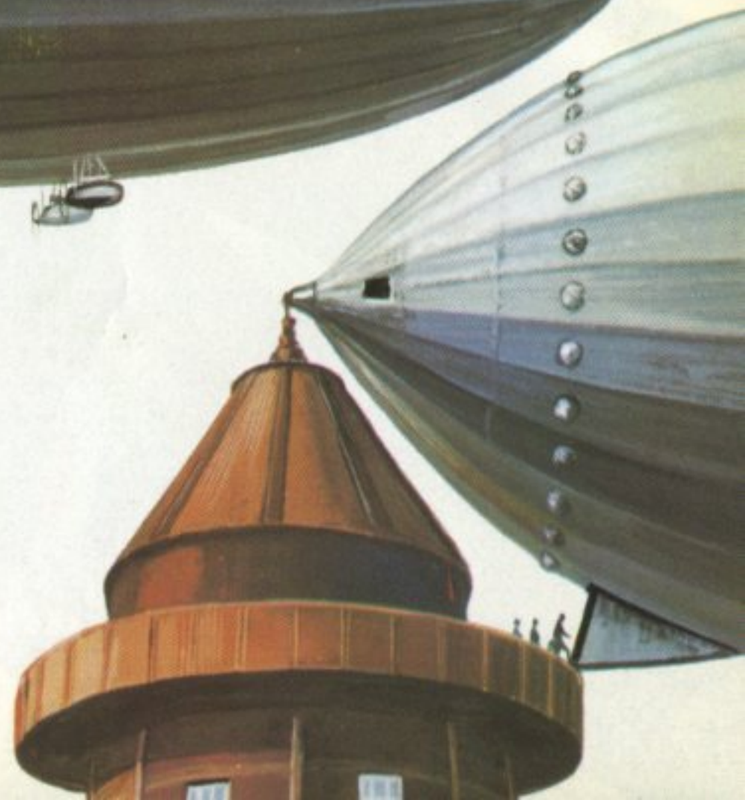


62 The passenger airship R 100 built by the Airship Guarantee Company in Howden and completed in 1928. This airship made several successful trips, including a double crossing of the Atlantic to Canada, but was dismantled in 1931. The inset shows a section of the passenger saloon.

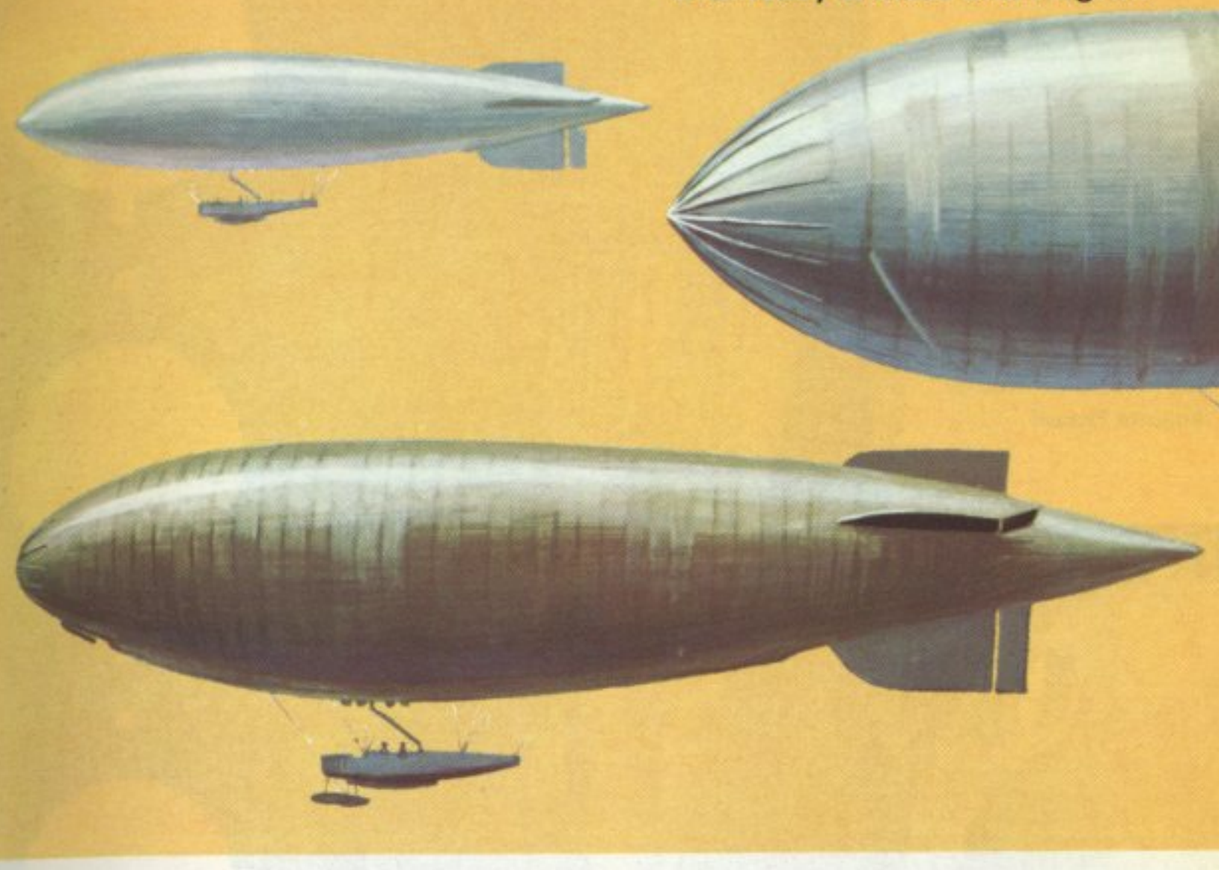
63 The passenger airship R 101 was built at the Cardington airship works of the British government and was completed in 1928. Without ample previous trial runs this airship left on an ill-considered flight to India on 5 October 1930. At Beauvais in France it struck the ground, caught fire and was totally destroyed. Among those losing their lives in this disaster was the chief designer of the airship, Lt Col V. C. Richmond. *Bottom right:* The airship fastened to its mooring mast at Cardington.



V. C. Richmond



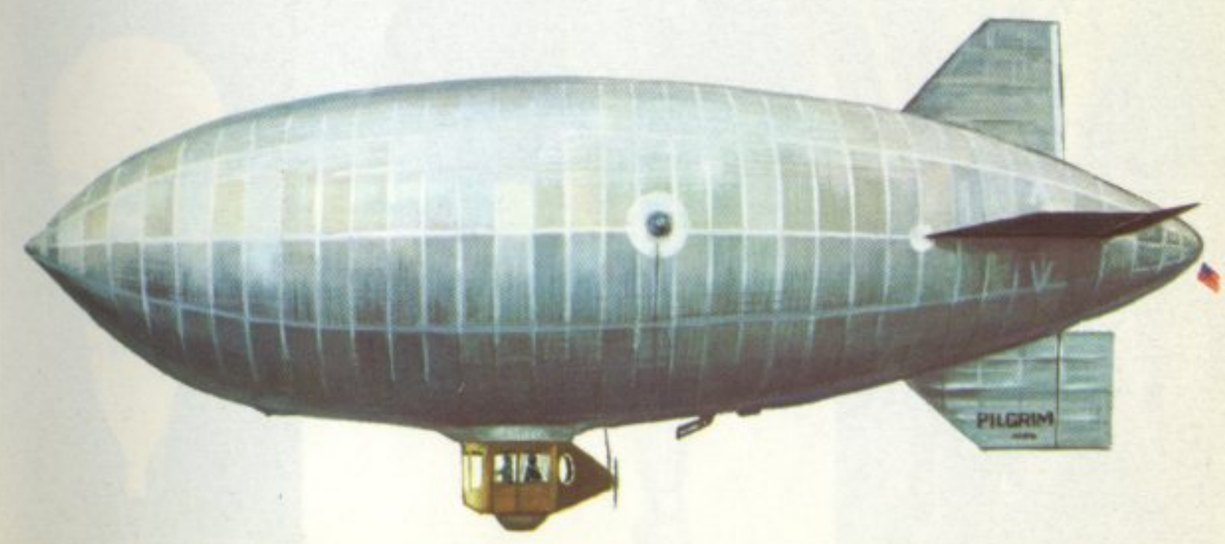
U.S. Navy B class and Pilgrim



64 The metal-clad, helium-filled ZMC-2 airship was acquired by the U.S. Navy in 1929 as an experiment. It was in service a full decade without ever being involved in any mishaps. *Bottom left:* rear of ZMC-2 showing the stabilising fins.

65 U.S. Navy B class coast patrol airships of 1917/18. They were of the non-rigid type like the British Blimps and proved so successful that the larger and faster C class was based on them.

66 Goodyear's famous *Pilgrim* of 1925 was the first non-rigid airship to be fitted with an enclosed cabin integrally attached to the envelope. It was also the first of this company's fleet of many airships to be filled with helium.



Piccard

Auguste Piccard

67 Professor Auguste Piccard takes off with his assistant, Dr Max Cosyns, on his record ascent to an altitude of 54,790 ft (16,700 m) from the Dübendorf airport at Zürich on 18 August 1932. This balloon was designed specially for the high altitudes it was intended for; the diagram on the *right* shows how it gradually assumed its final shape.

Explorer II

A. W. Stevens

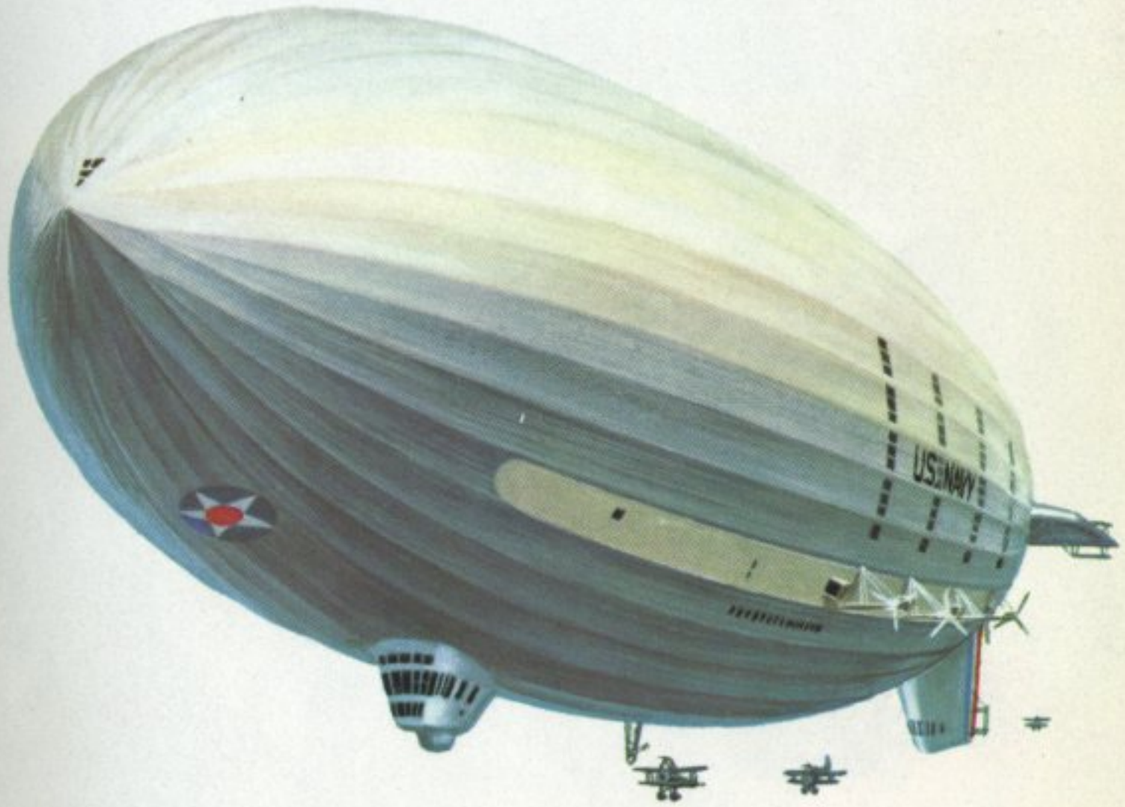
O. A. Anderson

68 The American stratosphere balloon *Explorer II,* manned by Captains A. W. Stevens and O. A. Anderson, reached a record altitude of 74,186 ft (22,612 m). *Right:* the car of *Explorer II* with the 40 ballast bags filled with lead. The packed emergency parachute can be seen at *top left.*

Akron

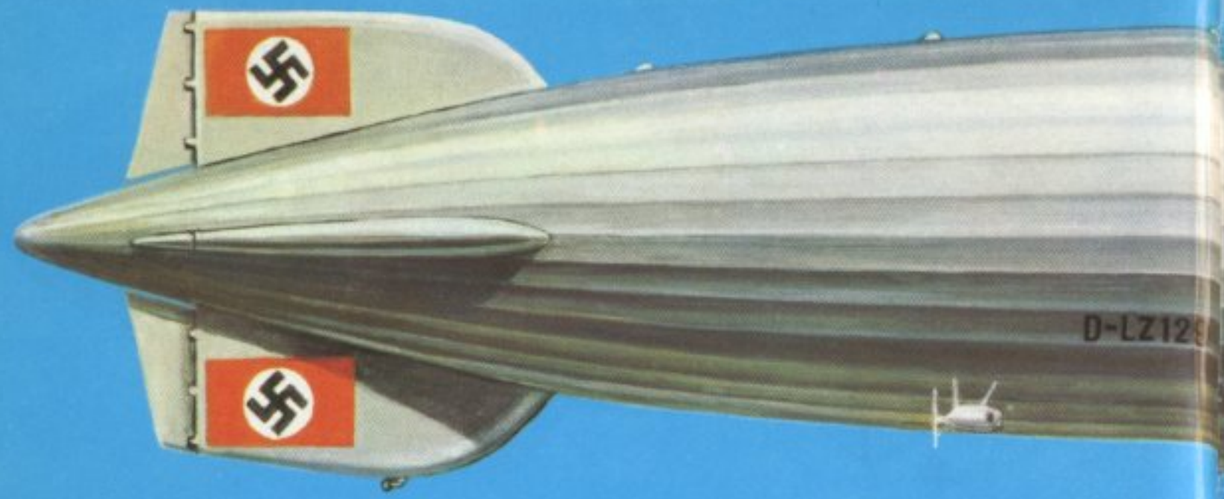
Macon

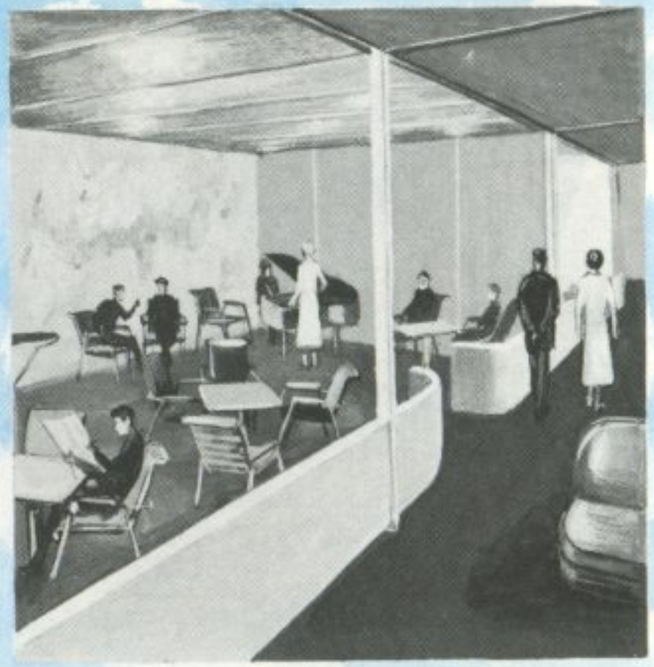
Charles E. Rosendahl

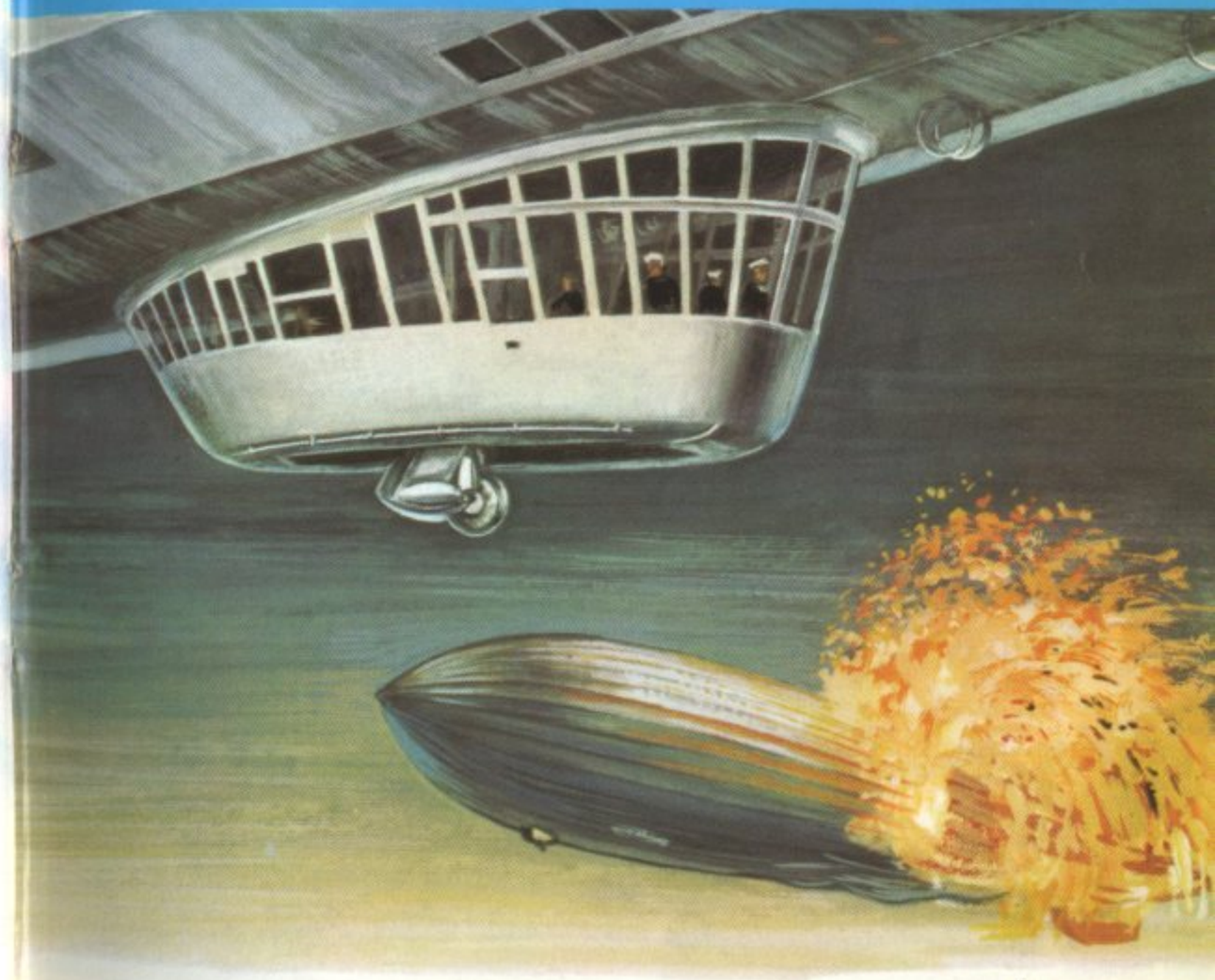


69 U.S. Navy airship ZRS-4 *Akron* was completed in September 1931. It was first under the command of Lieutenant Commander Charles E. Rosendahl, and carried four small Curtiss Fgc Sparrowhawk scouting biplanes which were released and later picked up again without any difficulties. This airship was considered a valuable addition to the other fleet units. *Akron* was lost at sea and 73 members of the crew lost their lives when the airship sank during a violent storm on the night of 3-4 April 1933.

70 U.S. Navy airship *Macon* was completed in April 1933. It participated in a number of fleet manoeuvres, but on 11 February 1935 was forced down at sea off the coast of California due to earlier, untreated structural damage; all aboard, except two, were rescued. *Macon* also served as an aircraft carrier and *opposite* is shown one of its Curtiss F9C Sparrowhawks hooked on to the 'trapeze' extending below the airship.







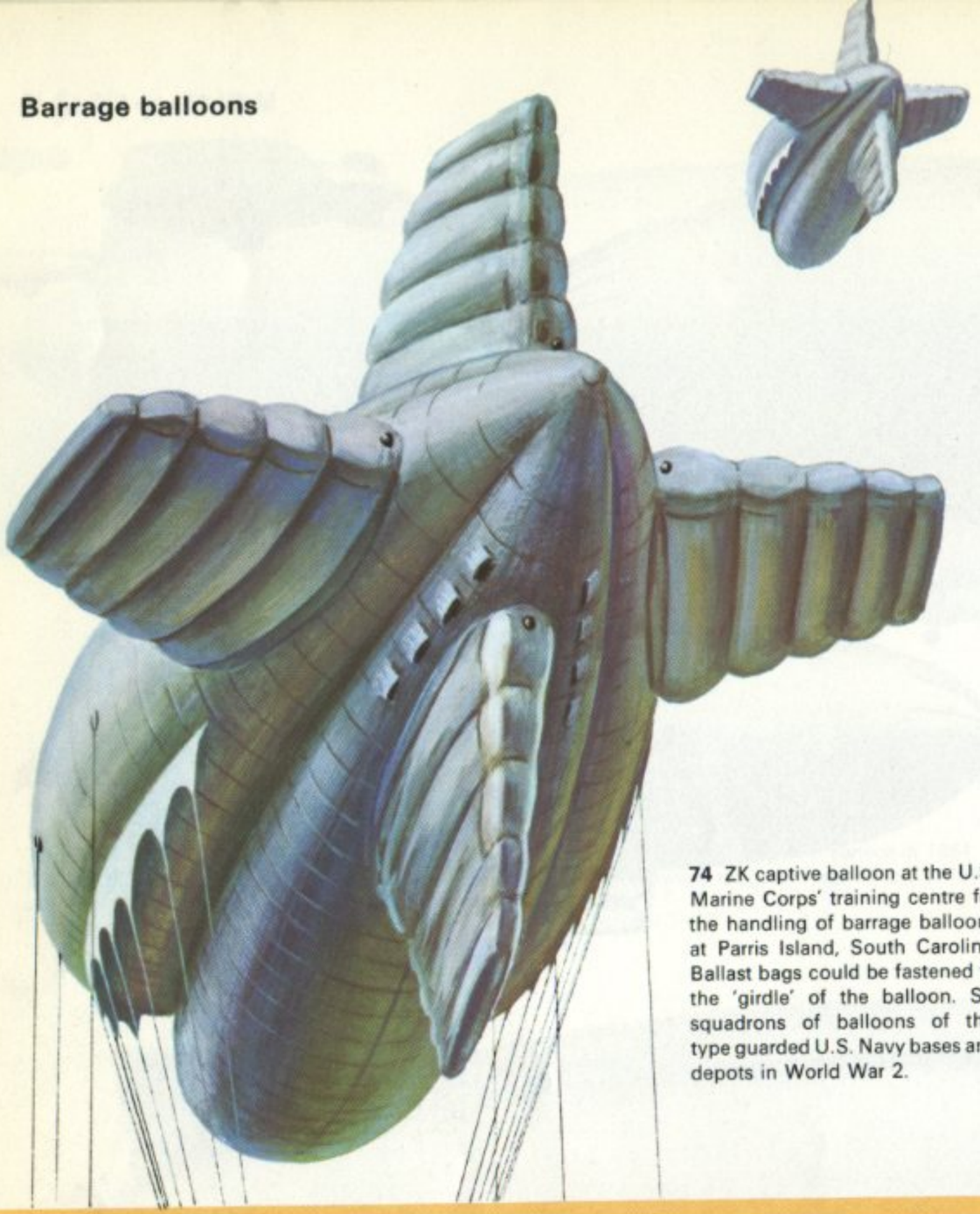
71 The passenger airship Zeppelin LZ 129 *Hindenburg* was the world's largest airship and was built expressly for trans-Atlantic operations. Its one weak feature eventually sealed the fate of this airship: it was filled with inflammable hydrogen instead of with helium, as planned. *Above:* One of the port engine cars and a view of the passenger lounge. *Opposite:* The disaster at Lakehurst on 6 May 1937.

U.S. Navy K class

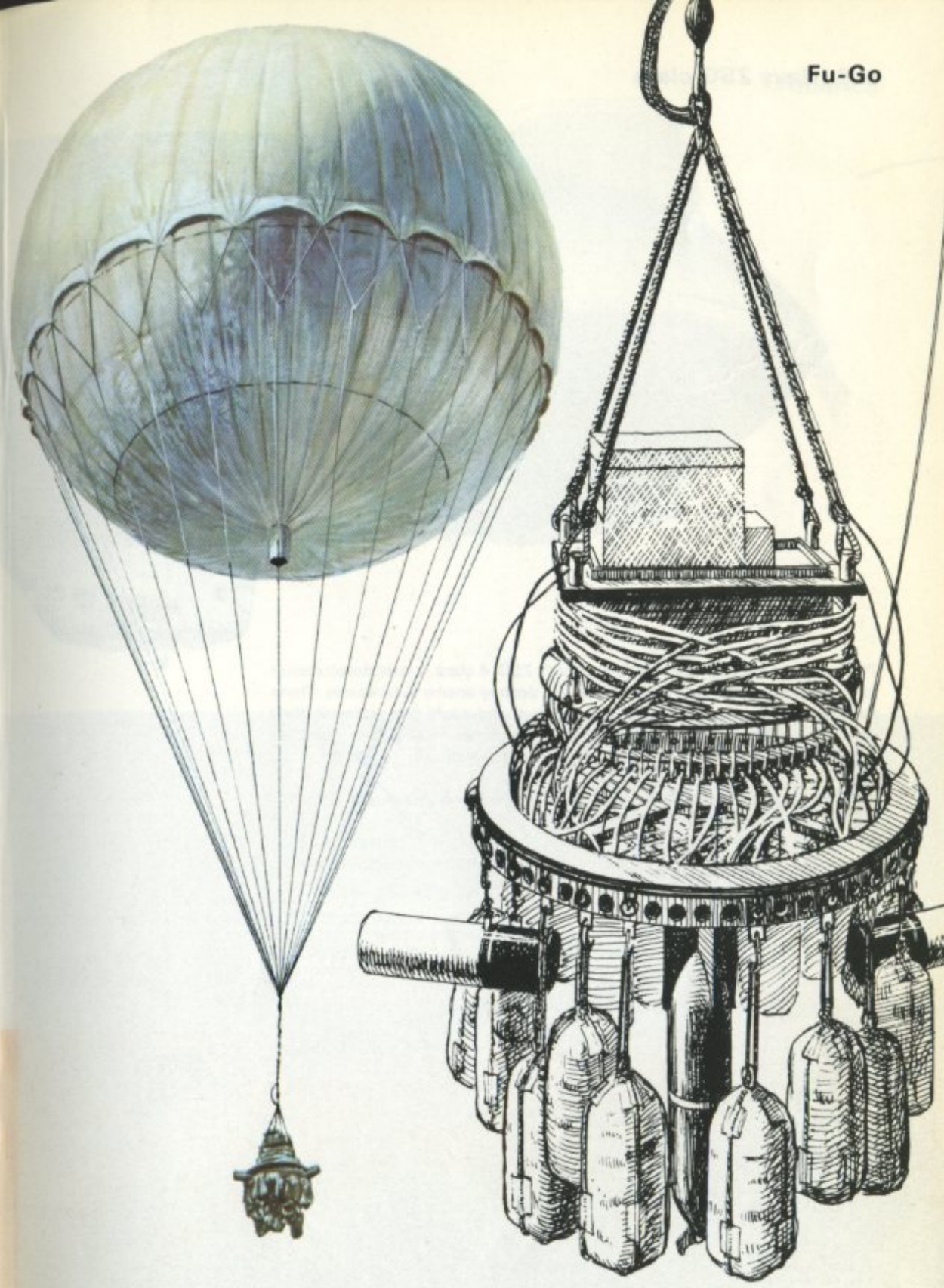
U.S. Navy N class

72 Patrol airship of the U.S. Navy's K class, which in World War 2 were used as convoy escorts and to shadow enemy submarines. *Opposite:* The training airship L-8 of the U.S. Navy's L class; it was the former Goodyear advertising airship *Ranger* which was taken over by the Navy during the war.

73 Patrol airship ZPN-1 belonged to the N class of the U.S. Navy and entered naval service in 1951. It became the prototype of a series of patrol airships with extra-long cruising range and endurance; in 1957, one N class airship stayed aloft for 264 hours.



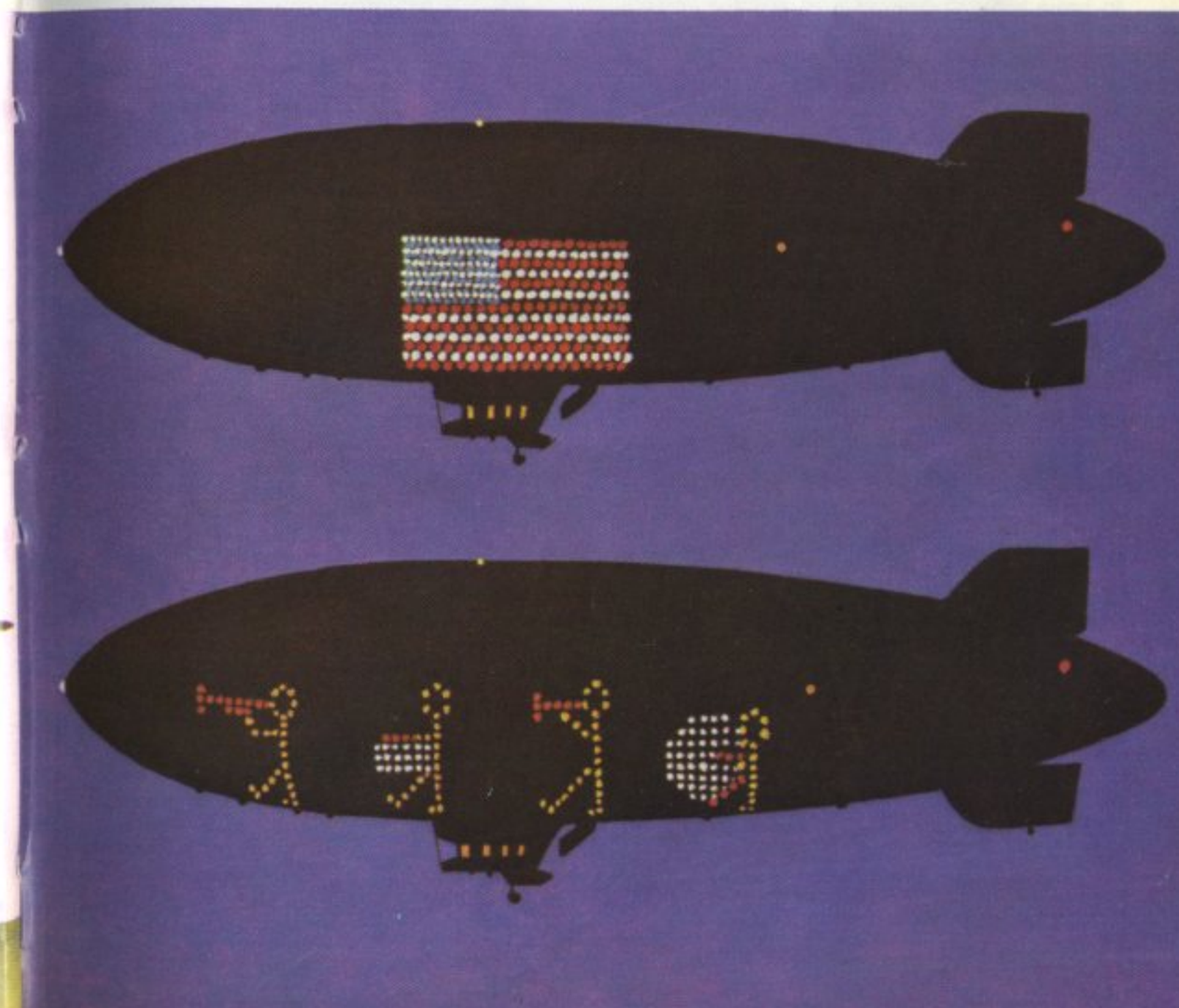
74 ZK captive balloon at the U.S. Marine Corps' training centre for the handling of barrage balloons at Parris Island, South Carolina. Ballast bags could be fastened to the 'girdle' of the balloon. Six squadrons of balloons of this type guarded U.S. Navy bases and depots in World War 2.



75 The Japanese 'Fu-Go' weapon of World War 2. During the last months of the war thousands of these balloon bombs were released in Japan when the wind was favourable. When the balloons had crossed the Pacific Ocean an ingenious system released their death-dealing load over the United States. *Right:* A close-up view of the control equipment of the 'Fu-Go' weapon and the mounting of its fire-bombs, percussion shells and ballast bags.

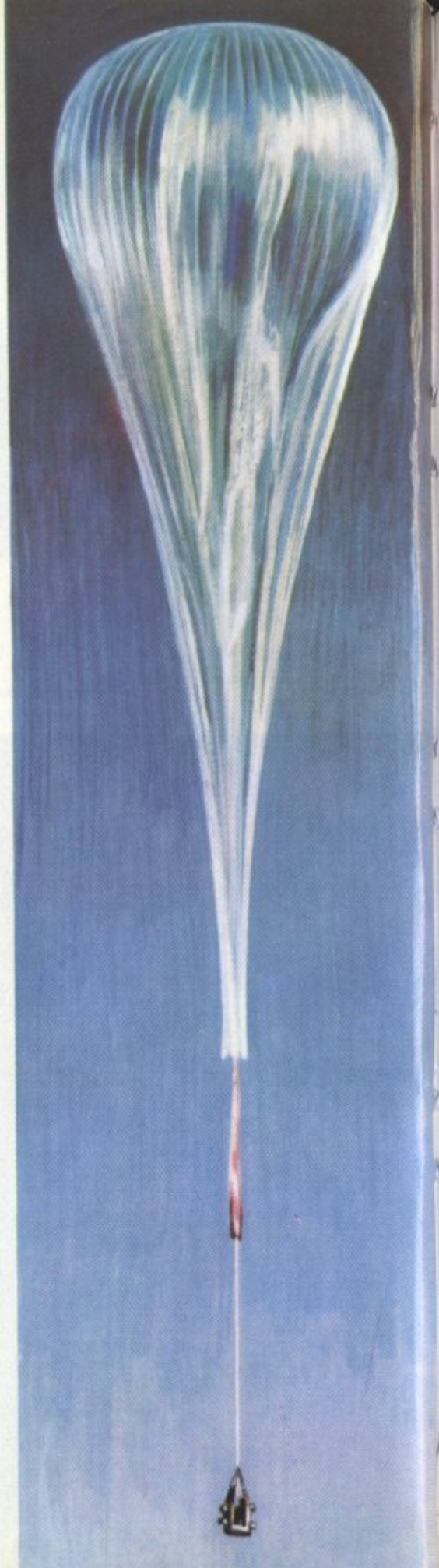
76 Experimental airship of the U.S. Navy's ZSG-4 class, a later development of the K class whose task was to track and destroy enemy submarines. These airships were fitted with refuelling equipment and could also replenish their water ballast in the air. They were also fitted with electrically driven winches permitting a complete change of crews without landing.

77 The advertising airship *America*, built by Goodyear Aerospace Corporation was completed in April 1969. Moving-picture style advertisements can be displayed in the skies at night by means of the so-called 'Super Skytacular' equipment which comprises 7,560 electric light bulbs of different colours that are mounted on both sides of the envelope.



Excelsior III

78 The stratosphere balloon *Excelsior III* of the U.S. Air Force in which, on 16 August 1960, Captain Joseph W. Kittinger ascended to an altitude of 102,886 ft (31,360 m) then jumped by parachute to begin his long descent. This was the longest-lasting parachute jump in the world and its purpose was to investigate the conditions to which future astronauts would be exposed while returning to Earth. *Below:* Kittinger in pressure suit and helmet.



Jambo

79 The hydrogen-filled balloon *Jambo* in which the British zoologist and journalist Anthony Smith, photographer Alan Root from Kenya and another companion took off from Zanzibar in early 1963 on a balloon trip of several weeks' duration across East Africa to the Serengeti National Park in Tanganyika. Their aim was to photograph the wildlife of the African plains from their silent craft.

Don Piccard

80 Modern balloon of the sporting type, manufactured by Don Piccard. The supporting air is heated by means of a propane gas burner. This style has become quite popular in recent years; neither sandbags nor a valve are required. Events have now come a full circle, for this is a return to the hot-air balloon of 1783.

1 The Montgolfier brothers – inventors of the man-carrying hot-air balloon

The brothers Joseph and Étienne Montgolfier came from Vidalon-les-Annonay, near Lyons, a small town in southern France. Joseph (1740–1810) was the first to become interested in aeronautical matters. This led to his making some small parachutes and he also pondered how to produce an 'air machine' to be filled with a gas lighter than atmospheric air. His brother Étienne (1745–1799) trained as an architect in Paris, and was then asked by his father to settle in Vidalon to take over and manage, jointly with his brother, the paper mill owned by the family. Joseph's ideas soon attracted him and together the brothers began to carry out a number of experiments with small balloons made of paper, which they filled with steam; for from observation of cloud formations they had concluded that these provided a means of producing lifting power. However, they soon dropped the idea of proceeding along these lines since the balloons collapsed almost immediately.

The two Montgolfier brothers had read the essay of the English physicist Joseph Priestley containing his observations about various gases, particularly hydrogen (or, as it was then called, 'inflammable air'). By observing the rising smoke and sparks from a fireplace, however, the Montgolfiers were of the opinion that there must be an easier way of making a balloon rise. They assumed that in the process of burning some sort of gas was produced which occasionally became visible as smoke, but this was an erroneous deduction. What actually takes place is that air expands as it is heated, whereby its specific gravity is lowered. Though the brothers did not realise why the heated air acted as it did they continued to conduct new experiments with model balloons filled with hot air that obligingly rose in the air. Their source of heat was a mixture of burning wool and moist straw, placed below the opening and pointing downwards. In this manner they produced what they termed 'electric smoke'. Without realising it at the time they had instinctively stumbled on to the correct solution. One day in December of 1782 a 706 cu.ft (20 cu.m) balloon they had made climbed to an altitude of 985 ft (300 m).

In time the French Académie des Sciences in Paris learned of these experiments and requested a demonstration in Annonay. This took place on 4 June 1783 when the Montgolfier brothers let a 28,252 cu.ft (800 cu.m) balloon ascend to an altitude of about 460 ft (140 m). Before its release this balloon had developed such a lifting capacity that eight strong men could scarcely restrain it. This successful experiment reverberated in scientific circles throughout Europe, so the Académie in Paris now asked for a demonstration in the French capital. However, here Charles stole a march on the Montgolfiers with his hydrogen balloon *Globe* (see No. 2), and Étienne (who was staying in Paris at the time to prepare the demonstration by himself and his brother) witnessed the other event. Soon it became their turn.

The Montgolfier brothers were assisted by their friend and fellow paper-manufacturer Reveillon, and turned up with a large and beautifully decorated balloon which was 74·15 ft (22·6 m) tall and 42·65 ft (130 m) in diameter. It was decided first to make a captive trial ascent, which took place on 14th September 1783 at Reveillon's garden in Rue de Montreuil, Faubourg Saint-Antoine. Everything went well until a storm broke out and the ensuing rain destroyed the balloon com-

pletely. The situation was now critical, for the brothers were about to demonstrate their skill before King Louis XVI and his court in Versailles. The situation was retrieved by working around the clock and soon a stronger and simpler balloon had been built. It was 57 ft (17·4 m) high, 41 ft (12·5 m) in diameter and its volume amounted to 35,315 cu.ft (1,000 cu.m). Like its predecessor it was splendidly decorated in blue and gold. After a captive test at the Reveillon factory on 18 September the balloon was taken the next day to Versailles.

The Montgolfier brothers had long intended to let some men ascend in their balloon on its first free trip, but here they met with the vigorous opposition of the king. It was therefore decided to grant a sheep, a rooster and a duck the honour of becoming the first air travellers. The animals were placed in a basket below the balloon, which rose from a platform in the palace yard on 19 September 1783. The king, with Queen Marie Antoinette, watched the filling of the balloon at close quarters until the ill-smelling clouds of smoke drove them back. The filling was completed in less than ten minutes, which was very fast compared to the long time required to produce a comparable quantity of hydrogen. After the last of three cannon shots had been fired (they were to become a tradition at the balloon ascents of that period) the balloon rose majestically and floated away, accompanied by many cheers. It must have been a fantastic sight, with the abundantly embellished balloon, the picturesque dresses of the spectators and, not least, the beautiful castle in its wonderful setting. Astronomers present with their telescopes were able to report that the balloon had climbed to an altitude of slightly more that 1,640 ft (500 m) before it landed eight minutes later in the Vaucresson forest about 2½ miles (4 km) away. The landing burst open the basket and the dazed animals escaped virtually unharmed.

This happy success and ending opened the obvious road to a manned balloon ascent. First it was contended that a condemned criminal should be reprieved in return for being placed in the balloon basket as a human guinea-pig, but a young French scientist named Jean-Francois Pilâtre de Rozier (1754–1785) came forward as a volunteer and succeeded in persuading the king that it ill behoved humanity if the honour of being the first to have risen into the air should be accorded to a criminal. So now a really large balloon, of 56,500 cu.ft (1,600 cu.m) volume, was built; it was 75·5 ft (23 m) tall, with a diameter of 50·9 ft (15·5 m). Below the balloon was a gallery where the aeronaut could stand to feed the fire in the pan – a sort of iron basket placed in the open neck of the balloon. First, some captive attempts were made, by taking a source of heat along on the ascent on 15, 17 and 19 October 1783. On the last of these occasions de Rozier first carried an acquaintance, Giroud de Vilette, as a passenger, then had François-Laurent, Marquis d'Arlandes, a captain in the infantry, along with him. The latter was also to accompany de Rozier on the eventual free flight.

Thereafter the balloon was conveyed from Reveillon's garden in the Rue de Montreuil to the Château La Muette in the Bois de Boulogne outside Paris whence the historical ascent was to be made. In the morning of 21 November the lifting capacity of the tethered balloon was tested once more and estimated to amount to about 1,708 lb (775 kg). Misfortune was barely avoided when the balloon was caught by a strong gust of wind and damaged before it could be brought back to the platform. Its two occupants remained

unperturbed, but the large crowd of spectators grew impatient and shouted threats; but with the willing help of many volunteers and clever seamstresses the balloon was repaired and ready again within two hours.

Most of those present doubted that the ascent would succeed. One of the spectators, the Duc de Chartres, inquired of de Rozier in a worried whisper: 'I do not suppose you will take off?', only to be assured, 'Indeed I shall'. Action soon followed the words. With the balloon ready once more, the intrepid aeronauts again climbed on board the gallery. At 1.54 p.m. all moorings were released and the balloon began to climb slowly; it was slightly cloudy. D'Arlandes commented later: 'The silence surrounding us surprised me, so I waved my handkerchief at the crowd.' This was criticised by Rozier, who exclaimed: 'You are doing nothing, and we are barely climbing at all.' Soon they caught a feeble north-westerly wind and crossed the Seine at a low altitude, then passed between the military academy and Les Invalides. They fed the fire some more straw to prevent a descent among the houses in Rue de Sèvre and continued their air voyage. However, holes began to appear in the paper and fabric covering the balloon, caused by the many sparks from the fire pan, so the two men decided to look for a landing site. Meanwhile, they were kept busy dousing the fire with sponges dipped in pails of water that fortunately they had been far-sighted enough to bring along. Twenty-five minutes after their take-off the balloon touched the ground again at Butte-aux-Cailles, nowadays known as the Place d'Italie.

With this exploit de Rozier and d'Arlandes go down in history as the first two human beings to rise in the air. In time many more ascents were made with the 'Montgolfière' type of balloon and, admittedly, it is a wonder that they caused no loss of lives, for often these hot-air balloons were forced to land after being more or less severely damaged by fire. Joseph was the only one of the Montgolfier brothers who ever took to the air himself, and he made but one ascent. This occurred at Lyons on 19 January 1784 when he, de Rozier and five other passengers made a trip in his large and very handsome balloon *Le Flesselles*.

The Montgolfier brothers are the indisputable pioneers in the field of man-carrying balloons, yet after several near-disasters with hot-air balloons it was already evident in 1784 that the competing hydrogen balloon, the 'Charlière', was the coming type because it was safer.

2 J. A. C. Charles – the inventor of the hydrogen balloon

The balloon experiments of the Montgolfier brothers (see No. 1) aroused much excitement in French scientific circles and the Académie in Paris invited them to the capital of France for a demonstration there. Before this came about, however, one of the youngest and most promising members of the Academy, the physicist Jacques Alexandre César Charles (1746–1823), offered to turn out a balloon in co-operation with two skilled engineers and craftsmen, the Robert brothers. The Academy accepted this offer and money was collected for the building of a relatively small spherical balloon, of 13·1 ft (4 m) diameter, with an envelope made of rubberised silk, and for the equipment with which to develop the newly-discovered gas, hydrogen. For the intended filling of the balloon about 2,100 cu.ft (60 cu.m) of the gas would be required, and this quantity was to be procured by pouring sulphuric acid and water on to iron filings in a barrel. The resulting hydro-

gen was to be fed to the balloon through a connecting hose from the barrel. Several associated difficulties, such as the high heat and steam also created, had first to be surmounted, after which Charles fixed the date for the first ascent of his balloon, which he named *Globe*.

The ascent was to take place on 27 August 1783 from the Champ de Mars in Paris, where the Eiffel Tower is now located. On the previous night the balloon was transferred there from the workshop at Place des Victoires, but the ascent first planned had to be abandoned because the crowds which were expected to congregate there would have been too large.

When the balloon ascended, practically all the inhabitants of Paris, headed by the members of the Academy, seemed to have gathered to witness the event. After some supplementary gas had been added to the *Globe* the firing of a gun announced that the balloon was about to ascend. It took off during a shower and disappeared behind the roofs in a north-easterly direction. Three-quarters of an hour later the balloon landed in the small village of Gonesse, some six miles (9½ km) away from Paris, and there caused great consternation. The frightened farmers took the balloon for a monster and attacked it with pitchforks, scythes and blunderbusses.

Some months later Charles and the Robert brothers were ready with another balloon which could carry two men, but by then de Rozier and d'Arlandes had already been aloft in their hot-air balloon. However, the other team had been far-seeing and meanwhile made such progress that the gas-filled balloon they had now created, with a diameter of 26·75 ft (8·15 m), was perfected at once except for minor alterations and has remained the standard type in use throughout the centuries. The new, large balloon was now provided with an open neck serving as a safety valve, which *Globe* had lacked. Deservedly, the name of the inventor is perpetuated in the 'Charlière' descriptive term bestowed on the gas-filled balloon.

The passenger-carrying basket was shaped and decorated after the fashions of its day, somewhat after the style of the small cars found in today's merry-go-rounds. It must have been quite a problem how to suspend these fancy, but rather unpractical, gondolas properly from the balloon envelope.

The balloon ascent of Charles, accompanied by the elder of the Robert brothers, Marie-Noël, started from the Tuileries Gardens on 1 December 1783 and was witnessed by some 400,000 people. The American scientist and statesman, Benjamin Franklin, was among those who witnessed the glorious spectacle.

In spite of the advanced season the weather was favourable for a balloon ascent. Charles inaugurated the sensible practice of launching a small pilot balloon (his was of a bright green colour, hence long visible) prior to his own ascent to give him an idea in which direction, and how strongly, the wind was blowing. As a courteous deference to Joseph Montgolfier, who was in the crowd, he asked the latter to release the small pilot balloon.

After a gun-shot had announced that the balloon was ready to take off, it rose successfully at 1.45 p.m. to the accompaniment of cheering shouts from the crowds. Two hours later the two men floated at an altitude of 820 ft (25 m) south-west of Paris. At sunset Charles decided to descend in a field near the small town of Nesles, some 31 miles (50 km) from the French capital. It was a smooth landing, and there were plenty of willing helpers to hold the basket on the ground. One of

the first to arrive was the Duc de Chartres who, with friends, had pursued the balloon on horseback. Charles wrote a brief account of the balloon trip and the landing was duly certified by the local authorities.

The sun was down by now, but Charles was in such high spirits after his adventures during the day that he decided to ascend once more, but this time alone because the balloon had lost some of its hydrogen. In spite of this the balloon climbed rapidly, attaining an altitude of about 9,840 ft (3,000 m), where Charles caught his second glimpse of the sun that day. His ears began to ache badly, so he hurriedly valved gas, whereupon the balloon began to descend. Charles threw out some ballast and then landed gently near Tour du Lay, not very far from Nesles, after having stayed in the air for about half an hour the second time. The following day the balloon was returned to Paris in triumph.

In spite of this successful first trip, Charles never made another balloon ascent. His second venture into the upper air regions had likely been too much of an experience.

It remains only to report that Charles and the Robert brothers also built an elongated balloon ordered by the Duc de Chartres, who had become a keen balloon enthusiast. The duke almost paid for this balloon with his life as, strangely enough, it was not equipped with a safety valve.

3 The balloon ascents of Vincenzo Lunardi in Great Britain

Vincenzo Lunardi made the first balloon ascent in Great Britain on 15 September 1784. Lunardi was born at Lucca in Italy on 11 January 1759 and, after spending his childhood in the East Indies, was at a relatively early age employed by the Neapolitan ambassador in London, Prince Caraminico. Lunardi was then a good-looking, temperamental and vainglorious youngster who soon established himself in the gay and hectic life prevailing in the British capital of that period. He believed that he would become still more attractive by taking up ballooning at a time when the achievements of the French aeronauts were the current topic in fashionable places. Lunardi was a dandy, yet endowed with much common sense and well aware of his lack of knowledge in the new field of aeronautics. For this reason he associated himself with one of his friends, George Biggin, who enjoyed the reputation of being a patron of the arts.

Before the construction of a balloon could be tackled it was necessary to find a suitable place for its ascent. Lunardi first tried to obtain permission to go up from the grounds of the Chelsea Hospital. However, somebody else had already beaten him to it – a Frenchman, de Morel, who had made the first attempt with a whimsical hot-air balloon shaped like a Chinese temple. This monster declined to leave the ground, which disappointed and infuriated the spectators; in their rage they destroyed the balloon as well as some surrounding property. Dr John Sheldon did not fare much better; his captive balloon also was damaged and he abandoned his ascension attempt. It was thus readily understandable when the management of the Chelsea Hospital refused to grant permission for Lunardi to use its grounds for his balloon ascent. However, the commander of the Honourable Artillery Company, Sir Watkin Lewis, finally overcame official reluctance and placed the Moorfields training grounds, on the northern outskirts of London, at Lunardi's disposal – with the proviso that from his collected money an amount of £500 was to be set aside to guarantee coverage of any possible

damage caused and the sum of £100 established as a fund for the benefit of the family of a recently-deceased artillery officer.

Now Lunardi could finally proceed with his arrangements to have built a hydrogen balloon of the Charles type. It was, strangely enough, not fitted with a valve on top and so became dangerous and difficult to handle. The enlarged netting arrangement, on the other hand, introduced a distinct improvement feature, for the cording was reduced first to 'crows' feet' from which the leading cords were fastened to a hoop from which the car was suspended. The car itself also was of a more practical form and devoid of superfluous, heavy ornamentation. The envelope of the balloon was made of oiled silk, and had a diameter of 33·14 ft (10·10 m) which resulted in a volume of 18,200 cu.ft (515 cu.m). A chemist, Dr George Fordyce, was in charge of the filling and also built the equipment for manufacturing the hydrogen.

The ascent took place in the early afternoon of 15 September 1784. It had taken all of the previous night and the whole of the morning to fill the balloon, and the 100,000 or more restless and impatient spectators rendered the task all the more difficult. There was no way of predicting how they might react if kept waiting too long, so the decision was made that Lunardi was to ascend alone in the balloon, which was not yet quite filled, and leave Biggin behind on the ground. Lunardi was accompanied by a dog, a cat and pigeon, and provisions were amply supplied. A special stand had been erected for the Prince of Wales who was present and he tipped his silk hat in deference as the balloon began to rise. Everybody else present followed the royal example. There was a hushed atmosphere of fear and doubt; not a sound was heard.

Lunardi, who had hopes of advancing through the air by rowing, had brought along oars of different shape, one of which broke when he started. But he remained convinced that the oars were instrumental in his reaching a cornfield near North Mimms, some 13 miles (21 km) north of London. Here he landed at 3.30 p.m., divested himself of his remaining ballast and released the cat, which by now was quite benumbed with cold. Though Lunardi throughout the trip had stayed at altitudes of below 1,000 ft (305 m), he had registered temperatures as low as −16°C. Now that the balloon was relieved of some weight it rose again and Lunardi jotted down and dropped a flowery report about the esoteric clouds below him and the sun sparkling the wide landscape. From this it is evident that this time he climbed to a higher altitude. Some thirty minutes later the balloon once more landed softly in a meadow near the town of Ware in Hertfordshire. The scared farmers at first refused to approach this 'devilry' until a girl, who was also present and much impressed by the finely-dressed young gentleman who had descended from the sky in his pretty red- and blue-striped balloon, grasped one of the lines; then the others pitched in to help, though with some hesitance.

This first balloon ascent in Great Britain turned Lunardi into the hero of the hour and, dressed in the honorary uniform of the Artillery, he was presented to King George III. A monument was erected on the spot where Lunardi landed for the second time; its popular name is Long Mead, and it is still there.

Lunardi went on to build larger and better balloons and ascended once more from Moorfields. On this occasion his balloon was decorated with a huge Union Jack, in which manner he 'wished to express his respects and

devotion to everything which the word "British" stands for'. His faithful friend Biggin and a Mrs Letitia Sage, an actress, were to have accompanied him on this trip, but once more the lifting capacity of the balloon was poor, so Lunardi started alone on 13 May 1785. Soon afterwards he had to come down again, near Tottenham Court Road, because the envelope turned out to be leaking. The well-tried patience of Biggin was finally rewarded later that year when, on 29 June, he was able to ascend himself, accompanied by Mrs Sage. This trip lasted an hour and had the distinction of being the first time 'a British female air traveller' had gone aloft. This was the term by which Mrs Sage henceforth liked to be described. She was a beautiful lady, but from a ballooning point of view she unfortunately tipped the scales at 200 lb (91 kg).

Lunardi made several more balloon ascents in Great Britain during 1785, but in August 1786 one of his young assistants lost his life in a tragic accident. During the preparations for an ascent at Newcastle upon Tyne, Ralph Heron was pulled aloft as one arm got entangled in the anchor rope when the balloon took off prematurely. The rope broke and the hapless youngster plunged to his death. Lunardi was not to blame, yet, after the incident, everywhere he went in Great Britain he was now persecuted as intensely as he had previously been acclaimed. He left the country for good, but continued his balloon ascents in Italy, Spain and Portugal. His health later failed, and he died in Portugal on 31 July 1806.

4 Blanchard and Dr Jeffries cross the English Channel by air

Jean-Pierre Blanchard (1753–1809) played a prominent part in the history of ballooning and must be considered the first true professional aeronaut in a period with many other more or (most often) less pure amateurs. Blanchard was born in Normandy of poor parentage and lacked much formal education, but he soon displayed a bent for mechanics. Before long he was attracted by the problems of flight and built a kind of bird-like aerial bicycle with flapping wings – which, however, never did fly. The balloon achievements of the Montgolfier brothers and Charles inspired him to try a combination of the lifting power of the balloon with flapping wings for propulsion. He conducted a number of experiments along these lines in the spring and summer of 1784, but they did not attract much attention. In the autumn of that year he left for London, where he quickly became the central figure in a small group of balloon enthusiasts numbering, among others, the American Dr John Jeffries.

In June 1785 Blanchard carried out the first experiments with parachutes in Great Britain, by dropping from his balloon a small parachute made of silk to which a cat was attached. Afterwards Blanchard maintained that he had made two parachute jumps himself in 1777 and 1793 respectively, but he never substantiated these claims with valid evidence.

Blanchard made his first successful balloon ascent in London on 16 October 1784, when he was accompanied by one of his patrons, Dr John Sheldon. This trip finally convinced Blanchard that neither the wings he had brought along nor his newly-developed 'moulinet' (a kind of revolving airscrew) contributed to the lift or provided any propulsion.

After making some joint balloon ascents Blanchard and Dr Jeffries decided to attempt to be the first to cross the English Channel by air. Although Jeffries footed all the bills in

connection with this plan, Blanchard tried in underhanded ways to leave his sponsor behind, because he did not wish to share the honour of such an achievement with others. The American doctor must have been good-natured to have put up with all the wily tricks of the irascible little Frenchman. At the end of 1784 the balloon and the equipment for production of its hydrogen were brought to Dover Castle, where the filling of the balloon took place. When weighed off with the two participants in the basket, to everybody's surprise the lift proved less than calculated – until Blanchard was found out. His ego was deflated when he had to decrease his 'own' weight by the removal of an abdominal leather belt filled with lead, with which he had fortified himself for the occasion.

It was a clear and calm day, with only a slight north-north-westerly breeze, when the balloon took off from the edge of the cliffs of Dover at 1 p.m. on 7 January 1785. The balloon was heavily laden with much superfluous equipment, even including Blanchard's useless wings. The ballast was spent quickly, and soon everything else, even most of their clothes, was dropped, whether it could really be spared or not. Dr Jeffries confided later to friends that in their frantic efforts to lighten the balloon there was at one point a ludicrous angle to it 'when they did their utmost to relieve themselves as much as possible'. One is tempted to speculate whether similar minute, sober, yet practical effects may not have converted other sublime, historical events similarly from disaster to triumph. Anyhow, Blanchard and Dr Jeffries managed to stay in the air and at 3 p.m. gained the French coast to land in the midst of the Felmores forest outside Calais, where their balloon was brought to a stop by a tree; help was soon at hand. On this spot a marble monument was later erected, crowned with a balloon. Their balloon basket is to this day on display at a museum in Calais, which made them honorary citizens.

Upon his return to London Blanchard tried to cash in on his fame by the establishment of what he termed an 'Aeronautical Academy with various displays'. This proved only a qualified success, so he decided to return to France. In the years from 1785 to 1789 Blanchard ascended in both hot-air and hydrogen balloons in various countries on the Continent, where such an event was often still a novelty. When the French Revolution broke out in 1789, Blanchard was arrested by the Austrians in Tyrol and charged with the distribution of revolutionary propaganda literature. He managed to escape to America where, on 9 January 1793, he made the first balloon voyage in the New World at Philadelphia in the presence of George Washington, the President of the United States. Blanchard returned to France in 1798 and continued his aeronautical career. In February 1808, at The Hague in Holland, he made a hot-air balloon ascent and on this sixtieth and last air voyage of his suffered a heart attack from which he never fully recovered. On 7 March 1809 he passed away peacefully in Paris, well aware of the fact that he would go down in history as one of the true pioneers of ballooning.

To supplement the record of Blanchard, his widow Madeleine-Sophie became an aeronaut in her own right. In the years following his death this slender little woman became a favourite of the Parisians, thanks to her colourful balloon ascents, often at night, to the accompaniment of fireworks. On 7 July 1819 Madame Blanchard herself met her death, during an ascent from the Tivoli park

in Paris when her balloon caught fire from the fireworks she carried aloft. She made a rough landing on the roof of a house in the Rue de Province and then plunged to the ground.

5 The conquest of the air claims its first victims

After the French balloon pioneer Jean-François Pilâtre de Rozier, on 21 November 1783, had made the world's first air voyage in the company of the Marquis d'Arlandes, he decided – even before the successful Channel air crossing of Blanchard and Dr Jeffries on 7 January 1785 (see No. 4) – to go by air from France to England. For this undertaking he built a new type of balloon, which was really a combination of the hot-air balloon with a hydrogen balloon, so after him has been termed 'Rozière'. But, alas, it was to cost him his life. The spherical hydrogen balloon comprised the top part, and de Rozier's idea was that it should provide the lift while the cylinder-shaped hot-air balloon below it would serve not only to save the hydrogen filling but also to regulate the ascent and descent. The hydrogen balloon had a diameter of 32·8 ft (10 m), the hot-air balloon a width of 13·12 ft (4 m) and a height of slightly less than 23 ft (7 m). The circular gondola, or gallery, was fastened to the netting covering the top part of the hydrogen balloon. The pan with the fire was placed in the bottom open mouth of the hot-air balloon and could be raised and lowered at will.

This whole contraption looked for all the world most like a giant mushroom, and was not too confidence-inspiring. Its creator appeared totally unconcerned about the dangerous combination of an open fire and hydrogen, concentrating his attention instead on finding a favourable wind direction for his venture. A free balloon is not dirigible, but since the winds blow in different directions at various altitudes de Rozier figured that with his new type of balloon he would be better able to pick a favourable wind and maintain the right altitude for it. A young girl from Yorkshire, Susan Dyer, had just become engaged to de Rozier, and with feminine intuition had a presentiment of the impending danger. She implored him to abstain from his project, but he refused to give in and would only promise that this should be his last ascent. He felt that his reputation was at stake because the French government had advanced him 42,000 francs to help him realise his plan.

In December 1784 de Rozier settled in Boulogne-sur-Mer, along with his young assistant Pierre Romain, to await favourable weather. This did not occur until 15 June 1785, and meanwhile Blanchard and Dr Jeffries had crossed the Channel by air from England to France; however, undiscouraged, de Rozier and Romain started that morning from Boulogne at 7.15. The balloon climbed rapidly, but several spectators noticed that the gallery appeared to be suspended at a slant. The balloon first drifted out to sea as planned, but after attaining an altitude of about 4,920 ft (1,500 m) began to approach land again. Then disaster struck quickly and remorselessly. De Rozier was just then releasing a large amount of gas and a spark, either from the fire pan or, more likely, of static electricity caused by the rubbing of the line manipulating the copper gas valve against the goldbeater's skin of the balloon envelope, was seen to ignite the escaping hydrogen. The remains of the exploded balloon plunged to the ground not very far from the spot where Blanchard and Dr Jeffries had landed triumphantly scarcely six months earlier. Those hastening to the scene of the disaster found de Rozier dead; Romain just

managed to whisper 'Oh, Jesus' before he, too, expired. The conquest of the air had claimed its first victims.

That day was to claim still one more human life. Poor Susan Dyer was among the horrified spectators who witnessed the death plunge of the balloon, and the dreadful sight was more than she could stand. She sank to the ground in a faint and passed away shortly afterwards.

6 The world's first military observation balloon

Towards the end of the eighteenth century the first French republic became involved in warfaring with several European countries that had joined forces and formed a strong coalition to combat the new revolutionary rule. The so-called 'Committee of Public Safety' had been formed, which appointed a committee to evolve the best means of military preparedness. One member of this committee, Guyton de Morveau, proposed the employment of observation balloons to support the French armies during the military campaigns. This proposal was acclaimed and two highly gifted scientists, Jean Marie Joseph Coutelle and Nicolas Jacques Conté, were entrusted with carrying it out. They devised equipment for producing hydrogen by passing steam over red-hot iron, having been forbidden the use of sulphuric acid, since sulphur supplies were needed for gunpowder production.

Coutelle was commissioned a captain and ordered to report to General Jourdan, who, with his army corps, was striving to hold off the Austrians in the fortress of Maubeuge. There he submitted his plans which were promptly approved and, together with Conté, he established his temporary headquarters at the Château de Chalais-Meudon outside Paris. Here the world's first military observation balloon was built; it was named *L'Entreprenant*. Its capacity was 10,950 cu.ft (310 cu.m), and both the netting and the lines were reinforced to enable them to withstand the influence of strong winds. Since it would serve as a captive balloon, two cables were provided as stays. There was a crew of two, one making observations, the other handling the balloon. The signals were transmitted to the ground either by means of flags or as written messages lowered in bags weighted with sand and attached to the cables with small rings.

L'Entreprenant was demonstrated to the members of the scientific committee in March 1794. Everybody was pleased with what they witnessed and held high hopes for its future use, and a few days later – on 29 March – the world's first military balloon corps was formed, with Coutelle as commander-in-chief. Conté also had received a captain's commission and was appointed commanding officer of the Meudon section in charge of all manufacturing and training activities.

With all its necessary accessories, including the equipment for the production of hydrogen, *L'Entreprenant* was transferred to the Maubeuge fortress, where Coutelle ascended with it cheered by the soldiers and to the accompaniment of a gun salute. From his high elevation Coutelle was soon able to report the locations of the Austrian and Netherlands armies outside the city. By the time he made his fifth ascent, the enemy troops had recovered from the shock that the appearance of the balloon had caused them and fired upon it with a gun from a hidden position. When one of the enemy cannonballs glanced off the bottom of the balloon basket Coutelle coolly signalled his men on the ground to let out more cable. Rising to an altitude of some 1,300 ft (400 m), he was soon beyond the reach of the first anti-aircraft shots ever fired.

The balloon section fully lived up to what France expected of it, so was ordered to accompany General Jourdan to the Charleroi fortress which had been taken by the Austrians. In broiling sun and with great difficulties the inflated balloon was moved the 18½ miles (30 km) from Maubeuge to Charleroi. There its appearance in the sky outside the fortress demoralised the garrison so completely that with no further cause it surrendered immediately. The next day was a still greater triumph for Coutelle. With General Morlot as observer, he stayed in the air with *L'Entreprenant* for the full ten hours' duration of the battle of Fleurus. Practically all movements of the French troops were directed exclusively from the air, and as a result the Austrians suffered a resounding defeat.

After these magnificent achievements with the observation balloons in the campaigns a second balloon section was formed, which participated among other engagements at Stuttgart, Donauwörth, Augsburg and Würzburg. On one occasion Coutelle ascended when the wind blowing was of such force that the 64 soldiers holding on to the cable could barely keep control of the balloon. While these men were having their troubles some Austrian officers turned up waving a white flag. They had observed the difficulties that Coutelle laboured under, so volunteered the offer that Coutelle was welcome to pay their headquarters a visit, and the balloon could be hauled down safely. Coutelle turned down this generous offer, but in return demonstrated his balloon, and the handling of it, to the enemy officers. Wars could be conducted in such a gentlemanly manner in 1795!

In 1796 the French possessed four balloon sections, each with its own balloon. They were, besides the already renowned *L'Entreprenant*, *Céleste*, *Hercule* and *Intrépide*. In 1797 General Bonaparte consented to the inclusion of a balloon section in the army for his campaign in Egypt, but it was not turned to good advantage there and its equipment ultimately was lost in August of the following year in the sea battle of Aboukir, where the vessel *La Patriote* transporting it was sunk. When General Bonaparte returned to France in 1799 he dissolved the balloon sections, as well as the Meudon establishment, which had already been starved for several years of adequate funds. As a result of these unintelligible miscalculations and dispositions on the part of the great strategist, France was not to use balloons again until she went to war with Germany in 1870–71.

7 A. J. Garnerin – father of the first practical parachute

One of the spectators attending Charles's historical ascent in the world's first manned hydrogen balloon, in Paris on December 1783, asked what purpose it served. Also present on this occasion was the American scientist and statesman Benjamin Franklin, who countered with: 'Of what use is a new-born baby?' This was, indeed, an apt comparison, for few then had an imagination vivid enough to conceive the transformation of the balloon into a dirigible airship. The big problem confronting the small number of people pondering the problem of propulsion was where to find a suitable power source.

At the same time there were others who, although they did not care particularly to tackle these problems, had the vision and possessed the enterprise to see and take advantage of the novelty and entertainment angle of the balloon as showmen. For some

years to come no large celebration or exhibition anywhere in the world could fail to turn out a success if only the programme included a balloon ascent. But the crowds soon tired of just seeing a balloon arise and disappear. Some more novelty then had to be added, and the stage was set for the age of the professional aeronauts. These pilots shunned no means of thrilling their public, and among them one in particular stood out.

The Frenchman André Jacques Garnerin (1770–1823) specialised in parachute jumps from his balloon, and thereby contributed in his own way to the development of aviation. Garnerin made his first balloon ascent in Metz in 1787, but the French Revolution soon put an end to his more extreme schemes, particularly the combination of balloon ascents and descents by parachute.

During the revolutionary war Garnerin was taken prisoner by the Austrians, who held him for three years. Then he returned to Paris to carry out his plans. On 22 October 1797 he tried his first parachute from a balloon above the Monceau park. When fully opened it had a diameter of 39·4 ft (12 m) and during the ascent hung folded like a long cylinder below the balloon supported by a ring of about 6·6 ft (2 m) diameter fastened on the inside of the parachute fabric near the top of the parachute canopy. A metal tube, mounted in a piece of wood of cylindrical shape at the top of the canopy, surrounded the rope which attached the parachute to the balloon. The rope could be cut by Garnerin, who was suspended in a basket at the end of the lines.

He disengaged himself from the balloon at an altitude of 2,300 ft (700 m), and the parachute opened perfectly. The balloon, incidentally, exploded shortly afterwards. The parachute canopy was made of wind-tight material and, accordingly, the air inside it could not escape. As a result the parachute oscillated violently, yet Garnerin managed to land unharmed. He immediately mounted a horse and rode back through the park, cheered by the crowd. After the previous suspense, during which they were almost paralysed with fright, everybody on the ground felt relieved to witness Garnerin's hazardous descent.

In 1802 Garnerin proceeded to London, where he made his fifth successful jump from an altitude of 9,850 ft (3,000 m). This time his parachute oscillated so badly that he became very 'seasick' and was badly bruised on landing. The obvious perils of these parachute descents did not unnerve Garnerin, however, and the stability of his parachute was improved somewhat when one of his friends, the astronomer Lolande, influenced him to provide a small hole at the top of the canopy through which some of the trapped air could escape. Garnerin's wife, Jeanne Geneviève, whose maiden name was Labrosse, and his niece, Elisa Garnerin, shared his enthusiasm for parachuting. The former, on 10 November 1798, became the first woman to make a parachute descent, and the latter became the world's first professional woman parachutist. Garnerin's reputation as an aerial performer soon became a household word throughout Europe, and his services were much in demand in Germany, Italy and Russia.

Great showman that Garnerin was, on one occasion he planned an ordinary balloon ascent in the company of an attractive young lady. *Honi soit qui mal y pense*, and perhaps she *was* only his niece; however, according to a contemporary newspaper comment: 'The police have forbidden citizen Garnerin to make an air voyage jointly with a female since he could not prove that this companionship will in any way aid the perfection of the art. An air voyage undertaken by two members of opposite sexes must furthermore be considered quite improper and immoral.'

At the coronation of Napoleon Bonaparte as emperor, in Notre Dame de Paris on 2 December 1804, Garnerin was appointed official performer of the homage in the air on that occasion. To this end he built a number of colourful balloons, the largest of which was richly decorated with flags, golden initials and laurels. A tale is told about this balloon crossing the Alps and descending on the tomb of emperor Nero in Rome. Undoubtedly this would have made the superstitious Napoleon ill at ease, but no substantiating proof has ever been provided that this actually occurred.

The performances of Garnerin were imitated extensively, and often led to ludicrous oddities. Some would ascend mounted on horses, others would let their animals descend alone by parachute. Still others, like Garnerin, would set off fireworks in the air, which might well end in disaster. Yet there is no denying that, in spite of his showmanship, Garnerin must be considered the father of the first practical parachute, a device which was in time to save the lives of thousands of pilots and other aircrew.

8 J. P. Colding – first Danish aeronaut

The exciting news of the balloon ascents of the Montgolfier brothers spread like wildfire all over the world and similar experiments were soon repeated in many places. Already, in the same year of 1783, small balloons were launched in Copenhagen, but the first manned ascent in the Danish capital was made on 1 October 1806 by the Belgian 'Professor' Etienne Gaspard Robertson who had previously ascended in Moscow and Stockholm. The first Danish aeronaut was Johan Peter Colding, who began in the not unusual way of sending up small balloons with fireworks and animals fitted with parachutes. He made his initial ascent in a hot-air balloon on 10 November 1811 from the drill grounds of the Rosenborg castle, at which royal palace Colding had been decorated at an investiture with the Order of Knighthood of the Danish Flag Name on 28 June 1809.

The chief distinctions of this Danish aeronaut are his initiation of two present-day common practices: air mail and aerial psychological warfare. In 1808, with the financial and moral support of King Frederik VI of Denmark, he sent a number of balloons across the Great Belt with letters, and several of these letters have been preserved. That area is mainly made up of many small islands, and only the Jutland peninsula is contiguous to the European continent. The Danish capital is located on one of the two largest islands and at that time no submarine cable had been laid in the Great Belt separating them. Foreign news was always anxiously awaited, not least in those days of the Napoleonic wars, but sometimes ice or war activities prevented the mails from going through; it therefore made sense to investigate whether carrying the letters by air could overcome the hiatus. At that time the Spanish auxiliary troops waiting to cross these waters had mutinied, and British warships were cruising up and down to prevent their passage. One of them observed a strange object afloat. A boat was lowered to investigate and salvaged what turned out to be one of Colding's mail balloons that had come to grief. The letters at least were returned to the Admiralty in London and one of them

is still on file in the Public Record Office. In it, in Danish, are printed instructions 'To the Finder' from Colding, repeating King Frederik's command of 8 May 1808 from the Danish headquarters in Copenhagen informing everybody of 'our most gracious will that Candidate Colding carry out certain aerostatic experiments at the Great Belt, making it incumbent on all our public servants or who else it be not to hinder him in any way, but to support his task to the best of their ability and hand in the letters to the nearest telegraph office for speedy transmission, showing this Royal Order and, upon demand, be paid a suitable reward'. They are to add an endorsement about the location where the air machine was found.

When shortly afterwards King Gustaf III of Sweden was assassinated, one of those involved fled to Denmark and, convinced that his native country would be best off by joining the combined rulership of the kings of Denmark and Norway in a united Scandinavia, printed a pamphlet to persuade the Swedes to switch their allegiance to the Danish king. Frederik VI seized the opportunity and lost no time in having a large quantity of these pamphlets sent to Colding with instructions to despatch the copies to Sweden by balloon when the wind was favourable. In those regions the westerly winds predominate, and so in the shadow of the ghost of Hamlet this aeronaut released a balloon almost daily, each carrying 30 pamphlets from his quarters at the Kronborg castle in Elsinore. They could generally be observed to descend on the other side in Scania. The guards on coastal duty had orders to turn in their cargoes to the local governor for destruction, but in the beginning they were reluctant to approach these strange aerial visitors. When in time a specimen was retrieved and submitted to the new Swedish king, Gustaf IV became much incensed at what he considered a most unfair manner of somebody else mixing himself up in foreign affairs; and said so in no uncertain terms when sending an envoy with it to the Danish king to solicit his assurance of keeping aloof from such despicable practice. Frederik VI only made matters worse by replying to the effect that if Gustav IV really wanted to know, he would readily admit to being the instigator of this 'Balloon Letter'.

These two incidents in the history of aeronautics were only modest beginnings of what were, within a century and a half, to develop into important and common practices: those of fast mail delivery by air and effective psychological aerial warfare. They forecast coming developments, for history has an odd way of repeating itself. In Shakespeare's words, 'great oaks from little acorns grow'.

9 The 'Royal Vauxhall' balloon filled with coal gas

The Englishman Charles Green (1785–1870) must be reckoned one of ballooning's great pioneers, for he made balloons cheaper to operate by being the first to fill them with ordinary coal gas. As early as 1807 a number of streets in London were lit by gaslight; Green realised the advantage of using this gas to fill balloons, because the filling was cheaper and faster. Since coal gas is also less affected by changes in temperature, the balloons can likewise stay in the air longer, but a good gas of light quality is required for the filling of the balloon.

Green made his first ascent with a balloon filled with coal gas on 19 July 1821 from Green Park in London, during the celebrations of the coronation of King George IV. Named

George IV Royal Coronation Balloon, its size was approximately 15,900 cu.ft (450 cu.m). During this ascent it climbed to an altitude of about 10,000 ft (3,050 m) and everything went well, but only as Green gradually gained experience did he become a skilled aeronaut. At the beginning of his ballooning career many of his starts and landings were hazardous.

By 1835 Green had made a total of 200 balloon flights and had introduced the trail-rope which was 1,000 ft (305 m) long and was generally lowered before the landing to slow down the balloon's descent and regulate its height. On favourable occasions during an air voyage the trail-rope can also be used to help conserve ballast, by stabilising the balloon's altitude, for as the balloon sinks a greater portion of the rope will rest on the ground and the balloon thereby becomes relieved of its corresponding weight. When ground obstacles are not likely to be encountered the trail-rope can also be paid out at night to serve as a 'feeler' of the altitude of the balloon above the ground.

Green's most adventurous and renowned balloon ascent was undertaken on 7 and 8 November 1836 with the balloon *Royal Vauxhall* of 70,000 cu.ft (1,982 cu.m) capacity, built to the order of the owners of the Vauxhall amusement park in London, whence it started. It was an impressive red and white striped balloon which had already made three previous trips. The first ascent occurred at 6 p.m. on 9 September 1836 and took place before a distinguished crowd of spectators headed by Lord Palmerston. Thanks to the large carrying capacity of the balloon the car could on this occasion hold no fewer than nine persons. They were, besides Green and his wife, his brother James, the politician Robert Holland, and five others. In spite of this load the balloon climbed rapidly and reached an altitude of 13,000 ft (3,962 m) in five minutes. It was a creditable performance by both Green and his balloon that this first trip was an unqualified success.

On his ascent in November of that year Green carried as passengers the patron of operas, Thomas Monck Mason, and Hollond, who had planned this flight as a duration trip and footed the bill for it. Besides ample ballast the three air travellers carried various instruments and signal lights along with them; nor were they wanting for provisions and beverage. They took off in the early afternoon with the balloon heading south. After some slight altitude adjustment they crossed Dover and made for Calais, continuing their silent passage over Europe where the various shining cities began to appear in the dusk. When the sun dawned again after a long and dark night, the three men in the basket had no idea of where they were. Below them they could only make out a rugged landscape with the higher regions covered by snow. After they had stayed in the air for seventeen hours, Green decided to descend and they landed smoothly at the outskirts of a forest, where farmers approached to inform the three air adventurers that they were close to the town of Weilburg in the Duchy of Nassau. Thus they had covered a distance of about 480 miles (772 km) from their starting point. This was the longest balloon voyage on record and they were entertained and celebrated royally in Weilburg. Their balloon was renamed *Nassau* and transported to Paris to go on exhibition there.

This outstanding success was to be succeeded by a tragic incident. In 1837 Green was persuaded, much against his better judgment, to take up the 61-year-old painter and amateur scientist

Robert Cocking in his balloon, from which the latter intended to jump by parachute. In his youth Cocking had attended some parachute exhibitions in London by Garnerin (see No. 7) and had thereafter for many years experimented with what he himself considered some improved types. In the evening of 24 July Cocking launched himself and his parachute from the *Nassau* balloon to plunge to the ground with the folded parachute streaming behind him. Cocking almost carried Green and his other companion, Edward Spencer, to their deaths too, for once the balloon was relieved of Cocking's weight it became completely uncontrollable. It was only thanks to Green's skill and presence of mind that the balloon managed to land safely again.

In 1840 Green projected a crossing of the Atlantic Ocean by balloon from Europe to America. He proposed to provide propulsion and the required sustained lift by means of a propeller driven by clockwork. However, Green had to abandon his plans when that year he was injured during a difficult balloon landing in Essex.

In 1838 and again in 1852 he made some altitude ascents with *Nassau* in pursuit of scientific aims. In the latter year he and the astronomer John Welsh from the Kew observatory in London made four such ascents between August and November. On their last trip they reached an altitude of no less than 22,930 ft (6,989 m). That very year he also achieved the goal which he had previously set himself, that of making his 500th balloon ascent. Then he retired to his house in Highgate, London, and took no further active part in ballooning, but he continued to follow keenly everything concerning the conquest of the air. Green died from a heart attack on 26 March 1870.

10 The steam-engine-driven airships of Henri Giffard

Today the French engineer Henri Giffard (1825–1882) is generally credited with the distinction of producing the world's first truly dirigible (steerable) airship. Already at an early age Giffard made a fortune from his various inventions for the improvement of locomotive steam engines. He gained his first aeronautical experience from the building of giant balloons for exhibition purposes. Thus he designed a large captive balloon for the World's Fair in Paris in 1867 which provided the public with a bird's eye view of the fairgrounds. This was Giffard's largest captive balloon and became a popular feature; a total of 35,000 people received their 'air baptism' in this way. Another of his captive balloons, named *Captive*, saw service in London in 1869 and was later converted into the free balloon *Le Pôle Nord*. It was used by the well-known French aeronaut Gaston Tissandier to collect money for the polar explorer Gustave Lambert.

After his first ascent in a free balloon Giffard decided to try his hand as an airship designer. His first attempt was a 144 ft (44 m) long non-rigid airship with a diameter of 39·4 ft (12 m) and a volume of 88,287 cu.ft (2,500 cu.m). The envelope was tapered at both ends and covered completely with a net to which a 66 ft (20 m) long pole was attached, with a triangular sail-like rudder affixed to the rear end. A small gondola could just hold the aeronaut and the steam engine. The latter was of Giffard's own design, weighed only 99·2 lb (45 kg) and was able to develop 3 hp, yet the total weight, including boiler, fire tray, water and fuel, amounted to only 551 lb (250 kg). The three-bladed propeller had a diameter of about 10·8 ft (3·30 m).

This small airship left the ground for the first time at the Hippodrome in Paris in the presence of a large crowd on 24 September 1852. On this occasion Giffard was dressed in style, wearing a 'Prince Albert' frock-coat and waving his top hat, while the astonished spectators saw the airship move ahead leaving a trail of white steam behind. This was the first flight anywhere of an airship under its own power and ended without any mishaps at Trappe, some 15½ miles (25 km) south-west of Paris. The airship had maintained an average speed of 5 m.p.h. (8 km/hr) and an altitude of 4,920 ft (1,500 m). The small rudder had made it possible to steer the airship to some degree and on a later trip Giffard even managed to complete a full circle with the airship.

However, these flights were made in perfect weather conditions and Giffard realised very well that his airship was no better than a free balloon if only the slightest wind was blowing. What he lacked was an engine developing more power for less weight. He was, however, unable to build a power source meeting these requirements, so in 1855 he built instead a larger envelope which was 230 ft (70 m) long, 32·8 ft (10 m) in diameter and held 113,000 cu.ft (3,200 cu.m) of gas. The gondola was now attached directly to the netting, but did not turn out to be such an effective design. With Gabriel Yon, the well-known manufacturer of balloons, as his assistant, Giffard made a trial trip from Courcelles, south of Lille, but the envelope could not maintain its shape due to loss of gas, and as a result some of the wires supporting the gondola gave way, fortunately when near to the ground, for the envelope slipped completely from the netting and exploded. Giffard and Yon were lucky to escape alive from this serious mishap.

Giffard in his last attempt aimed at a truly large airship. It was to be 1,968 ft (600 m) in length; have a volume of 7,769,200 cu.ft, (220,000 cu.m), and be powered by a steam engine weighing more than 30 tons. The cost of building a monster airship like this proved prohibitive, so the project was eventually abandoned. A few years later this capable and enterprising man became blind, which spelled *finis* to what future plans he may have entertained for further conquests in the air.

11 Lowe's balloon section in the American Civil War

When the nineteenth century dawned, John Wise was the dominating figure in American ballooning circles; he will be remembered chiefly for his scheme to cross the Atlantic in a balloon (see No. 15). His only equal in the New World at that time was his constant rival, Thaddeus S. C. Lowe, who was twenty-five years younger. Lowe made his first balloon ascent on 17 July 1858 and, like Wise, soon became obsessed with the notion of crossing the Atlantic in a balloon and lost no time in endeavouring to carry out this plan. By 1859 he had raised sufficient money in New York to enable him to proceed with the building of a very large balloon, first named *City of New York* and later *Great Western*. It was of no less than 724,000 cu.ft (20,500 cu.m) capacity, with a diameter of 104 ft (31·7 m), and was more than 200 ft (61 m) tall. It was thus the largest balloon built up to that time. As Wise had planned to do with his balloon *Atlantic*, Lowe also carried a lifeboat below the enclosed gondola.

The first disappointing obstacle that Lowe encountered was the inability of the gasworks in New York to fill his balloon, due to lack of facilities to produce the required quantity of gas. However, this was remedied when the president of the Point Breeze gasworks

in Philadelphia came to the rescue with an assurance of being able to meet Lowe's requirements. The balloon was accordingly transferred to Philadelphia, but had to be stored there first for the duration of the winter. Finally, on 28 June 1860, the balloon was ready for its first trial ascent. By a coincidence this was the very same day that *Great Eastern*, then the world's largest steamer, turned up in the harbour of New York after her maiden voyage across the Atlantic Ocean. The balloon fulfilled all expectations, and every effort was aimed at enabling a start for Europe to be made in September of that year. During the filling of *Great Western* on 7 September a strong gust of wind caused the balloon to collide with an obstacle and be badly damaged. A second filling began on 29 September, but this time the balloon exploded due to a weakness resulting from the first mishap. After this, there was no more money left to spend on the project.

Professor Joseph Henry, a recognised scientist of the Smithsonian Institution in Washington, D.C., who had also acted as adviser to Wise, suggested now that Lowe also should make a long cross-country balloon trip before he attempted again to cross the Atlantic by air. Lowe followed this advice and left immediately for Cincinnati with his balloon *Enterprise* of 20,130 cu.ft (570 cu.m) which he used for exhibition purposes. After waiting some time for fair weather he finally set out in April 1861 on a long trip across Virginia and, when finally landing in South Carolina, he had covered a distance of some 620 miles (1,000 km). Unexpected strong winds blowing from the north had forced him down at Pea Ridge near the town of Unionville (now Union). During Lowe's balloon ascent the Civil War between the Northern and Confederate States had started, and he was imprisoned as a suspected Yankee spy, but soon released again after satisfying the suspicious Southerners that his balloon trip had served scientific purposes only. His return trip proved difficult and Lowe completely abandoned his long-distance ballooning plans to present himself instead to President Lincoln in Washington to offer his services. The President appointed Lowe chief of the Army's aeronautical division, under the command of General McClellan, whose forces had taken up their positions on the Potomac river.

Lowe's first captive balloon ascents for the Federal Army gave no better results than those achieved by such other volunteer balloon operators and observers as John Wise, John La Mountain, Samuel King, and the brothers James and Ezra Allen. The reason for this was that, with the exception of General McClellan, all army officers failed to realise the potential value of aerial observation in warfare. Besides having to overcome this passive resistance on the part of the ground forces to availing themselves of the services of the military aeronauts, the latter were confronted with numerous other difficulties. To begin with, their balloons were not too well adapted to active service and, after being filled at some distant gasworks, encountered many obstacles on the long approach to the firing lines.

In time, however, the rivalry between the competing aeronauts was overcome, better equipment was procured and working conditions also were improved. A better atmosphere was likewise created when Lowe, after the battle of Bull Run on 21 July 1861, was able to report to Washington his important observations to the effect that the Confederate forces, after the victory they had won there, appeared disinclined to pursue their success. That

year, in June, Lowe had for the first time conveyed his aerial observations to the ground by electric telegraph, the wire of which was attached to the cable holding his balloon *Enterprise*.

At the end of 1861 the Federal forces had a total of seven observation balloons at their disposal, all built by Lowe. They were named *Union*, *Constitution*, *Washington*, *United States*, *Intrepid*, *Eagle* and *Excelsior*, and varied in size from 15,000 to 32,000 cu.ft (425 to 906 cu.m). Generally they operated at an altitude of up to 5,000 ft (1,525 m). No attempt was made to camouflage these balloons; on the contrary, they were brightly embellished with the colours of the American flag or with the insignia of the American eagle. Lowe succeeded in developing equipment for the production of hydrogen which was suitable for transportation, and thereby provided a badly-needed mobility for the balloon units. In 1861 the converted collier *G. W. Parke Custis*, operating on the Potomac river, served as mother-ship of the balloon *Washington*.

The balloons serving with the Federal forces unquestionably restricted the hitherto unhampered mobility of the Confederate troops, who tried their best to destroy them, but without much success. Twice aerial observations saved the Federal forces from severe defeats, during the battles of Fair Oaks and Gaines's Mill in 1862. The Confederate attempts to establish a balloon section on their side were few and fairly feeble. This was due to their lack of vital equipment from which the enemy blockade cut them off. Best known is the Confederate balloon that was built in Savannah at the instigation of Captain Langton Cheves. Its envelope could hold only 7,500 cu.ft (212 cu.m) of coal gas, and because it was made up of many odd pieces, which gave it a motley appearance, it was rumoured that southern belles had patriotically sacrificed their silken evening gowns for the cause. Hence it was referred to as 'The Silk Dress Balloon', and was en route to the front on board the Confederate armed tugboat *Teaser* when the latter became stranded on a bar in the James river. Thus both the vessel and the balloon became an easy prey to the mobile and well-armed Federal ironclad *Monitor*.

The American Civil War became a testing ground for new weapons and practices, and foreign military observers, not least from Germany, carefully investigated these military developments. One such young German officer on a leave of absence, who was attached to the Federal forces for a while, was Count Ferdinand von Zeppelin, who noted the activities of Lowe and his balloon section. On an exploring trip to the sources of the Mississippi river, von Zeppelin later received his own balloon initiation with an ascent at Minneapolis. After his return to Germany and subsequent retirement from military service, von Zeppelin was eventually to devote all his time and fortune to his idea of a rigid airship and, by sheer personal perseverance, ultimately bring forth a number of impressive Zeppelin dirigibles.

Lowe's aeronautical career turned out less successful. Neither he nor the other civilian aeronauts were ever fully recognised by the military professionals. Faced with a lack of sympathetic understanding on the part of an ever-changing succession of commanding officers, Lowe resigned in 1863. He was succeeded by the Allen brothers, who were even less able to assert themselves, and soon the balloon section was dissolved completely. Thereafter the U.S. Army possessed no balloons for the next thirty years.

12 The giant balloon 'Le Géant'

Nadar's balloon *Le Géant* was one of the largest and best known in Europe during the nineteenth century. Nadar, or Gaspard Félix Tournachon to give him his real name, was the most renowned French photographer of his time, and early in his career became interested in aeronautical problems. He began to experiment with photographs taken from balloons, and in 1855 conceived the idea of mapping from the air. The French general staff was rather sceptical of the practical value of such a procedure, and the famous astronomer Bertsch tried to prove to Nadar that the idea was not feasible at all. Yet Nadar continued his efforts. His first attempts were a total failure, but suddenly, one day, a church could be discerned on one of the plates. Nadar remembered that this exposure had been made while the safety valve of the balloon was closed, and deduced that escaping gas had previously formed a thin veil below the balloon preventing anything from showing on the plates. In later years he obtained even better results.

Nadar was a strong believer in aircraft of the heavier-than-air principle, and in 1863 wrote an essay on the principle and proper use of the airscrew, practically predicting the shape of helicopters to come. It is ironic, therefore, that Nadar had his giant balloon *Le Géant* built as a means of making money to help finance an aircraft of the 'proper' heavier-than-air type. The envelope of this huge balloon was made of silk and held almost 212,000 cu.ft (6,000 cu.m) of gas. The total height of the balloon was 197 ft (60 m) and its lifting capacity more than 4½ tons. The balloon basket was remarkable in its own right and looked for all the world like a small two-storey summer cottage. It contained a captain's cabin with bunk, a toilet, a store-room, a photographer's studio complete with darkroom, and a printing press. On top was an open platform for walks. The overall dimensions of the basket were: 13·1 ft by 8·2 ft (4 by 2·5 m). The bottom of the basket was provided with shafts for the mounting of wheels.

The first ascent of this balloon took place on 4 October 1863 from the Champ de Mars in Paris, with about 100,000 visitors paying admission. It had been designed and built at the plant of the well-known Godard family of aeronauts. When the balloon ascended it was in charge of Louis and Jules Godard and carried twelve more passengers including Nadar and another of the Godard brothers, Eugène, who was an experienced balloon pilot himself. The trip was of only a few hours' duration.

The next trip followed two weeks later, on 18 and 19 October, and lasted much longer. It turned out dramatically indeed. The same Godard brothers were in charge again, and this time Nadar was accompanied by his wife and only two more passengers. After a stay in the air of sixteen hours the balloon was crossing Hanoverian territory and the thrilled passengers were gathered on the promenade deck admiring the beautiful sunrise. Meanwhile, however, the Godard brothers began to worry about what would happen when the heat of the sun began to warm the enormous volume of gas. They feared that the balloon might actually burst, and so they valved much of the gas and prepared to land. The balloon descended rapidly and, much to everybody's surprise, they found that the weather was really stormy close to the ground. There was nothing else left but to proceed with the landing, for because of the heavy loss of gas the balloon could not be forced to climb again. The last bags of ballast were

sacrificed just before the bag hit the ground, and then the valve went out of order. The occupants' previous serene enjoyment quickly turned into panic during the ensuing nightmare ride. Passengers grasped whatever support was within their reach in the huge basket, while the partly-emptied envelope acted as a large sail and drove them across the surface of the earth at a speed of 30 m.p.h. (50 km/hr) which resulted in frequent jumps of the basket high in the air. Every obstacle in its path was torn asunder, and even large trees and telegraph poles broke like matches. An approaching train barely managed to pull to a stop with screeching brakes before the impetuous giant tore through the embankment. This went on for thirty minutes, until some dense forests in the neighbourhood of the small town of Rethem, some 30 miles (50 km) north-west of the city of Hanover, finally arrested the balloon for good. It then exploded, as a macabre finish. By then, alone of the passengers, the wife of Nadar remained in the badly-damaged basket car. The rest of the party, along with numerous pieces of wreckage, were strewn in the wake of the balloon. It must be considered almost a miracle that everybody remained alive, but all were more or less badly injured.

Le Géant underwent thorough repairs and took to the air again, both in Great Britain and other European countries, but she never recovered her former vitality and was no longer capable of making any long trips. High ticket prices were charged for ascents in the balloon, but it did not turn out to be the goldmine that Nadar had expected. She was not a suitable means of transportation, for passengers never knew where they would be carried, and it was always difficult to make safe landings. The lack of some ripping device accounted for this to a great extent, but Nadar himself was no skilled balloon pilot either.

Not much was heard subsequently of Nadar as a balloonist. When Paris was besieged in the Franco-Prussian War of 1870–71 he and other balloon pilots present in the French capital established an air mail service by means of balloons to maintain some sort of communication with the outside world. Nadar also participated in the production of the microfilms which enabled pigeons to carry replies and other messages back to Paris; and, finally, at one stage of the siege Nadar maintained some captive balloons above Montmartre for military observations.

13 What altitude did 'Mammoth' attain?

Professor James Glaisher (1809–1903), the meteorologist, was one of the scientists of highest standing of his time. He was in charge of the weather service of the Greenwich Observatory in London and in that capacity soon visualised the potentialities of the balloon as a tool for studies of the air 'ocean'. Accordingly, between 1862 and 1866 he made some thirty ascents in the company of the balloon pilot Henry Tracy Coxwell (1819–1900), all of them for scientific purposes. They served to establish the composition of the atmosphere, and Glaisher also made physiological observations of the reactions of living entities at various altitudes. Glaisher was encouraged to undertake this work by, and received financial aid in carrying it out from, two wealthy British engineers, William Fairbairn and James Nasmyth.

Before proceeding with his projects Glaisher had to find a suitable balloon and a capable pilot. He chose Coxwell, who opined that a new balloon had better be built for their special task. Coxwell was no novice in the field of balloons. As far back as 1847 he gained

his first ballooning experience in his younger days and during the following two years he demonstrated in Germany with his balloon *Sylph* how a city could be bombed with 'air torpedoes' launched from a balloon; his carried twin baskets on these occasions. When the Franco-Prussian War broke out in 1870 the German Army ordered two balloons and the necessary gas-generating equipment for them from Coxwell and asked him to head two balloon sections to be formed, each comprising twenty men. However, they saw little active service with the forces of von Moltke because the gas generators lacked field mobility.

While Coxwell was busy building the new balloon, of 90,000 cu.ft (2,548 cu.m) capacity – it was later named *Mammoth* – the vigorous and sturdy Glaisher trained in order to be able to stand the fatigue to which balloon ascents to high altitudes were to expose him. Originally he had not intended to be an active participant in them himself. He selected his instruments equally painstakingly and also pondered minutely the many investigations to be conducted.

On 17 July 1862 *Mammoth* was filled with coal gas at the gasworks in Wolverhampton and then rose on her first trial trip which, though brief, still brought Glaisher and Coxwell to the considerable altitude of more than 26,000 ft (7,925 m). Strangely enough, neither then nor later did they ever avail themselves of any oxygen equipment on their various altitude trips. They adapted themselves to the thin air of the upper regions, yet they were soon to learn that there was a limit to what they could endure.

They made one more trial trip in August the same year and then set out, at 1 p.m. on 5 September 1862, on the altitude ascent which was to go down in history as one of the greatest of all balloon achievements. They penetrated the layers of cloud at about 11,000 ft (3,353 m), there to encounter bright sunshine which accelerated their further climb while *Mammoth* continued to revolve slowly around her vertical axis. Neither of the two men experienced any discomfort until they reached an altitude of about 29,500 ft (8,990 m), although the breathing of Coxwell was occasionally heavy. Glaisher attended to his observations and read, for instance, a temperature of −26°C, but when the balloon continued to climb still higher he had difficulty in reading the instruments. As the line manipulating the valve now also got stuck Coxwell had to climb up to the hoop carrying the basket to free the line. Suddenly Glaisher was unable to raise first one arm and then the other. He recounted later: 'I tried to shake my body in an effort to rid myself of my uneasy feelings and I succeeded partly, but felt numb, and as I glanced at the barometer my head sank on my left shoulder, then I tumbled backwards down in the basket. I tried to talk to Coxwell, who was still seated in the hoop, but no words came forth. I could think clearly until the very moment that darkness enveloped me.' Coxwell realised that both he and Glaisher were in imminent danger, for now his arms likewise turned limp. Before Coxwell also grew unconscious he managed to sink his teeth into the line to the valve and pull it several times. Then the balloon began to sink, following its previous steady climb of about 1,000 ft (305 m) per minute. Glaisher awoke when Coxwell stood over him and shook him while repeating the words 'temperature' and 'observations' and simultaneously rubbing his hands with cognac. Glaisher was gradually able to rise from the bottom of the basket and, addressing Coxwell, to exclaim, 'I had lost my wits completely.' Coxwell

replied, 'Indeed you had, and so had I, almost.' Now that they had again reached a level where the oxygen content of the air was more plentiful, the two men soon recovered and managed to land the balloon on a large meadow by the village of Clee St Margaret, outside Wolverhampton. Neither Glaisher nor Coxwell suffered any after-effects from their perilous, but valuable, balloon voyage. Posterity stands in admiration of their achievement on that occasion, all the more because of their advanced ages: Coxwell was then 43 years old and Glaisher his elder by ten years.

How high did *Mammoth* climb on that day? According to Glaisher's own statements they reached an altitude of 37,000 ft (11,278 m), but this figure has later been questioned by other experts basing their judgment on the progress of the ascent and descent on that occasion. They maintain also that the barometer readings were unreliable under the prevailing conditions prior to the balloon reaching its ceiling. But all unanimously agree that the daring aeronauts almost certainly exceeded an altitude of 30,000 ft (9,145 m) by an ample margin.

During the years up to 1866 Glaisher made a number of additional scientific balloon ascents, both by day and at night, and Coxwell was the pilot on most of them. In 1863 Coxwell demonstrated his balloon before a British Army committee that was to pass judgment on the suitability of balloons for reconnaissance. Before Coxwell died in 1900 (at the age of 80) he had made about 1,000 balloon ascents in his long and stirring career. Glaisher became one of the founders of the Aeronautical Society (now the Royal Aeronautical Society) in 1866 and continued to take an active interest in all aeronautical matters right up to his death in 1903 at the age of 94.

14 The Balloon Bridge from Paris during the siege by the Germans in 1870–71

One of the strangest chapters in the history of ballooning, as well as in the annals of France, is the air-bridge that was established when Paris was besieged in the Franco-Prussian war of 1870–71. When the German armies, on 19 September 1870, held the French capital in their iron grip, the timing was most inopportune and very critical for the French: a new government had recently been formed in the city of Tours, in southern France, while the Ministry of Defence remained in Paris; and now the connections between them were severed.

Several balloon pilots such as Nadar, the Godard brothers, Gaston Tissandier and others were staying in the besieged city and immediately approached the postmaster-general, Germain Rampont-Léchin, with the proposition that communication with the outside world be re-established by means of balloons. A carrier pigeon fancier, van Roosebecke, proposed further that the balloons carry pigeons which could later return to Paris with messages from the provinces. These ideas met with the ready approval of Rampont, who took immediate steps to have them realised; and the first balloon departed with mail on 23 September from Place Saint-Pierre in Montmartre. Jules Duruof was the pilot, and he used his old and leaky balloon *Le Neptune*, which three hours later landed well behind the enemy lines at Évreaux, some 56 miles (90 km) west of Paris. On 26 September the balloon *La Ville de Florence* took off, carrying more mail, a passenger, and van Roosebecke's carrier pigeons. Three days later Louis Godard followed in his *Les États-Unis* which was, as the name also hinted, a combination of two smaller balloons *Hirondelle* and *Napoléon*. Before the month was up,

Gaston Tissandier also had left Paris with mail and carrier pigeons in his balloon *Le Céleste*, and that about exhausted the supply of balloons available in the besieged city. So Rampont had the manufacture of balloons initiated on a large scale in the now idle Gare du Nord and Gare d'Orléans railway stations in Paris. The balloon envelopes were sewn by many of the skilled local seamstresses from whatever materials were available, then varnished and suspended from the high station ceilings to dry. Sailors were selected for brief balloon pilot training because, sensibly, from their previous handling of sailing vessels they were judged best adapted to the new task on hand. With their relatively great inexperience it is remarkable indeed how few injuries they sustained in often very difficult landings under trying winter and war conditions. When Paris capitulated on 28 January 1871, a total of 66 balloons had left the besieged city, carrying 2½ million letters and newssheets, or more than 9 tons, besides 368 carrier pigeons (of which 57 returned to their Parisian dovecotes with microfilmed messages) and five trained dogs (none of which managed to return to Paris); yet only two of the balloons were lost – at sea – and five captured by the enemy.

Many of the Paris mail balloons were named after renowned personalities of the past and present, such as: *Montgolfier*, *Daguerre*, *Garibaldi*, *Isaac Newton*, *Victor Hugo* and *George Sand*. Most of them were of 70,630 cu.ft (2,000 cu.m) in size.

Best known of the balloon ascents during the siege of Paris is that of the *Armand Barbès*, piloted by Alexandre Trichet, on 7 October 1870, because his passengers were the very active politician Léon Gambetta and his friend and secretary, barrister Eugène Spuller. Gambetta was wounded in one hand when their balloon was fired upon in crossing the enemy lines at an altitude of only 1,970 ft (600 m). He was leaving Paris to organise the resistance against the occupation of France in the rest of the country, and was almost taken prisoner by the Germans when he landed in a field by the village of Épineuse, near Clermont, 31 miles (50 km) north of Paris, as the Germans had only shortly before held that city.

Another balloon, the *George Sand*, piloted by Joseph de Révilliod and carrying two American passengers, Reynolds and May, left simultaneously from Place Saint-Pierre, whence many of these Paris mail balloons often departed, to accompanying shouts of 'Long live the Republic'. This balloon was built to the private order of Reynolds, who had received a large munitions order from the French government and saw no other means of delivering the contract to the factory in the United States. His employers rewarded him with a commemorative gold watch suitably inscribed to testify to his display of ingenuity.

The Germans were in a rage because of their impotence to stop the French mail balloons, and threatened to shoot the pilots as spies when caught. The Krupp establishment was a long time in turning out the first anti-aircraft gun, yet the enemy fire from the ground gradually became troublesome to the balloons departing from Paris, hence the later ascents were made at night. One of these took a spectacular and dramatic course and, though involuntary, for many years remained the longest air voyage.

The balloon *La Ville d'Orléans* started from the Gare du Nord at midnight on 24 November 1870, carrying important despatches, more than 550 lb (250 kg) of mail and a cage with six carrier pigeons. Paul Rolier was

the pilot, and he was accompanied by Léonard Bézier, a skilled marksman. At an altitude of 8,860 ft (2,700 m) they headed north in the pitch-dark night. At dawn's early light they were flabbergasted and horrified to find themselves out over the open sea, extending as far as they could see. They sighted some ships, but these were unable to help them. They were convinced that certain death now was their fate, so two pigeons were released with news of their situation and some mail was dropped to lighten the balloon, which continued on its way. There was more agony in store for the weary and famished aeronauts. It began to snow heavily, with the effect that the snow accumulating on top of the balloon forced it down fast and Rolier and Bézier had reconciled themselves to succumbing by drowning in the ice-cold sea when, to their great surprise, all of a sudden a desolate, snow-covered landscape appeared below them. They lost no time in jumping for their lives as soon as the basket approached the ground. Lightened by their weight, the balloon took off again and was instantly lost to sight. The two men set out on a laborious walk through the deep snow, and after a long and cold night reached a cabin where they found heat and some food which they dug into, but there was nobody present. After a while two surprised woodsmen returned, but they could not understand each other's language. Then Rolier took to signs, drew the outlines of a balloon and also wrote the word 'Paris' in the snow. The significance thereof was grasped; the unexpected guests had literally fallen from out of a cloudy sky. The Frenchmen at first surmised that they must have landed in Russia; but when they noticed a matchbox on which, beside the name of the makers, was printed the location 'Christiania' (as the Norwegian capital was then called), they had a better idea of their whereabouts. In that continental war the sympathy of all Norway was on the French side, so that when they were brought to the nearest city and expressed their wish to be taken to the French consul in Christiania, they received willing assistance. Their visit there turned into one continuous triumphal procession. They were fêted and celebrated everywhere. Their balloon was recovered, the metal in its valve melted and small medals struck from it which were sold as souvenirs, raising a sizeable sum of money for the benefit of the war injured in France. To this day the basket of *La Ville d'Orléans* is on display at the Norwegian Technical Museum in Oslo.

This balloon had been in the air for 14 hours 40 minutes after its departure from Paris when Rolier and Bézier came down at Lifjel, in the Telemark district of southern Norway. They returned to France by boat, via England, with the recovered mail from the balloon.

The Paris balloon mail service was an impressive achievement of which all the world took notice. It was an outstanding success, even though the attempts to bring return mail into Paris, also by balloons, failed. Henceforth strategists everywhere had to reckon with the third element as well in considering future warfare. In France it resulted in the establishment of the Chalais-Meudon aeronautical establishment outside Paris in 1877, in the charge of the Renard brothers, Charles and Paul.

15 Wise's 'Atlantic' balloon

John Wise was one of the outstanding balloon pioneers in the United States. He devoted 44 years of his life to this branch of aeronautics, and wrote two valuable volumes on the subject. Wise was particularly interested in navigation in the air and held the conviction

that in the upper regions 'streams of air' (as he termed them) would be encountered, much like our rivers. If they could only be localised it should be possible to exploit them for transportation of passengers and cargo by balloons. There was something to the theories of Wise. These strong air currents actually exist, and they play their active part in today's air travels. Today we call them 'jet-streams', only they are found at much greater altitudes than Wise assumed.

Right from the outset Wise strove in his career as a balloon pilot to practise what he preached, for he aimed at nothing less than the crossing of the Atlantic Ocean by balloon. Wise first ascended in a balloon in early 1839 and already, by his balloon ascent on 27 April of that year, had made a very important contribution to the exploitation of the balloon by introducing the ripping panel. This is a panel which is glued to the upper half of the balloon envelope; the pilot can pull it open, by means of a line inside the balloon, just before the basket touches the ground in landing. By so doing the balloon is quickly deflated and any long dragging in strong winds is prevented. Previously a grapnel was used to prevent this dragging, but this system was liable to cause much damage and/or severe injuries if catching hold of obstacles. Strangely enough, many years were to pass before Wise's example became general practice.

During the war of the United States against Mexico in 1846–8 Wise offered, immediately after the outbreak of hostilities, to build a captive balloon to be stationed at the San Juan de Ulua fort that covered Vera Cruz in Mexico. The balloon was to release percussion shells and 'aerial torpedoes' over enemy territory. The military authorities were not interested, however, feeling – not without cause – that guns and mortars were sufficient weapons for that war.

When the Civil War in America began in 1861 several of the best-known balloon pilots there, including 'Professor' Wise (as he styled himself by then) offered their services to the Federal forces. At that time it was common practice among American professional aeronauts to entitle themselves 'Professor', and they all felt that they could render valuable service to the northern cause since it should be feasible to make aerial observations of the enemy's movements from captive balloons. We have already reported, in the section on Thaddeus Lowe's activities in the Civil War (No. 11), that these voluntary balloon observers did not get due credit for their war work. They took an active part in several of the major battles, yet their headquarters failed to realise the tactical advantages to be drawn from the use of captive balloons – though it must also be admitted that the available equipment was not very suitable.

In 1859 Wise began to embark upon his dream, which was to cross the Atlantic in a balloon by utilising the easterly winds blowing at high altitudes. For the purpose, he had a 50,000 cu.ft (1,416 cu.m) balloon built, which was supported by two smaller balloons as standby if the main balloon envelope should require any repairs while in the air. The crew would number four. They were provided with ample quarters in the roomy, enclosed cabin. Provisions and equipment were to be stored in a 'cellar' below the floor. The transatlantic balloon was to carry a lifeboat suspended by a cable below the car. The enormously wealthy balloon enthusiast Oscar A. Gager was the main financial backer of the Wise project.

The balloon was named *Atlantic*, and in July 1859 Wise decided to make

a cross-country trial trip with it. He ascended from St Louis, and on this occasion was accompanied by Gager, John La Mountain, an old hand at ballooning himself, and a reporter named Hyde from the *St Louis Republican* local newspaper. They found a favourable westerly wind, and when landing nearly 20 hours later on the eastern bank of Lake Ontario, close to the town of Henderson, they had covered a course of 1,100 miles (1,770 km), or, in a straight line, a distance of about 809 miles (1,302 km), which remained a balloon world record for many years. This air voyage had been very dramatic; a tempest had raged, forcing them to drop the lifeboat, and a pouch with letters which they also carried, to escape death by drowning.

On 22 September the same year La Mountain made one more trial trip, accompanied by the well-known newspaperman J. A. Haddock. It was planned to be of short duration only when they rose from Watertown in the state of New York at 5.30 p.m., but thrilled and excited by the magnificent scenery unfolding below the balloon they did not decide to land until dusk at 9 p.m. when they found themselves in a desolate region and faced four days' and nights' walking through cold and wet forests before reaching an inhabited spot. There they learned to their astonishment that they had landed with their balloon some 155 miles (250 km) north of Ottawa in Canada.

The *Atlantic* balloon was never to cross 'The Pond' by air, one likely cause for this failure being that the envelope turned out to be less sturdy than estimated. Wise himself was to die 'with his boots on': on 29 September 1879, at the age of 71, this indefatigable pioneer balloon pilot made his last ascent, from St Louis, accompanied by a local banker, George Burn, only to disappear in Lake Michigan.

16 Tissandier's unsuccessful record attempt with the balloon 'Zénith'

We have already reported (see No. 13) that two Englishmen, Glaisher and Coxwell, were the first to climb in a balloon to an altitude of more than 30,000 ft (9,145 m). The first attempt to better the record set with the *Mammoth* balloon was made in France. The moving spirit was the well-known scientist, author and aeronaut Gaston Tissandier (1843–1899). He was accompanied on this ascent by the physicist Joseph Eustace Crocé-Spinelli and by the former naval captain Henri Théodore Sivel, who had married into a family of active aeronauts and had become an experienced balloon pilot himself. The 106,000 cu.ft (3,000 cu.m) balloon *Zénith* used for this ascent belonged to Sivel and Tissandier, who had on 23–24 March 1875 made a trip of 23 hours' duration in it, travelling a distance of 356 miles (573 km) from Paris to Arachon in the Gironde district.

As *Zénith* now rose from the gasworks at La Villette at 11.32 a.m. on 15 April 1875, in an attempt to beat the record of the *Mammoth* balloon, the three occupants of the basket, forewarned by the trying experience of Glaisher and Coxwell on their altitude attempt, had outfitted themselves with individual oxygen breathing equipment. This comprised three bladders of air mixed with oxygen, each connected through a tube with a hand-held mouthpiece for the intake of the mixture by the aeronauts. This arrangement had worked perfectly when they had tried it out previously on the ground in a vacuum chamber. They began to inhale the oxygen mixture when the balloon had climbed to an altitude of 22,970 ft (7,000 m) and, simultaneously, optimistically dropped a good portion of their sand ballast.

As they reached 24,300 ft (7,400 m), suddenly all three of them began to feel increasingly ill at ease in spite of their use of oxygen. They became short of breath and their pulses throbbed faster. They felt exhausted and Tissandier even lost consciousness for a moment. The balloon now began to sink fast, and they had to throw out still more ballast in order to make the balloon resume its climb. At an altitude of 26,250 ft (8,000 m) Tissandier blacked out again, but Crocé-Spinelli aroused him by shaking him strongly, only to have Tissandier faint once more a little while later. He re-opened his eyes at 3.45 p.m. and observed that the balloon was sinking fast, but saw also to his dismay that both of his companions lay prostrate at the bottom of the basket. Their faces were black and blue, and blood foamed from their mouths. With great skill Tissandier managed to land *Zénith* safely, though hard, by the village of Ciron, near Le Blanc, some 155 miles (250 km) south-west of Paris. It was then 4 p.m., and doctors called in could establish only that both Crocé-Spinelli and Sivel had departed this life some time ago. Tissandier himself took violently ill shortly after his landing, but recovered quickly after resting briefly on the ground. Deeply grieved, he took charge of the motionless bodies that those hastening to the spot had placed next to the balloon basket. Undoubtedly they lost their lives because the mouthpieces, used instead of more suitable face masks, had depended upon the men remaining conscious in order to keep them in position. The flow of oxygen may also not have been quantitatively sufficient. The survival of Tissandier can be ascribed to his being in a better physical condition than his two companions. That Glaisher and Coxwell managed to descend with no ill effects from more than 30,000 ft (9,145 m) undoubtedly is also explained by their good health and condition, combined with their being accustomed to high altitudes from their long stays in those regions. Finally it has also been asserted that *Zénith* on this ascent was exposed to more degrees of frost than *Mammoth* met with on hers.

Crocé-Spinelli and Sivel today lie below a beautiful monument at the Père-Lachaise cemetery in Paris, not far from the tomb of Madame Blanchard who was killed in 1819 when, after landing on the roof of a house, she fell out of her balloon basket and plunged to the ground (see No. 4).

17 Dupuy de Lôme's airship driven by 'galley slaves'

During the siege of Paris in the Franco-Prussian War of 1870–71 the French government commissioned the naval engineer Henri Dupuy de Lôme to build an airship which was to attempt to reach the besieged city by an aerial route. He tackled this task sensibly in many respects. First he built a 118·5 ft (36·12 m) long, egg-shaped airship envelope with a diameter of 48·7 ft (14·84 m), holding 121·990 cu ft (3·454·4 cu m) of gas. It was fitted internally with a ballonet which was inflated by means of a hand pump. A second triangular rudder was provided for steering purposes. The suspension of the gondola from the envelope was not unlike the much later practice of small non-rigid airships, in having its own separate attachment cables.

In respect of propulsion, Dupuy de Lôme lacked the time to experiment with something new and took the retrograde step of resorting to manual power, by the use of eight sailors to operate the four-bladed propeller. The inflation of the ballonet called for hand power as well, so the total weight of his 'power plant' was likely to have

exceeded the weight of a steam engine of comparable power.

The completion of Dupuy de Lôme's airship was delayed for various reasons and its first and only flight did not take place until 2 February 1872, some time after the war had ended. The airship left Fort Neuf in Vincennes, outside Paris, and some hours later successfully reached the nearby village of Mondécourt, having attained a maximum altitude of 3,350 ft (1,020 m). The eight 'galley slaves of the air' managed to convey the airship at a speed of almost 6 m.p.h. (10 km/hr), a creditable performance due not least to Dupuy de Lôme's liberal allowance of rum. The newspapers were keenly interested in this airship and were quick to make the comment that the engine was operating exclusively on rum.

This particular airship project was not developed any further, but some valuable experience had been gained from it: first that airships could be considered dirigible to some extent and, secondly, that further exploitation of this possibility called for a really powerful engine that could drive an airship forward at a greater speed than any prevailing wind.

18 The electrically-driven airship of the Tissandier brothers

In their search for a suitable powerplant the airship pioneers of the nineteenth century investigated all available possibilities. In the previous chapter we have even seen how Dupuy de Lôme resorted to man-power.

At a Paris exhibition in 1881 devoted to electricity, an electrically driven airship model was demonstrated. It had been conceived by the Tissandier brothers, Gaston and Albert, and as it attracted much attention they decided to build a full-size airship. They gave the envelope a length of 91·9 ft (28 m) with a maximum diameter of 30·2 ft (9·2 m), resulting in a capacity of 37,434 cu.ft (1,060 cu.m) of gas. A large galvanic battery supplied the current to drive a 1·5 h.p. electric motor of Siemens manufacture, with a two-bladed propeller mounted on its shaft. The total weight of this installation amounted to some 606 lb (275 kg), which gave a rather unsatisfactory power/weight ratio of 1:400. The gondola was shaped like a cage with a frame of strong bamboo cane covered with fabric. With a crew of two men, the all-up-weight of the airship came to 2,755 lb (1,250 kg).

On 8 October 1883 the Tissandier brothers made a first flight of slightly less than an hour's duration from the suburb of Auteuil, on the western outskirts of Paris, to Croissy-sur-Seine in the neighbourhood of Saint-Germain. There was only a light wind blowing and the maximum attained speed amounted to little more than 3 m.p.h (5 km/hr). The small triangular rudder was insufficient to maintain a course and it was therefore quickly decided to enlarge its area. Although only a few other small alterations were made besides this change the airship did not ascend again until 26 September 1884 at 4 p.m., again from Auteuil. Taking advantage of a north-easterly wind, the airship headed south after describing some turns over Paris which proved the rudder now more effective, but the speed was still on the extremely low side. After being in the air for two hours, Gaston Tissandier decided that it was advisable to land and so descended by the village of Marolles-en-Brie close by Villeneuve, having covered a distance of 15·5 miles (25 km) from his starting point, as the crow flies.

The trial trips had been pretty successful, yet the Tissandier brothers abandoned further development work as their airship had broken no new

ground, and proved too slow even under favourable weather conditions. This decision was also influenced by the simultaneous appearance of the much more manœuvrable airship of Renard and Krebs (see No. 19).

19 **The airship 'La France'**

What could be accomplished with free balloons, and the extent of their limitations, had been demonstrated convincingly during the siege of Paris; and so many in France produced various schemes for dirigible airships. Dupuy de Lôme had already attempted to build an airship with which to gain entrance to Paris by air during the siege, but it was not completed until 1872 as stated in chapter 17. Then, in 1878, two officers in the French Engineering Corps, Captains Charles Renard (1847–1905) and Arthur Krebs, conceived a design for an airship. First they built a small model which was demonstrated before the renowned politician and former Minister of the Interior Léon Gambetta, who had not forgotten his own escape from besieged Paris by balloon (see No. 14). Gambetta thought highly of their idea and when the War Office turned them down he financed them personally to the sum of 400,000 francs.

The airship was built at the Chalais-Meudon aeronautical establishment outside Paris during the summer of 1884 and was named *La France*. Paul Renard helped his brother with the work, which took two months from the time of the first stitch until it was ready for its maiden air voyage. The envelope of the airship was pointed in front and shaped like a torpedo, the gondola was no less than 114·8 ft (35 m) ft long, made of bamboo cane, and covered with silk and linen fabric. An electrical motor provided the power, taking current from an especially light-weight battery. The unit drove a four-blade wooden propeller of the tractor type, having a diameter of 29·5 ft (9 m). Renard had provided a very efficient rudder and elevator arrangement and the centre of gravity of the airship could be shifted by means of a sliding weight.

The 9th of August 1884 was a suitable day for the first trial flight and, with the two designers aboard, the airship arose and Renard started the engine; the large propeller began to revolve, pushing the airship forward. Renard and Krebs had not counted on being able to return to their starting point, but found themselves able to control the dirigible at will, and hence circled nearby Villacoublay, and then after a flight of 23 minutes' duration landed again safely in Chalais. *La France* thus was the first airship in history to return to its starting point and had attained a speed twice that of any previous airship. In the course of 1884 and 1885 *La France* made a total of seven trips. Five times – on 9 August, 8 September (when the airship ascended twice) and again on 22 and 23 September – it returned to its starting point. On the last two occasions the airship flew as far as, and crossed parts of, Paris. On the trip on 23 September three people were carried, namely Renard, who served as pilot; Duté-Poitevin, a well-known free-balloon pilot; and the later-renowned actress Gaby Morlay who attended to the electric motor and thus became the world's first woman airship passenger.

La France is often credited with being the first practical airship, which is a slight exaggeration, for her speed was so insignificant that her dirigibility was limited to days of almost complete calm; nor did the capacity of the battery suffice for anything but short trips. A petrol engine would have proved the efficiency of this airship beyond all doubt.

Renard had now demonstrated what a sensible airship should look like and next devoted himself to the scientific aspects of aeronautics, the critical speeds of airships being one of the problems he studied especially. Renard thereby contributed his important share to the rapid French strides in aeronautics in the years before World War 1. He held the rank of Colonel when he died on 13 April 1905. Strangely enough, he never took to the air again after 1885, but his name will live in the development history of aeronautics as the first to solve the dirigibility problems of the airship.

Specification of 'La France'
Volume: 65,826 cu.ft (1,864 cu.m)
Length: 165·4 ft (50·42 m)
Maximum diameter: 27·6 ft (8.40 m)
Total weight (carrying two persons): 4,410 lb (2,000 kg)
Engine: One 8 h.p. Théophile gramme electric motor
Speed: 14·5 miles per hour (23·4 km/hr)

20 **The British Army balloons**

The British Army introduced balloons among its equipment in 1878 when the Woolwich Arsenal in London began to build balloons under the direction of Captains R. P. Lee and J. L. B. Templer. This new development proved so promising that in 1879 a separate balloon section for observation balloons was formed. *Pioneer*, of 10,000 cu.ft (283 cu.m), became its first hydrogen balloon, and made its first ascent on 23 August 1878. By 1882 the Balloon Equipment Store, as the section was known, had gained general recognition, and in October of that year was transferred to Chatham, Kent, where it was assigned to the School of Military Engineering.

The small Balloon Establishment, as it was re-named a year later, was very active during the next few years, and its achievements included the production of steel cylinders for prolonged storage of hydrogen under pressure. In the 10,000 cu.ft (283 cu.m) *Heron*, it also introduced another improvement by using the so-called 'goldbeater's skin' in the making of balloon envelopes. As the description indicates, the primary purpose of this material had hitherto been to serve in the hammering out of gold-leaf. The material, derived from the intestines of certain animals, provided more flexible and gas-tight balloon envelopes; the Weinling family from Alsace, then residing in London, enjoyed a near-monopoly in its manufacture. They had previously made only small toy balloons, but at the instigation of Templer all seven members of the family were integrated into the Balloon Establishment and served with it for more than thirty years.

In 1885 a detachment with three balloons served with the military expedition to Bechuanaland under Captain H. Elsdale, who meanwhile had been promoted to Major, and of Lieutenant Trollope. It saw no real active service, but the commanding officer of the expeditionary force, General Sir Charles Warren, himself made a number of successful observations from the balloon *Heron*.

The same year another balloon section under the command of Templer, who also had been promoted to Major, and of Lieutenant Mackenzie participated in the actions in eastern Sudan. It played only a small part in them, due to lack of hydrogen and transportation facilities; but Mackenzie stayed in the air for seven hours at an altitude of 750 ft (229 m) while a column marched from Suakin to Tofrik, his 7,063 cu.ft (200 cu.m) balloon being towed by a car in the centre of the column.

Elsdale carried out much valuable pioneering work in the field of military

balloons before he was succeeded in 1888 by Major C. M. Watson. Right from the start, Watson aimed at rounding out the section as a self-contained unit with its own horses and drivers, and its own base. In 1889 a balloon section participated for the first time in the Army manœuvres at Aldershot, Hampshire, at the end of which one of the balloons took part in the parade headed by Elsdale, who meanwhile had succeeded Captain Lee. In the same year Aldershot was made the permanent base of the Balloon Establishment, and in 1890 it was joined there by the newly-formed Balloon Section of the Royal Engineers.

At that time the standard uniform of a British officer on active service was composed of a tunic, breeches, riding-boots with spurs, a helmet, and a belt with sword and a sabretache. The balloon officers found it next to impossible to convince their army brother-officers that most of this outfit made no sense and was worse than useless while they performed their assigned duties in the balloon basket. In the beginning the others felt that the balloon officers' demand to be permitted to dispense with much of it called for severe censure.

At the end of 1899 Great Britain was heavily engaged in the war against the Orange Free State and Transvaal (the Boer War), in which four British balloon detachments participated. Each of them was followed by a train comprising six cars pulled by horses or bullocks, all of them transporting nine steel containers of compressed hydrogen, in addition to the usual field carriages belonging to every military unit. These 'bottle cars' were simply yet sturdily built to withstand the rough South African terrain, and the balloons were kept inflated all the time. The nine bottles on each carriage were inter-connected by means of detachable rubber hoses and contained sufficient hydrogen for the inflation of two captive balloons of 13,000 cu.ft (368 cu.m) each. At this distance in time it is difficult to assess how valuable these balloons proved to British headquarters, but they undoubtedly facilitated the surveying of the progress of the campaigns of the two somewhat uneven sides and enabled British generals to estimate the activities immediately behind the enemy lines. The signals from the air were thus important, but they were still transmitted in a rather primitive manner by flags in code to the ground troops.

By 1903 Templer had risen to the rank of Colonel and, upon his recommendations, the two balloon establishments were transferred to neighbouring Farnborough owing to the increased activities resulting from the war. This move was effected in the winter of 1905–1906 and laid the foundation for what has today become the Royal Aircraft Establishment research centre at Farnborough, whose airfield is also a display centre of world-wide fame.

21 The kite balloon

Almost to the end of the nineteenth century the spherical style of free balloon was the one used for military captive balloons. Their drawback was their unsteadiness in the air, for even if only a slight wind was blowing it made the task of staying in the basket to observe very difficult – and most unpleasant to the occupants, who were apt to become violently air-sick.

This was remedied by two German officers, Major August von Parseval and Captain H. Bartsch von Sigsfeld, who set themselves the task of turning out an improved type of observation balloon. The outcome was the 'Drachenballon', or kite balloon, so called because it combines both balloon and kite principles. Theirs was not really a new idea, but they improved on previous efforts. They created an oblong envelope which was partly supported by the wind when facing it at an inclined angle of 30 to 40 degrees. It was stabilised by means of a control surface, which was later replaced by a large air bag.

Beginning in 1893 they tried different combinations and various sizes of envelopes, from 21,200 cu.ft (600 cu.m) capacity to twice that size, and by 1898 von Parseval and von Sigsfeld had arrived at the type which gradually became the standard of most European armies. By now they had added a stabilising fin on the right and left sides of the envelope to prevent the captive balloon from twisting around its longitudinal axis and, like a kite, it was further provided with a long tail to which one to five parachute-like 'umbrellas' were attached. Combined with the stabilising bag, these devices held the balloon facing into the wind.

The August Riedinger balloon plant in Augsburg, Germany, began a regular production of this type of kite balloon, and also supplied various styles of engine-driven motor winches on which the observation balloons were raised into the air and later hauled down again to the ground. The cruisers in the navies of several countries were also equipped with kite balloons, to detect enemy submarines and protect the cruisers against their attacks. It soon became standard practice for the kite balloon to stay completely steady in the air at altitudes ranging from 3,280 to 6,560 ft (1,000 to 2,000 m), even in winds of up to 40 m.p.h. (65 km/hr).

Kite balloons were used extensively in World War I. They soon began to appear in great numbers on the western front, where the Germans employed them to direct their gunfire and report its effects. This, combined with the proclivity of the Germans for eating large quantities of sausages, explains why these kite balloon artillery observation platforms were soon nicknamed 'sausages' by the Allies, who in turn copied, built and used them extensively until the French came up with the improved 'Caquot' type of kite balloon (see No. 46). Although the kite balloons were in fixed positions, the fighter pilots flying to attack them soon had driven home to them forcefully that this meant first running the gauntlet of a well-adjusted barrage of fire from anti-aircraft guns mounted to protect them. This meant that the kite balloons must be attacked very fast from above in a determined dive on them because they could be hauled down fast. The downing of a kite balloon therefore ranked on a par with a victory in any other air battle. The balloon observer was one up on the aeroplane pilot in one respect, in that he had a parachute hanging on the outside of the basket and could jump to save his life in case of an enemy air attack. It was not until towards the end of the war that German fighter pilots were also outfitted with a parachute in their aircraft.

22 David Schwartz, the originator of the rigid metal airship

Until the last decade of the nineteenth century all airships were of either the non-rigid or semi-rigid type and could be termed nothing more than types of elongated dirigible balloons.

The Austrian engineer David Schwartz was the first to design and build a truly rigid airship, with structure and covering completely of aluminium. He conceived this idea first in 1893, but his original layout did not have sufficient strength. He therefore began to build an improved type in Berlin in 1895, but work on it almost came to a halt when Schwartz passed away suddenly in January 1897, but his

resolute widow carried on the work with great determination.

The envelope, more properly described as the hull, was a slightly elliptical cylinder, 45·9 ft (14 m) deep and 39·4 ft (12 m) wide with a pointed, almost conical nose as in the ballistic missiles of today. The rear end was slightly convex. It had a total length of 157·5 ft (48 m) and held 130·664 cu.ft (3,700 cu.m) of gas. The interior structure was composed of aluminium tubing covered by a skin of 0·08 in (2 mm) aluminium sheeting. The three propellers were also made of aluminium alloy; two were mounted, one on each side and in front of the gondola and the third above and astern of the gondola. All three were adjustable to effect control of the airship.

The operation of filling the airship was the responsibility of the well-known balloon pioneer Captain von Sigsfeld, and was conducted during the first days of November 1897, in the suburb of Schöneberg on the south-western outskirts of Berlin. Much to the surprise of the many spectators the small silver airship displayed a pronounced tendency to want to leave the ground. Unfortunately a wholly inexperienced person was in charge of the airship on its maiden voyage, and providence seems benevolently to have consigned his name to oblivion. The weather conditions furthermore were unfavourable for an ascent, with a strong wind blowing; and after the handling crew had let go of the lines holding the airship to the ground, it started to climb and began at once to drift before the wind. The frightened pilot worked the helm too much, which resulted in disengagement of the propeller driving chains from their cog-wheels; stricken with panic, he then valved gas, and the airship crash-landed. The unfortunate pilot was in shock resulting from his fall, but otherwise unharmed, whereas the little airship which had cost so much energy to build resembled nothing so much as a huge, compressed ball of silver-paper on the ground.

Yet the bold pioneering enterprise of David Schwartz and his collaborators had not been completely in vain, for it had been proved that a metal airship was capable of leaving the ground, and later airship designers were to benefit from the experiences gained from the construction of the Schwartz airship.

23 The Santos-Dumont series of airships

Alberto Santos-Dumont, the small Brazilian dandy, was without any doubt one of the most colourful figures in the long gallery of aeronautical pioneers. His family wealth sprang from South American coffee plantations, but he himself lived and worked most of the time in and around Paris. He footed the bill for more than a dozen small airships, most of which were his own creations. All of them were powered by petrol engines.

Santos-Dumont was born in 1891 and left his native country at the age of 18, heading for an education in the French capital where the new-fangled automobiles and ballooning caught his fancy. Following his first ascent, in a balloon belonging to the French aeronaut Alexis Machuron, he built one for his personal use. It was of 3,990 cu.ft (113 cu.m) capacity and named *Brazil*, but his interest inclined towards the elongated airship variety and he hit upon the sensible idea of picking one of the light and efficient de Dion-Bouton automobile engines as his power plant. The outcome was Santos-Dumont's 'No. 1', which was 82 ft (25 m) long, with a maximum diameter of 11·5 ft (3·5 m), and had a gas content of 6,360 cu.ft (180 cu.m). It made its first trial run on 18 September 1898,

from the new zoological garden in Paris, Jardin d'Acclimatation, but it was only of short duration as the airship ended up in a tree. The result of the next flight was somewhat better, but neither 'No. 1' nor its successor, the slightly larger 'No. 2' of 1899, was particularly successful. The failure was mainly due to the lack of an amply rigid keel, and thus the airship envelope was not sufficiently rigid in either case; and also, Santos-Dumont still stuck to the balloon arrangement of suspending the gondola by ropes. With his 'No. 3' airship he managed to cross Paris by air and circle the Eiffel Tower, which encouraged him to take up airship construction in earnest. To this end he had a large shed erected on land at Saint-Cloud outside Paris, which the French Aero Club had just acquired. There he had a workshop built as well, and installed equipment for the production of hydrogen, but in addition he had a branch connection laid to the main pipes of the public gasworks, as he planned on using coal gas to provide the lift for his future airships.

The Santos-Dumont airships 'No. 4' and 'No. 5' were produced during the winter of 1900–01. They constituted improved designs with more powerful engines and were both fitted with reinforced keels accommodating the pilot.

The many aerial jaunts of Santos-Dumont with his various airships were often risky affairs and seldom lacked sensation. He seemed to lead a charmed life and a fortune-teller foretold that he would die in his bed in the end. Once his engine caught fire in the air, but he coolly put it out by smothering the first thin flames with his straw hat. On another occasion his airship collapsed and dropped on to the roof of a house in the centre of the French capital; the firemen were called out, who soon rescued him and brought him, unharmed, down one of their tall escape ladders. Those were the days before any air traffic control or other safety restrictions! Santos-Dumont could do much as he pleased, for he was the darling of the city, and it appealed to the Parisians to glance skyward and see him come skimming along their boulevards at roof level and then perhaps to park his 'steed' while leisurely and unperturbedly enjoying his luncheon at one of the fashionable outdoor restaurants.

The acme of Santos-Dumont's air career, and his most outstanding airship achievement, was winning the 100,000 francs Deutsch award by accomplishing the stipulated air performance in circling the Eiffel Tower. The money had been put up in 1900 by the French petroleum magnate Henri Deutsch de la Meurthe, to go to the first to leave Saint-Cloud by air and return to that starting point within 30 minutes after rounding the Eiffel Tower, under official supervision. The distance to be covered totalled 6·8 miles (11 km) and so called for a speed of slightly more than 15·5 m.p.h. (25 km/hr). Santos-Dumont failed on his first attempt with 'No. 5', but succeeded with his new and improved airship 'No. 6'. He took off on 19 October 1901 at 2.42 p.m. There was a slight crosswind blowing, but he made directly for his turning point and rounded the lightning conductor on top of the slender latticework at a distance of 165 ft (50 m) while checking that only nine minutes of his allowed time had then been spent. The wind was less favourable on the return trip and the engine also started misfiring. Santos-Dumont quickly decided to let go of his controls for a moment while attempting to adjust the engine, but meanwhile also took the risk that the airship might run off course. His gamble paid off and he crossed the final control point in Saint-Cloud with 29

seconds to spare. Victory was his, and the glory sufficed for Santos-Dumont, true sportsman that he was. The prize money had meanwhile grown to 125,000 francs, which he divided into two parts: 75,000 francs were bestowed upon the poor of Paris while the remainder was distributed among those working for him in Saint-Cloud. There was another pleasant surprise to come for Santos-Dumont, for the Brazilian government awarded him another prize, likewise amounting to 125,000 francs, besides a huge gold medal.

This performance by Santos-Dumont's airship was sensational news both in Paris itself and in aeronautical circles everywhere in the world; yet he is to be remembered most for his phenomenal, and tiny, airship of only 9,217 cu.ft (261 cu.m) capacity, for it was with this little 'air scooter' that he undertook many of his aerial jaunts throughout the big city. He had by now established his airship base at Neuilly-Saint-James, and the air visits to his favourite restaurant, 'La Cascade', in the centre of Paris, his chubby mount meanwhile remaining moored outside, have already been mentioned. On 23 June 1903 he even paid an early morning visit to his residence on the corner of the Champs Elysées and Rue Washington, and kept the airship waiting outside the front door while he enjoyed a cup of coffee.

How did Santos-Dumont get away with it? Two explanations are evident. Firstly, he always stayed at low altitudes with his airships; as he frequently commented himself, 'why climb high?' Secondly, he always had his trail-rope dragging on the ground which afforded him some directional and altitude control at the cost of some slight loss in speed.

In spite of his many airship activities Santos-Dumont contributed no real technical advancements to the cause, but then it must in fairness be remembered too that he never received any government support. He always remained an individualist. In the book that Santos-Dumont wrote, entitled *My Airships*, he expressed clearsighted views about two of the technical wonders of his day, the airship and the submarine, when he stated that under hostile conditions they could be deadly adversaries, with the former a natural oppressor of the latter, if confronted. Two world wars were later to prove how right he was.

Around 1905 Santos-Dumont lost his interest in airships and began to devote his attention to heavier-than-air craft instead, and although he also made some progress in that field (see *Pioneer Aircraft* 1903–1914 in this series), he is remembered best for his early exploitation of the airship.

Specification of 'No. 6'
Volume: 21,965 cu.ft (622 cu.m)
Length: 108·3 ft (33 m)
Maximum diameter: 19·7 ft (6 m)
Lifting capacity: 1,521 lb (690 kg)
Engine: One 12 h.p. Buchet/Santos-Dumont four-cylinder water-cooled engine

24 Andrée's Arctic balloon 'The Eagle'

Chief engineer Salomon August Andrée, who headed the Swedish patent office, was born in 1854 and became Sweden's first active balloon pilot. Andrée became interested in ballooning during his stay in America in 1876, where he met the pioneer aeronaut John Wise and was to have gone up with him. Wise had by then given up his own plans of crossing the Atlantic by balloon, but still held extended balloon trips to be feasible.

Andrée participated as an engineer and scientist in an expedition to Spitsbergen in July 1882, and here his idea of a scientific Polar expedition was engendered. His plan aroused much interest in Sweden, where he received financial support enabling him to buy the balloon *Svea* of 37,257 cu.ft (1,055 cu.m) capacity. From 1893 to 1895 he made nine solo ascents, and on the fifth of them, on 7 April 1894, established a Scandinavian altitude record by climbing to 14,393 ft (4,387 m). Andrée used the trail-rope and a steering sail on all of his balloon trips, a combination which under favourable conditions afforded him some influence over his direction of flight.

A subscription provided the means for purchase of the Polar balloon *The Eagle*, which was built by Ateliers Aérostatique de Lachambre in Paris from plans on which the Swedish engineer Nordenfeld collaborated. The envelope could hold 151,853 cu.ft (4,300 cu.m) of gas and was made of Chinese silk, the top part consisting of three layers. It was estimated that the treated fabric was sufficiently gas-tight to enable the balloon to stay in the air for a maximum endurance of thirty hours under favourable conditions. Instead of the usual top valve, which in that position might well be clogged by snow and ice, two valves were provided some way down on the envelope. The smooth, varnished surface of the top part of the envelope was expected to prevent any accumulation of snow there. The instruments were installed in the circular balloon basket that was enclosed and held supplies and emergency equipment. The latter included a folding boat and three sledges. One single berth was provided, and to eliminate any magnetic disturbances the balloon carried nothing made of iron or steel. The balloon was equipped with three trail-ropes, each about 985 ft (300 m) long, mounted on a revolving drum below the basket hoop. The drag lines were provided with connecting links. There were eight additional ballast lines which were to relieve the ballast of their weight if it descended close to the surface. The three sails provided for steering were attached to the envelope at their tops and to horizontal bamboo canes at the bottom. All ropes, as well as the netting, were waterproofed.

Andrée neglected no details, but was not receptive to outside advice. He had selected the Danish Isle on the northwestern tip of Spitzbergen as his starting point and arrived there on 30 June 1896 with *The Eagle*, the physicist Nils Strindberg and the engineer Knut Fraenkel who were to accompany him. The balloon was inflated and stored in a shed built specially for this purpose while they waited for a favourable wind. For this they hoped in vain, so some weeks later the balloon was deflated and repacked for the winter, while the expedition returned to Stockholm in its transport vessel *Virgo*.

The following year the Andrée expedition returned to Danish Isle on 30 May and readied *The Eagle* again. Another long waiting period set in, but the morning of 11 July finally brought ideal conditions for a start, with a fresh breeze that would carry the balloon in a north-easterly direction. After some busy hours spent on last-minute preparations, Andrée and his two companions climbed aboard and ascended at 1.50 p.m. The large yellow and red balloon drifted leisurely away from the port, the trail-ropes leaving a broad wake behind. Once the balloon descended so low that the basket touched the water, and the men had to drop more than 440 lb (200 kg) of their precious ballast. Now their helpers left behind were horrified to note that most of the important ballast lines had been left behind on the shore. They

had been laid out in front of the balloon in the direction of the wind, but one of the connection inserts had accidentally disengaged. They were unable to remedy this and were highly worried, as they knew how much store the aeronauts set by these drag lines. Soon *The Eagle* disappeared below the horizon and was never to be seen again. The only news received from Andrée in the days that followed was a message despatched by carrier pigeon which on 15 July was shot and picked up at sea by a Norwegian whaling boat. It read 'All's well on board. This is our third carrier pigeon despatch'. Two similar messages drifted ashore with buoys in 1899 and 1900 respectively, and were the last signs of life from *The Eagle* and its crew. They were deemed to have perished in the Arctic deserts.

On 6 August 1930 the Norwegian sealing vessel *Bratvaag*, while on a scientific expedition, found the bodies of Andrée and Strindberg in a camp on White Island, about 250 miles (400 km) east of Danish Isle. Some weeks later the body of Fraenkel was found by the crew of another vessel, *Polar Bear*, outfitted by the newspapers *Daily News* in Stockholm and the Copenhagan *Politiken*. The fate of this balloon expedition was finally established by means of its well-preserved diaries and photographic plates contained in tins. *The Eagle* had stayed in the air for 65 hours, then was forced down on the ice for lack of ballast, having covered a distance of almost 500 miles (800 km), although the straight-line distance from Danish Isle amounted only to roughly 250 miles. They had 500 more miles to fly before reaching the North Pole. The three men immediately began their walk south, and after immense hardships arrived on White Island on 5 October, where they established a camp and died shortly afterwards, perhaps overcome by the cold, but possibly also from poisoning after shooting a polar bear infected with trichinosis and eating its meat.

The three bodies were shipped to Tromsø and there transferred to the gunboat *Svensksund*, which returned them to Stockholm where they were interred with a great display of respectful sympathies from the whole Swedish nation.

25 **The giant balloon 'Preussen' (Prussia)**

In Germany, two professors at the Prussian meteorological institute in Berlin, Arthur Berson and Dr Reinhard Süring, made a number of balloon ascents to high altitudes in the years 1893 and 1894. Berson, on 4 December 1894, ascended alone in the hydrogen balloon *Phoenix* of 91,000 cu.ft (2,577 cu.m) from Strasbourg and reached an altitude of 30,040 ft (9,155 m). This achievement and other experiments led to the building of the balloon *Preussen* (Prussia), the envelope of which could hold 296,643 cu.ft (8,400 cu.m) of gas.

Berson and Süring first made some minor trial trips with *Prussia*, then on 31 July 1901 ascended in it from Tempelhof in Berlin and reached an altitude of no less than 35,433 ft (10,800 m). They were not to be outperformed until Professor Piccard beat their record in 1931 (see No. 67), and Piccard benefited from the advantage of being aided by a pressure-proof car, whereas when the Germans ascended, nothing but open baskets were available in which they mounted their oxygen tanks. This oxygen had, moreover, to be inhaled through mouthpieces held by hand, which even then must have been considered a risky practice. On the other hand, their various measuring instruments were high-quality products. They were made by the firm of Bosch to the

specifications of Berson and Süring, who were also advised by Professor Richard Assmann from the aeronautical observatory in Berlin.

Berson and Süring both began to use oxygen when they reached an altitude of between 16,400 and 19,685 ft (5,000 and 6,000 m). They made their last observations at the altitude of 33,546 ft (10,225 m), where the temperature reading was −39·7°C. When, a little later, they tried to climb still higher by throwing out some sand ballast, Süring lost consciousness. Berson likewise began to grow weak and felt that he was about to faint, but just managed to pull the valve before he too passed out. When the balloon had descended to an altitude of 19,685 ft (6,000 m) the two scientists came to in time to retard the rapid fall of the balloon by dropping more ballast, and they landed safely at 6.25 p.m. after having stayed aloft for almost eight hours. Their perilous trip had carried them to what was then described as 'the maximum altitude where human beings can survive'.

At an international meteorological convention held in Paris in 1896 it was agreed that unmanned weather balloons carrying automatic measuring equipment would be preferable lest human lives be risked at high altitudes; which explains why the altitude record of Berson and Süring was not surpassed for many years.

26 **Zeppelin LZ 1**

Unlike the non-rigid and semi-rigid airships, the rigid type incorporates an internal girder frame. The credit for developing this type goes unequivocally to the German Count Ferdinand Adolf Heinrich von Zeppelin (1838–1917). His name has forever become so closely connected with this type of airship that to many people the word Zeppelin has become synonymous with rigid airships and is often used as a common designation for all giant airships. As a reminiscence of the early air raids in World War 1, when civilian populations were first exposed to bombs from the air, some even shudder slightly to this day at the mention of the name Zeppelin.

Von Zeppelin was born on 8 July 1838 and was well connected, his family being wealthy Junker aristocrats in the small kingdom of Württemberg in southern Germany. He chose a military career and as a cavalry officer participated with distinction in the Franco-Prussian War of 1870–71. Being of an adventurous spirit he had already in the early eighteen-sixties taken a leave of absence to join the Federal Forces on the Potomac river as a voluntary observer in the American Civil War. He took a special interest in Thaddeus S. C. Lowe and his observation balloons (see No. 11). After his return from America von Zeppelin reflected much on the military use of balloons and, better still, airships. Entries in his diary from 1874 reveal that he had laid down three fundamental maxims for a successful airship. It must (1) be of large dimensions; (2) possess superior power of propulsion, and (3) have a supporting body made up of separate gas cells.

Von Zeppelin's ideas soon became widely known and were acclaimed in military circles, especially after the success achieved by the arch-enemy France, where the non-rigid airship *La France* had accomplished a number of flights (see No. 19).

In 1890, at the age of 52, von Zeppelin wrote an undiplomatic memorandum in which he made the criticism that the Prussian war office dominated the army of Württemberg. After that von Zeppelin was no longer in favour with the German emperor, Wilhelm II, and had to retire with a general's rank. As a civilian he now devoted himself

to airship problems in earnest. He displayed much energy in overcoming the many obstacles thrown in his way, and the severe criticism advanced against his project, and by 1896 he had raised working funds to the amount of 800,000 Reichsmarks for the foundation of the Aktiengesellschaft zur Förderung der Luftschiffahrt (Company for the Promotion of Airships), which sounded all very innocent, in order not to arouse any suspicions abroad.

Von Zeppelin could now begin to build his first airship. Lacking the required technical knowledge himself, he sought outside assistance and the help of Prof. Dr. Ing Müller-Breslau, who evaluated and revised von Zeppelin's airship layout, transforming it into a practical proposition. Construction work started in 1899 in a shed supported by 95 floats and anchored on Lake Constance near the city of Friedrichshafen. The framework of the airship's hull was composed of ring-shaped cross-sections interconnected by longitudinal beam members. Seventeen gas cells were installed between the main bulkheads and were filled with hydrogen. All components of the lattice-girder framework were made of an alloy of zinc and aluminium, and the framework was covered with linen fabric which was coated with a shrinking cellulose varnish, later termed 'dope'. The bottom of the hull was reinforced by a kind of keel, below which the two control and passenger gondolas were mounted. A Daimler petrol engine was installed in each gondola, and each drove a pair of propellers mounted away from the hull to port and starboard, and somewhat below the centre-line. Rudders were mounted on the hull, forward and aft. A heavy leaden weight hung suspended between the two gondolas, 85·3 ft (26 m) below the hull, and from its centre position could be pulled towards either gondola according to whether the airship was to climb or descend. This arrangement was improved upon after the first trial flight, when it was replaced by a sliding bar below the hull and extending over the greater part of the length of the airship. The movable weight on this bar was increased to 331 lb.

The maiden voyage of this first Zeppelin airship took place in the evening of 2 July 1900, when at 8 o'clock LZ 1 (Luftschiff Zeppelin 1) was pulled slowly out from its floating shed resting on a large raft. The Count was on board himself along with some mechanics who were to service the engines. The grizzled airship pioneer now ordered a small tugboat, with its bowline attached to the airship, to pull LZ 1 away, kite fashion. The huge airship appeared reluctant to leave the raft, but when the hawser was cut the airship began to cruise about with its propellers churning, to the cheers of the newspaper reporters and many other excited onlookers crowding the lakeside. Fifteen minutes later a mishap occurred as the sliding weight got stuck and the framework was deformed dangerously.

An emergency landing was made on the lake and the damage repaired. Thereafter LZ 1 took to the air again on two more occasions during that autumn, but these three trial runs, of a total duration of slightly more than two hours, revealed that the airship attained too little speed and responded slowly to the rudders, and that its strength was deficient in many respects. Since all available money had been spent, further work on this airship was abandoned and it was dismantled in early 1901.

The results so far had not been very encouraging, and von Zeppelin was criticised severely in public discussions. This did not deter the elderly Count at all; on the contrary, it stirred him

to new action. With the benevolent support of Kaiser Wilhelm II of Württemberg he was allowed to start a lottery and numerous newspapers published his 'Emergency Call to come to the Rescue of the Airship type of Aerial Navigation'. By 1904 Count Zeppelin once more commanded sufficient money to tackle the building of bigger and better airships.

Specification of LZ 1

Volume: 399,054 cu.ft (11,300 cu.m)
Length: 420 ft (128 m)
Diameter: 39·4 ft (11·7 m)
Engines: Two 14·7 h.p. Daimler four-cylinder inline petrol engines
Speed: 17·4 m.p.h. (28 km/hr)
Operational ceiling (theoretical): 3,117 ft (950 m)

27 Zeppelin LZ 7 'Deutschland' (Germany)

A decade after Count Zeppelin rose for the first time from Lake Constance in his LZ 1 he was beginning to achieve some considerable success, but had also suffered some severe setbacks, not to mention an occasional financial crisis. In the persistent pursuit of his airship goal most of his personal means had been spent. Right from the start the Zeppelin airships were planned as formidable weapons for a future war, so, great patriot that he was, Count Zeppelin grieved that the military authorities had withheld money for their purchase.

A review of the line of Zeppelin airships developed in the early days reveals that the second one, LZ 2, was completed in November 1905 and was wrecked on its second trip in January of 1906, when it made an emergency landing in stormy weather. LZ 3 (Z I*) began a series of successful flights in October 1906, and after being rebuilt was accepted by the German Army, with which it remained in service until the autumn of 1913. Beginning in June 1908, LZ 4 made some extended flights. On one of them, in July of the same year, this airship crossed the Swiss border and proceeded as far as Zürich before returning to Friedrichshafen. Count Zeppelin was in charge of the airship himself when in August it set out on the so-called 'Grand Tour', which was to be a 24 hours' endurance flight to satisfy the army authorities of the capabilities of the Zeppelin type of rigid airship. On 5 August, LZ 4 had been in the air for 20 hours, and was heading back for Friedrichshafen, when an engine breakdown forced the airship down at Echterdingen for the necessary repairs. A sudden storm threw the anchored airship against some electric wires, and it exploded, fortunately without the loss of any lives. This seemed to be the final, all-paralysing blow to the Zeppelin cause, but events turned out differently. The patriotic feelings of the nation were aroused, and from everywhere personal sympathy welled forth towards the grief-stricken, game old Count. Newspapers all over the country started collections for him, money poured in on a general scale and at generous rate, and even school children contributed their pennies. Within a few weeks the impressive amount of 6 million Reichsmarks was turned over to Count Zep-

* (a) All the Zeppelin airships bore the designation 'LZ', followed by a factory number expressed in Arabic figures. (b) The airships of the German Navy bore the designation 'L', followed by their naval service number expressed in Arabic figures. (c) The Zeppelin airships of the German Army were initially designated by a 'Z', followed by a service number expressed in Roman figures, but a new practice was adopted in 1915. From then on the German Army also adopted the 'LZ' designation for its Zeppelin airships, but followed by the army service number expressed in Arabic figures.

pelin, who placed the money in trust and founded the Luftschiffbau-Zeppelin GmbH (Zeppelin Airship Yard), in Friedrichshafen.

LZ 5 (Z II) was completed by May 1909 and in the same year made an impressive round trip between Lake Constance and the city of Bitterfeld in Saxonia, covering the distance of 746 miles (1,200 km) in 38 hours and 40 minutes. As an army airship it suffered the same fate in April 1910 that had befallen LZ 4 at Echterdingen.

LZ 6 was ready for operations in August 1909 and proved a successful type. It became an even faster airship when in October of that year it had a third and more powerful 145 h.p. Maybach engine added to the two 115 h.p. Daimler engines previously installed. This airship was acquired by the newly-formed national company Deutsche Luftschiffahrts A.G. (German Airshipping Co. Ltd.) better known by its abbreviation DELAG. The Zeppelin company was instrumental in the formation of DELAG, partly in order to have a civilian outlet for its airships instead of being dependent wholly on military contracts, and in addition to gain some practical experience in airship operating and handling. DELAG was managed by Dr Hugo Eckener, who was to become the most renowned of all airship pilots. LZ 6 caught fire and was destroyed on 14 September 1910 in its home base shed at Baden-Oos in the Black Forest, because of carelessness on the part of some workmen.

LZ 7 made its maiden voyage on 19 June 1910, and Count Zeppelin transferred it himself by air to Düsseldorf, where it was taken over by DELAG and named *Deutschland* (Germany). On 24 June this airship carried thirty-two passengers on a flight to Essen-Bochum-Dortmund and return. Early in the morning of 28 June *Deutschland*, carrying twenty passengers, mainly newspaper reporters, took off on an air cruise over the Elberfeld region. All had a good time and enjoyed themselves by dropping postcards with 'Aerial Greetings from high in the Sky', but by 11 a.m. the rear engine malfunctioned, so the decision was made to make an intermediate landing in Münster, where an auxiliary force was stationed. But the previous fine weather had been followed by a storm and sleet showers, and for several hours the airship fought the elements without making much progress. By 5 p.m. *Deutschland* was crossing the Teutoburger forest; she was now heavy from the rain, and a squall forced her down on some tree-tops, smashing the rear section. The rest of it was on the ground in the forest. Again, on this occasion, no one was injured.

As a replacement airship, DELAG received on 30 March 1911 *Ersatz Deutschland* or *Deutschland II*, which had been built quickly, to some extent from salvaged parts of LZ 7, but its career was brief too. After only three flights this airship was badly damaged while being hauled out of its shed.

The engines installed in the Zeppelin airships before World War I were not very powerful, so the craft lacked the speed for maintaining regular scheduled services; even so, a number of German cities built airship sheds from which the DELAG fleet of airships made almost daily cruises of several hours' duration. In this manner a great number of venturesome people received their air baptism and foretaste of future air travel, and here it might be mentioned that the big German steamship company Hamburg-Amerika Line was a financial partner in DELAG and acted as its ticket agents. It is also worth mentioning that even the ubiquitous *Baedecker* did not miss the 'airboat'. In several of these

far-sighted 'airport' cities, special illustrated travel guides were published describing the air sights of the region.

Specification of LZ 7 'Deutschland'
Volume: 681,574 cu.ft (19,300 cu.m)
Length: 485·6 ft (148 m)
Diameter: 45·9 ft (14 m)
Engines: Three 120 h.p. Daimler four-cylinder in-line petrol engines
Maximum useful load: 14,991 lb (6,800 kg)
Maximum speed: 37·3 m.p.h. (60 km/hr)
Operational ceiling: 6,560 ft (2,000 m)
Maximum range: about 1,243 miles (2,000 km)

28 **The Lebaudy-Julliot airships of the 'République' class**

Simultaneously with Santos-Dumont's experiments with small non-rigid airships (see No. 23), the French engineer Henri Julliot was working at a design for a much larger dirigible airship. He was employed by the wealthy sugar manufacturers, the Lebaudy brothers, Pierre and Paul, who had commissioned the project. Julliot's first airship, *Lebaudy-Julliot* 1, also named 'La Jaune' (The Yellow) because of the colour of the fabric used for its balloon envelope, was completed in November 1902. This airship was of the semi-rigid type and of an advanced design. An oblong metal frame was affixed to the bottom part of the balloon envelope and extended aft as a keel to which the rudder and elevator were attached. The keel was fitted with small horizontal and vertical stabilising fins, but the main, larger stabilising fins were attached to the balloon envelope. The latter maintained its shape by means of an interior ballonet that was divided into three parts. This airship made its maiden voyage on 13 November 1902, at Moisson, and fully lived up to expectations; in fact, it turned out to be by far the best airship yet. The *Lebaudy-Julliot* 1 was modified in 1904 and again in 1905 and made 63 successful trips in all, the longest of which was 61 miles (98 km). The French government bought this airship for army use in 1905, and ordered a sister vessel from Julliot. The latter in turn underwent modifications and then in November 1906 was lost, a fate that had befallen numerous other airships. The airship was at the time participating in military manœuvres near Verdun when, during a storm, it tore away from its moorings. It was last seen over Ireland where one of its propellers dropped and was found, then disappeared in the Atlantic Ocean. Fortunately, the airship had no crew on board.

Lebaudy-Julliot later built the following airships: *République*, delivered to the French Army in June 1908; *Russie*, to the order of the Russian government, in May 1909; *Liberté* for the French Army in August of the same year; *Autrichienne* in May 1910, ordered by Motor-Luftfahrzeug Gesellschaft in Vienna, and *Morning Post*, bought in October that year by the London newspaper of that name which later presented it to the British government. This airship was subsequently stationed at Aldershot. In 1911 the two airships *Capitaine Marchal* and *Lieutenant Selle de Beauchamp* were delivered to the French Army. After the outbreak of World War I the French Army in October 1914 received a giant, as far as Lebaudy-Julliot airships went, the *Tissandier*, which with a gas content of 706,290 cu.ft (20,000 cu.m) was the largest airship to their design. It was powered by three engines, each of them driving a four-blade propeller. This airship, however, proved too clumsy and was in service only a short time.

The *République* airship was a typical exponent of the Lebaudy-Julliot designs. It made its maiden voyage from the yard in Moisson, some thirty miles (50 km) outside Paris, on 24 June 1908, and was accepted by the French Army shortly afterwards. On 6 September that year it completed a non-stop flight of 6½ hours' duration covering 124 miles (200 km) at an average speed of 19–22 m.p.h. (30–35 km/hr). After several other successful flights *République*, under the command of Captains Bois and Fleuri, participated in the military manœuvres in Bourbonnais in central France, which began on 3 September 1909. When on 25 September the airship left La Palisse, north-east of Vichy, to return to its base at Chalais-Meudon, one of the propellers broke and pierced the balloon envelope. *République* plunged to the ground from an altitude of 656 ft (200 m) and was completely wrecked, and two officers were killed.

In 1915 Julliot emigrated to America where he became head of Goodrich's aircraft division and designed some small blimps and various observation balloons.

Specification of the 'République' class
Volume: 114,773 cu.ft (3,250 cu.m)
Length: 215·2 ft (65·6 m)
Diameter: 33·8 ft (10·3 m)
Engine: One 75 h.p. Panhard-Levassor four-cylinder petrol engine
Useful load: 2,640 lb (1,200 kg)
Cruising speed: 31 m.p.h. (50 km/hr)
Maximum range: about 124 miles (200 km)

29 **Clément-Bayard/Astra 'Ville de Paris'**

The successful Lebaudy-Julliot airships (see previous chapter) reinspired French confidence in this type of lighter-than-air craft, and even the government abandoned its previous hesitation about the placement of orders for military airships. Undoubtedly another contributing factor to the changed attitude towards airships was the fear that 'the Zeppelins' would spread from the neighbouring country now that the German Army displayed a more active interest in this type of aircraft. Thus Lebaudy-Julliot now faced competition from the Astra and Zodiac firms which also began to build airships of the non-rigid type. The airship design of the Clément-Bayard automobile concern was of particular interest. These airships were first built by the Astra Société des Constructions Aéronautiques. Their characteristics were the peculiar tail arrangement of, originally, four to eight oblong, sausage-like or pear-shaped envelopes filled with hydrogen which served as stabilisers. When viewed from behind their shape was, in cross-section, that of a clover-leaf.

Astra divided its production into three main groups, one comprising single-engined airships with one propeller, of which a total of eight were built; another with twin-engine installations and two or three propellers, of which one and four respectively were built; and finally a group of so-called Astra-Torrès airships. Their interesting design feature was that the shape of the envelope was maintained by a strong interior rigging as well as by means of a 17,657 cu.ft (500 cu.m) large ballonet which was kept inflated with air delivered by a fan of 254,266 cu.ft (7,200 cu.m) capacity per hour. The rigging to all intents turned the Astra-Torrès airships into the semi-rigid type and simultaneously permitted suspension of the car close to the envelope. The Astra-Torrès design was derived originally from a Spanish Torrès-Quevedo airship that in March 1911 was flown to France where the Astra company at Issy-les-Moulineaux, outside Paris, made certain repairs to it.

The prototype of the airships of the first group was *Ville de Paris*, which made some sixty successful trips in the years 1907 and 1908. It was built for sporting purposes to the order of Henri Deutsch de la Meurthe, the petrol magnate, but he donated it to the French government in 1907, after the loss of the army airship *Patrie*. *Ville de Paris* was based at Verdun whence, on 18 December 1907, it made a round trip to Sartrouville-Lagny covering 68 miles (110 km) in 3 hours 50 minutes. On 24 December this airship made a similar trip of 86·4 miles (139 km). Its longest flight was accomplished on 15 January 1908 over a triangular course to Sartrouville and Valmy and return to Verdun, when 148 miles (238 km) were covered at an average speed of 23 m.p.h. (37 km/hr). In 1908 *Ville de Paris* was modified in the workshops at Chalais-Meudon, where the balloon envelope also was renewed, and was fitted with a propeller of greater efficiency. This resulted in higher speeds of around 28 m.p.h. (45 km/hr) being attained by *Ville de Paris II*, as the airship was now named, on 25 October and 5 December. During the last years of its career this excellent and reliable airship served as a training vessel for army personnel.

The only airship built by Astra for civilian use was *Ville de Lucerne*, formerly *Ville de Pau*. It was owned by Compagnie Générale Transaérienne in Pau, and before the outbreak of World War I carried 2,590 passengers on 267 trips without any mishaps.

In 1913 the British government bought an Astra-Torrès airship, which was flown to Farnborough and designated 'No. 3'. At the outbreak of the war the Royal Navy used this airship for photo-reconnaissance of Ostend and Zeebrügge in Belgium, but later it served to train new airship crews.

When the war started in August 1914 the French Army possessed about a score of airships, but only *L'Adjudant Vincenot* and *Dupuy de Lôme*, of the Clément-Bayard type, were of any real military value. The last-named airship was mistaken for a German Zeppelin by French anti-aircraft gunners and shot down in the vicinity of Reims with the loss of one crew member.

Specification of 'Ville de Paris'
Volume: 112,830 cu.ft (3,195 cu.m)
Length: 198·2 ft (60·42 m)
Diameter: 34·45 ft (10·5 m)
Engine: One 70 h.p. Chenu
Lifting capacity: 7,760 lb (3,520 kg)

30 **Parseval PL 1 to PL 27**

Major August von Parseval, an army officer and later a professor at the Technical Academy in Berlin, built his first airship in 1906. It made its maiden voyage in May of that year and had an envelope holding 81,224 cu.ft (2,300 cu.m) of gas. It was built by the Motorluftschiff Studiengesellschaft (Society for the Study of Powered Dirigibles) which Kaiser Wilhelm II was instrumental in having formed. This airship was, like all the others designed by von Parseval, of the non-rigid type. The shape of the envelope was maintained by means of a ballonet at each end, which were used to trim the airship. Air was pumped into them by an engine-driven fan. The suspension of the control and engine gondola was a unique feature of this design as a so-called 'sliding rig' through a system of rollers kept the gondola in a horizontal position even when the envelope was in an inclined position during climbs and descents.

The PL 1 of 113,007 cu.ft (3,200

cu.m) capacity was built in 1909 to the order of the Imperial Aero Club. PL 2 and PL 3 were taken over by the German Army and numbered P I and P II respectively. On 15 September 1908 PL 2, with five people on board, covered 180 miles (290 km) in 11 hours. The envelope of PL 3 contained 197,762 cu.ft (5,600 cu.m) of gas and this airship was equipped with two N.A.G. engines of 110 h.p. each. It made some passenger trips during the ILA international aircraft exhibition at Frankfurt-on-Main, for which it was awarded the prize of honour offered by the German emperor.

In 1909 the production of Parseval airships was transferred to the LFG company (Luftfahrzeug Gesellschaft) which maintained plants in Berlin and Bitterfeld. P I and P II, along with Zeppelin Z II and one more army airship, the Gross-Basenach M II, took part in the large-scale army manœuvres held in the Cologne region in November 1909.

The PL 4, of 81,224 cu.ft (2,300 cu.m) size, was furnished to Austria, and the smaller PL 5, with a volume of 51,207 cu.ft (1,450 cu.m), served sporting purposes. PL 6, of 317,430 cu.ft (9,000 cu.m) capacity, was a passenger airship which in August 1910 made a number of flights over the cities of Berlin and Munich. In the German capital they took place at night as searchlights projected advertisements for the Stallwerck chocolate factory on to white screens affixed to the sides of the balloon envelope. At the outbreak of war in 1914 the German Navy took over PL 6; but Prince Henry, the Emperor's brother, who was Grand Admiral and Inspector-General of the German Navy in the Baltic district, held this airship unfit for active military service, and it was used only as a training airship. Both the German Admiralty and Army headquarters thought little of non-rigid airships, but showed poor technical judgment in this respect, for though the Parseval airships were small and seemed vulnerable, they were also cheap and quick to produce; and were easy to move about on active service. PL 6 was dismantled in 1915.

PL 7 was of 268,391 cu.ft (7,600 cu.m) capacity and equipped with two 110 h.p. N.A.G. engines with chain-driven propellers. They were, as on all previous Parseval airships, made of fabric with weights attached to the blade peripheries which kept the fabric stretched when revolving, but this was the last of these airships to follow this practice. It was bought by the Russian Army, fitted with a Telefunken radio and named *Eilgut* (Express merchandise). This airship was delivered by air to St Petersburg in November 1910.

The 282,517 cu.ft (8,000 cu.m) PL 8 was an army airship originally destined for the Brussels World's Fair, and PL 9 and PL 10 were both small and fast sporting airships of around 70,630 cu.ft. (2,000 cu.m) each. PL 11 was again a German Army airship and relatively fast, being equipped with two Körting engines of 250 h.p. each, driving steel propellers. Its envelope held 388,460 cu.ft (11,000 cu.m) of gas. Being reversible, the braking effect of the propellers could arrest the forward speed of the airship when landing. An auxiliary 10 h.p. Daimler engine served to start the main engines and also drove the fan supplying air to keep the two ballonets inflated.

PL 12 was a passenger airship, while PL 13, equipped with Maybach engines, was delivered to Japan. PL 14 was ordered by Russia; PL 15 and PL 17 were purchased by the Italian Army; PL 16 remained in German service. In June 1913 Great Britain bought PL 18, which received the English designation 'No. 4'. The British Admiralty ordered three more Parseval airships

PL 19 to 21, but due to the outbreak of World War 1 they were never delivered. By an irony of fate, 'No. 4' was the first British aircraft to see active service in the war, as this airship patrolled the entry to the River Thames on 5/6 August 1914. It was broken up on 17 July 1917. In Great Britain, Vickers was to build three Parseval airships, Nos. 5 to 7, under licence, but they were used only for training purposes. PL 19, which was originally to have been delivered to Great Britain, was lost accidentally above the city of Libau in the Baltic on 25 January 1915.

Airships PL 22, 23 and 24 were never completed, but one more Parseval airship saw active service. This was the naval PL 25, which for a time was stationed at the Tondern airship base on the Danish border, then still German territory. It was dismantled at Biesdorf near Berlin in 1915. PL 26 was a relatively large airship, of 1,059,440 cu.ft (30,000 cu.m) capacity, which caught fire and was destroyed in its shed at Bitterfeld after making one trial flight only. PL 27 was the last and largest Parseval airship built during World War 1, for the construction of non-rigid airships was restricted by the rubber shortage then prevailing in Germany due to the Allied blockade of the German coasts; this airship type required rubberised envelopes to attain the necessary strength. PL 27 survived the war, but proved a troublesome airship; it was tail-heavy, for one thing. Here was an instance where swords really were turned into ploughshares, for the huge balloon envelope of PL 27 was cut up and made into civilian raincoats.

The design and construction of non-rigid airships of the Parseval type was resumed after World War 1 by the Wasser- und Luftfahrzeug GmbH (Water- and Air Travel Co. Ltd), which built the two advertising airships PN 28 and PN 29, PN standing for Parseval and Nagsfeld, the post-war airship designer of this concern.

Specification of PL 2 (P I)
Volume: 141,260 cu.ft (4,000 cu.m)
Length: 190·3 ft (58 m)
Diameter: 34·1 ft (10·40 m)
Engine: One 100 h.p. Daimler four-cylinder
Cruising speed: approx. 34·2 m.p.h. (55 km/hr)
Operational ceiling: 4,920 ft (1,500 m)

Specification of PL 27
Volume: 1,105,344 cu.ft (31,300 cu.m)
Length: 515·1 ft (157 m)
Diameter: 64·3 ft (19·6 m)
Engines: Two 240 h.p. Maybach
Cruising speed: 56 m.p.h. (90 km/hr)
Operational ceiling: 14,765 ft (4,500 m)

31 The British Army airship 'Nulli Secundus'

In 1902 the commanding officer of the British Army Balloon Factory at Farnborough, Colonel J. L. B. Templer, visited the Brazilian Alberto Santos-Dumont in Paris, to study his various small airships (see No. 23). Upon his return the colonel recommended to the British government that a number of small non-rigid airships be built, but this proposal was not looked upon favourably because of the tight budget at that time. However, the Balloon Factory managed in 1904 to build two sausage-shaped envelopes of gold-beater's skin, but had by then spent all its available funds. In 1907 Templer's successor, Colonel J. E. Capper, resumed this work and managed to build the first British Army airship, the semi-rigid *Nulli Secundus*, based upon

the already available envelopes. The design was rather imperfect: for example, no interior ballonet was provided to maintain the pressure inside the envelope, and the airship also lacked any stabilising arrangement. The control surfaces, a large rudder and some tiny elevators, soon proved almost completely ineffective, with the outcome that the airship really had to be handled as if it were a free balloon. Several engine installations were tried and the final choice fell upon a 50 h.p. Antoinette. The airship made some brief flights in the vicinity of Farnborough, and then it was boldly decided to fly this precarious aircraft across London. The airship started, in great secrecy, on 5 October 1907 and was piloted by Colonel Capper; as his assistant, Capper had picked the famous aeronautical pioneer 'Colonel' S. F. Cody, because the latter was the only person available who was strong enough to start the engine. The airship reached London after a flight of some 3½ hours' duration and circled St Paul's Cathedral and Buckingham Palace, but could then make no progress against the strong headwind although the engine operated at full r.p.m. with the propeller churning merrily, its blades looking much like tennis rackets. So *Nulli Secundus* force-landed near the Crystal Palace and was so badly damaged during the night that this airship never took to the air again. This flight had, nevertheless, been a remarkable performance, and represented an endurance record for semi-rigid airships.

The improved *Nulli Secundus II*, which made its first flight on 24 July 1908, was a larger craft with a volume of 85,000 cu.ft (2,407 cu.m). The gondola was of the Lebaudy type and affixed to the keel, which in turn was attached to the envelope by means of a waterproof 'girdle'. A feature of the *Nulli Secundus* airships were the wide belts across the top and extending over most of the envelope circumference with additional, diagonal belts towards the tapered ends. The keel of the second *Nulli Secundus* contained a separate balloon used in manœuvring the airship. A single elevator was mounted forward and twin rudders astern. *Nulli Secundus II* had a short life and made only two more flights, the first lasting eighteen minutes. The second flight was with personnel from the Navy to make them air-minded and give them the feel of the air. Shortly afterwards this airship was broken up.

Throughout the following year of 1909 the future of all military air activities hung in the balance until a specially appointed advisory committee decided that henceforth large rigid airships were to be the domain of the navy while it was left to the army to build small-sized airships and to be responsible for aeroplanes.

Specification of 'Nulli Secundus'
Volume: 56,000 cu.ft (1,586 cu.m)
Length: 120 ft (36·6 m)
Diameter: 26 ft (7·9 m)
Engine: One 50 h.p. Antoinette
Maximum speed: 16 m.p.h. (26 km/hr)

32 Walter Wellman's 'America'

Early one morning in October 1910, six men and a cat climbed aboard a car covered with oilskin that was suspended below a large, clumsy and patched balloon envelope inflated with hydrogen. To the cheers of a crowd numbering thousands of spectators the 'powered balloon' *America* soon disappeared into the fog, heading for its distant goal: Europe. A whole continent anxiously awaited the first radio report from the airship. It soon arrived and read, surprisingly, 'Come to fetch that darn cat'!

This was only the aftermath of a long line of events engulfing a person of Don Quixote-like character, though of a more modern style than his predecessor. Newspaper reporter Walter Wellman was a keen amateur explorer, with a flair for raising money to finance his various enterprises. Behind him then were already two gallant attempts to penetrate to the North Pole by ship and dog-sled. The first time was in 1894, when he became shipwrecked at Spitsbergen; the second time, in 1899, he was halted by large formations of ice. In 1905 Wellman's newspaper, the *Chicago Herald*, sent him to London, where he first heard the news of Julliot's successful airships in France (see No. 28). His first reaction to these aircraft was that they must present an opportunity for his conquest of the North Pole. Some months later he was able to announce that sufficient money had been raised to start the Wellman-*Chicago Record-Herald* Arctic expedition. In January 1906 the balloon authority Louis Godard in Paris was in full swing on an airship with which Wellman counted on reaching the North Pole that same summer. Later christened *America*, this airship was of the non-rigid type and had a length of 165 ft (50·3 m). The car was made of steel and covered with fabric. There was a wooden propeller at each end and they were driven by three petrol engines developing a total of 80 h.p.

While Wellman stayed in Paris the Norwegian sealing vessel *Fridtjof*, as the expeditionary ship, transported all the equipment from Tromsø in Norway to Blubbertown in north-western Spitsbergen, which was the base of the expedition. Here Wellman arrived with *America* on 8 July 1906 accompanied by his chief mechanic, Melvin Vaniman. Nine weeks later an airship shed had been erected there, but various delays at the base or caused in Paris forced the abandonment of a start by the airship that year, as it was already September and the effects of the long Arctic night began to be felt. The airship still had not been assembled, and was re-loaded on *Fridtjof*, which returned to Paris after leaving three members of the airship crew behind to spend the winter at Spitsbergen.

Wellman and his companions were back on Spitsbergen with a much-improved *America* towards the end of June 1907. Both the envelope and the car of the airship had been lengthened, and now a single 75 h.p. Lorraine-Dietrich engine was installed, driving two steel propellers mounted on outriggers on each side of the airship. The engine was fitted with an additional carburettor and thus could operate either on petrol or be fed on hydrogen drawn from the envelope. This dangerous arrangement was in 1912 to cause Vaniman's death when his trans-Atlantic airship *Akron* exploded shortly after its departure from Atlantic City.

America carried fuel for a flight of 120 hours' duration, which provided a range of some 2,160 miles (3,476 km). The flight to the North Pole and back would amount to about 1,430 miles (2,300 km). The airship carried provisions to last the expedition ten months in case of a forced landing, in which event the occupants would have to rely on the sleds and ten dogs which the airship also carried. The 'equilibrator' constituted a technical refinement that was to keep the airship at a constant altitude above the surface. It corresponded to Andrée's trail-rope in his *Eagle* (see No. 24) and the working principle was the same in both instances. In Wellman's case it comprised a long leather tube holding the stores. He considered this an ingenious invention which he described in terms of

'recoverable ballast'. His competitors in the news-reporting field had other names for it: they called it a 'sausage' or a 'stuffed boa constrictor'.

The start was again delayed by bad weather and did not take place until 2 September, which once more was much too late in the season. The crew of *America* comprised Wellman, Vaniman and the navigator Felix Reisenberg. To begin with all went well, but then the weather deteriorated and the airship drifted towards the coastal mountains of Spitsbergen. The airship staggered among these penetrating rocky formations for more than four hours before a landing could be effected on the ice, where the envelope was deflated by pulling the ripping panel.

There followed another return to Paris, where the damage to *America* was repaired, and then the indefatigable Wellman was once more ready to set out for the North Pole in his airship. This time he started on 15 August 1909, but shortly afterwards the equilibrator tore apart and it was only by a stroke of good luck that the airship could be landed at sea close to Fridtjof Nansen's renowned Arctic ship *Fram*, which towed it back to Camp Wellman, as the base was now named. During this salvage operation the envelope tore apart and exploded with such a bang that the myriads of cackling birds in the bay for once kept silent.

Meanwhile Admiral Robert E. Peary had on 6 April 1909 reached the North Pole on his sledding trip. This finally made Wellman abandon his third attempt at reaching the North Pole by airship, for which the preparations were already well advanced. It is only fair to admit that if favoured a little more by fate he might this time have succeeded.

Wellman now took up the idea that with a larger and still better *America* he should be able to realise the dream of all aeronauts: the crossing of the Atlantic by air. He always acted impulsively, and in no time had received moral and financial support from three big newspapers: *The New York Times*, the London *Daily Telegraph* and his own *Chicago Record-Herald*. With $50,000 at his disposal Wellman was despatched to Paris, where the long-suffering *America* was modified once more, this time by being enlarged and equipped with an additional engine, an 80 h.p. E.N.V., and no fewer than four propellers. There remained one serious problem to solve: the effect of changing weather conditions on the lifting capacity of the envelope. At that time no non-rigid airship could stay in the air for eight or ten days while crossing the Atlantic without constantly alternating between having to drop ballast and valve hydrogen – a strain that it could not withstand indefinitely. So once more Wellman resorted to a new and improved equilibrator which was to perform several important functions: it should keep the airship at a more or less constant altitude, to reduce the loss of hydrogen and ballast; and 30 cylindrical steel tanks holding spare fuel for the engines were to be attached to the 300 ft (91·4 m) long trailing cable, the end of which, by dragging in the water, should help to indicate the course as well as act as surface connection for the new Marconi telegraph equipment. As it turned out the lifeboat was to prove the most important auxiliary item. It was slung directly below the centre of the car.

Many long preparations followed until at last it was Saturday, 15 October 1910, the date fixed for the start. The airship crew on this Atlantic crossing attempt was, besides Wellman and Vaniman, to consist of navigator Murray Simon, radio operator Jack Irwin, and two more men, Louis Loud and Fred Aubert. At 8.05 a.m. the line

to the tugboat *Olive* was cut after it had pulled the airship out from the harbour. The four propellers began to rotate and the large, grey monster headed eastwards out to sea. Then it was that Vaniman discovered the cat 'Kiddo', which Simon had smuggled on board, and which had caused the queer content of the first wireless message ever sent from an aircraft over the open sea to a land station. An attempt was actually made to lower the constantly-wailing animal to a motor boat responding to the radio message.

The airship's take-off was front-page copy in the Sunday editions of most newspapers all over the world, and the expectations of a happy ending to this venture ran high. Yet the plain truth was that *America* was badly overloaded at the start, which everybody on board the airship well realised as 90 per cent of the 1,212 lb (550 kg) heavy equilibrator dragged in the water. The engines also caused trouble. At 11.17 on Saturday morning the E.N.V. engine overheated and had to be stopped for a while. Later it broke down completely. The Lorraine engine likewise malfunctioned. The last report received in Atlantic City from *America*, at 1.45 p.m., was to the effect that everything was well on board, but the engines had to be nursed along. By 6 p.m. the prevailing cold had forced *America* so low that all spare fuel tanks dragged in the water and thereby slowed up the airship considerably. After being in the air for ten hours the airship had covered only 81 miles (130 km) instead of 202 miles (325 km) as scheduled. The crossing could be completed only if the airship enjoyed a following wind. But danger lurked ahead. When it grew dark the badly overheating and hard-pressed Lorraine engine which now provided the sole propulsive power began to emit a shower of dangerous sparks which hit the envelope, but the latter was, fortunately, soaking wet from rain and mist. The airship also only missed at the last minute a collision in the fog with the masts of the schooner *Addison E. Bullard*. All through the night of Saturday *America* struggled to maintain its easterly course. At 4 a.m. Sunday morning the red-hot engine had to have a respite and then the airship immediately began to drift before a south-west wind. Later it shifted to west-north-west and increased in strength. The engine had been restarted, but was powerless against this wind force. All through the day and the following night the crew fought a losing battle to lighten *America* in every conceivable way.

Monday the 17th dawned with sunshine and calm weather, but wrong handling of the controls on the part of Vaniman now caused the airship to climb to an altitude of 3,280 ft (1,000 m). This dangerous climb could only be arrested at the sacrifice of almost 20 per cent of the precious hydrogen content of the envelope. All of them knew that this spelled the doom of *America*. The airship would expire from exhaustion, so to speak, and it became imperative that the crew took to the lifeboat. They could only trust that they would be able to lower it safely. At 8 p.m. the crew accordingly left the car and entered the lifeboat. All through the moonlit night they scanned the ocean and finally at 5.07 on Tuesday morning they sighted a steamer which turned out to be the s.s. *Trent* of the British Royal Mail Steamship Co., bound for New York. Over the radio the steamer declared its willingness to come to the rescue of the airship, and after some difficult manœuvres the two vessels were finally positioned close to each other. Just as *America* was about to lower its lifeboat the nose of the airship rose perilously, but by the heroic work of Aubert, who climbed back into

the car, the airship was righted again. The lifeboat was now lowered into the sea, but when the aeronauts began to row away their boat was hit by the equilibrator of the airship on one of its oscillations. This knocked a hole in the bow of the lifeboat on the port side just above the waterline. Adding to the tribulations of this difficult sea-air rescue *Trent* almost sank the airship's lifeboat when, while keeping pace with the drifting airship, it barely managed to stop short of a collision with the lifeboat.

After three hours of trying rescue work the six exhausted aeronauts (not forgetting 'Kiddo', the cat) were safely on board the *Trent* and were warmly welcomed by both the crew and the passengers of the steamer. Meanwhile *America*, now relieved of much of its load, climbed skyward and disappeared from sight, never to be seen again. The airship had then been in the air for 71½ hours and, describing curves in north-easterly and south-westerly directions, had covered a distance of 1,010 miles (1,625 km). When *America* was abandoned it was 400 miles (644 km) off Cape Hatteras, the nearest point on the east coast of America. A grand reception awaited the crew of *America* upon their arrival at the port of New York on 19 October.

Wellman never again entered any type of aircraft, but henceforth devoted himself to his writing activities. He died on 31 January 1934 at the age of 75.

Specification of 'America' (1910)
Volume: 344,847 cu.ft (9,765 cu.m)
Length: 228 ft (69·5 m)
Diameter: 52 ft (15·85 m)
Engines: One 75 h.p. French Lorraine-Dietrich and one 80 h.p. British E.N.V.
Lifting capacity: 26,878 lb (12,192 kg)

33 **Baldwin's 'U.S. Military I'**
Until the end of World War 1 only a few airship types were built in America that were of native origin. Admittedly, prior to the outbreak of war there were 20 to 30 airships to be found in the United States, but all of them were small and primitive, and in no way comparable to the developments in Germany and France. But if America got a late start in the building of suitable airships, both the U.S. Army and U.S. Navy also remained active in the airship field until the thirties, whereas other countries had ceased almost completely to build these lighter-than-air craft by the end of the twenties. The U.S. Navy even continued to use airships of the non-rigid type right up until after the end of World War 2.

The first military airship in the U.S.A. was built by Thomas Scott Baldwin, a versatile American aeronautical pioneer, who in his long career was first a balloon pilot, he then became an experienced parachute jumper, giving successful exhibitions in many parts of the world, and finished up as an aeroplane pilot and manufacturer. During World War 1 he served as an army major.

The airship which the U.S. Army bought from Baldwin and assigned to the Signal Corps was delivered in August 1908 and designated *U.S. Military I.* It can best be described as a cylindrical dirigible balloon with an envelope made of two layers of Japanese silk, interspersed with one of vulcanised rubber, to withstand the effects of the sun and moisture better. The size of the interior ballonet was 2,800 cu.ft (79·3 cu.m). The gondola was of the same type as used by Renard for *La France* (see No. 19), but was uncovered. It was suspended only 5 ft (1·5 m) below the envelope by means of about 80 wires. The wooden tractor propeller had a diameter of 10 ft 8 in (3·25 m)

and was driven by the engine through a 20 ft (6·1 m) steel extension shaft. The biplane elevator was mounted forward in the slipstream, ahead of the engine. The rudder, with fixed horizontal tail surfaces, was mounted at the rear end of the extended, oblong gondola frame.

The *U.S. Military I* was mainly of experimental value, but did make some short flights from the army lighter-than-air base at Fort Omaha in Nebraska and from Fort Meyers in Virginia.

Baldwin built two other airships. His second design was sold to Germany while his No. 3, named *Californian Arrow*, was piloted by the well-known aeronaut Roy Knabenshue, who made exhibition flights at a number of places, including the St Louis World's Fair in 1904.

Specification of 'U.S. Military I'
Volume: 20,000 cu.ft (566·3 cu.m)
Length: 96 ft (29·26 m)
Diameter: 19·5 ft (5·94 m)
Engine: One 20 h.p. Curtiss four-cylinder water-cooled
Lifting capacity: 1,370 lb (621 kg)
Useful load: 500 lb (227 kg)
Maximum speed: 19·6 m.p.h. (31·5 km/hr)
Crew: 2 men

34 **The Willows airships**
Ernest Thompson Willows (1886–1926) was the son of a Cardiff dentist, but airships were his main interest, and today he is remembered as the only true British airship pioneer. Already in 1905, at the age of nineteen, he completed his first airship, of 12,000 cu.ft (340 cu.m) capacity. In November 1909 there followed the first flight of his *Willows II*, of 21,000 cu.ft (595 cu.m) capacity, which also carried only one person. The envelope cover was really a balloon with a shape lending itself to mechanical propulsion. Its shape was maintained by means of a 58 ft (17·7 m) long bamboo and steel tube bar suspended from a strong canvas band sewn round the bottom part of the envelope along its full length. The envelope also was kept fully inflated by means of an interior ballonet, the cubic capacity of which was 10 per cent of the main envelope. A triangular steel cage, suspended by cables below the boom, carried the engine and a seat for the pilot. A balanced rudder with fixed horizontal stabilising surfaces was attached at the rear end of the boom. The rudder had an area of 56 sq.ft (5·2 sq.m). There was no elevator, but the airship would climb or descend when the two counter-rotating Handley Page propellers were moved upwards and downwards to alter their angle of thrust. This was a novel and original idea, introduced by Willows and later adopted for some of the British Army airships built at the Balloon Factory at Farnborough. If a customer had come forward who wished to order an airship of bigger size than *Willows II* he could easily have been accommodated in this respect, but the main concern of the airship designer was to prove his layout a practical one. When used for military purposes it was an additional advantage that the Willows airship was easy to dismantle and transport on a horse-drawn carriage.

At 6.45 in the morning of 4 June 1910 Willows ascended from his workshop on East Moors, outside Cardiff, and seven minutes later landed close by the Town Hall. Thirty minutes later he took off again and returned to his workshop where he stored the airship in its small shed. He spent the night himself in a little hut on top of the roof of the shed to guard his airship against intruders.

Willows started on another flight on

the evening of 6 August 1910, in the glare from the headlights of his father's car. This time the Crystal Palace in South London was to be his destination. He navigated by the stars and also plotted his course from the lights of such cities as Bristol, Hungerford and Reading. When in doubt about his whereabouts, which happened several times, he just throttled back his engine and descended to an altitude of about 500 ft (150 m). Then, through a speaking trumpet which he carried along with him, he would ask for directions ahead from the astounded people, probably out for an evening stroll. He reached his destination at 5.40 a.m. on Sunday morning, but was now confronted by a new problem. There was no one present who could help hold down the airship on the ground, and also on the flight he had lost the grapnel of his anchor rope when it became entangled in a tree. He finally managed to land a few miles further on with the assistance of a night watchman. He had then covered a distance of about 150 miles (240 km). After a little hydrogen replenishment Willows finally reached the Crystal Palace by airship the next day.

There followed several more successful flights above and around London and then Willows decided that he would try to fly to Paris. He intended to be accompanied by a mechanic on this voyage, so he set about lengthening the airship gondola. By 4 November Willows was ready, and, carrying W. Goodden as a passenger in his airship, he arose at 3.25 p.m. from Wormwood Scrubs on the outskirts of London. The *Willows II* (sometimes also known as the *City of Cardiff*) crossed the British capital and left the English coast near Bexhill at 6.35 p.m. Two hours later the French coast came in sight, and then at 10 p.m. a heavy ground fog added to the darkness so that Willows soon lost his bearings. As only the airship gondola was damaged in the subsequent landing, the Almighty must have held out a protecting hand over – or had we better say under? – the two air travellers. A Frenchman hastening to the spot informed them that they were close to the village of Corbehem, outside Douai. Shortly after, three constables and a customs officer arrived. The former guarded the airship while the latter demanded the payment of 750 francs duty because the landing had not been advised in advance. Willows had plans to fly on to Paris, but had to drop them owing to foul weather, so he packed his airship and had it sent on to Paris by rail.

There was evidence of the high esteem in which Willows was held as an airship designer when, in February 1911, the Royal Aero Club issued its first four certificates to airship pilots. Willows was the sole civilian to receive one; army officers were the recipients of the other three.

With the coming of the war in 1914 Willows ceased his activities completely. He had then built a total of five airships, of which one each went to the army and the navy, the latter being given the naval designation of 'No. 2', later changed to 'SS 1'. His last design was the 'SS 2' which was built to the order of the navy by the Holt Thomas Airship Co. Ltd. This airship was one of the forerunners of the many small non-rigid dirigibles later used extensively on submarine patrol, the so-called 'Sea Scouts' or 'Submarine Scouts' (see No. 48).

When World War 1 ended Willows turned professional aeronaut and gave many exhibitions as a balloon pilot. During a flower festival near Bedford on 3 August 1926 his balloon was assisted down by spectators, who in their ignorance mishandled the trail-rope. The envelope escaped from its netting and disappeared, while the basket, with Willows and four passengers, plunged to the ground. All were killed. A tragic fate indeed, that the only true British airship pioneer should end his aeronautical career as an itinerant showman operating a captive balloon.

Specification of 'Willows II'
Volume: 21,000 cu.ft (595 cu.m)
Length: 86 ft (26·21 m)
Maximum diameter: 22 ft (6·7 m)
Engine: One 35 h.p. John A. Prestwich (JAP) eight-cylinder air-cooled

35 **Zeppelin LZ 13 ('Hansa')**
After the accidents sustained by his first passenger airships (see No. 27), Count Zeppelin played his final trump card on 15 July 1911 with LZ 10 *Schwaben*, which finally turned out to be a lucky airship for the Zeppelin concern and the DELAG operating company. Under the command of Dr Hugo Eckener, *Schwaben* carried a total of 1,553 passengers on 218 air voyages before being lost by fire in Düsseldorf on 28 June 1912, fortunately without any loss of human lives. It had by now been established that commercial airships could be operated successfully, and DELAG already had a second Zeppelin, the LZ 11 *Viktoria Luise*, in service. Later additions to the DELAG airship fleet were LZ 13 *Hansa*, and LZ 17 *Sachsen* (*Saxonia*). The German authorities would have liked to see them maintain regular, scheduled services between the most important cities, but the DELAG airships mostly carried out air cruises of two hours' duration with a maximum of twenty passengers on each circuit around the cities where airship sheds had been built. Army and navy personnel received training on many of these flights. The Zeppelin airship company built a series of this type, fifteen in all, including the army airships LZ 9 (Z II) to LZ 23 (Z VIII), which bore evidence of much technical advance. They still maintained the same cross-section throughout the length of the hull, except for the tapered ends, the ratio between cross-section and hull length being 1:10·57. A favourable streamlining of the hull had not yet been considered.

Like her sister airship LZ 11 *Viktoria Luise*, LZ 13 *Hansa* was of the so-called G-type and made its maiden air voyage on 30 July 1912. It was stationed for a time at Potsdam and later based in Hamburg. From both places this airship made a number of short and longer duration flights. By the end of October 1913 *Hansa* had accumulated a total flying time of 632 hours, and had covered a distance of 21,230 miles (34,166 km). Including the crew, this airship had then carried 6,217 passengers. On 19 September 1912 *Hansa*, to prove the progress made in the lighter-than-air field, made the first international voyage of any commercial airship, when it flew from Hamburg to Copenhagen, and after an intermediate landing there to change passengers returned to its home airport via Malmö in southern Sweden. Dr Eckener was as usual in command of *Hansa*, and on this occasion Count Zeppelin himself, now seventy-five-years old, was present in the control gondola, and seemed none the worse from this round trip of 435 miles (700 km).

With the outbreak of hostilities in 1914, *Hansa* was commandeered by the German Army and housed in the airship shed at Düsseldorf; it was later taken over by the German Navy and transferred to the central flying field at Johannisthal, near Berlin, where it was used to train crews for the growing fleet of Zeppelin naval airships. Before this

venerable airship ended its long career it had made more than 500 flights. It was honourably discharged, so to speak, when it was finally dismantled a year or so later.

Specification of LZ 13 'Hansa'
Volume: 660,380 cu.ft (18,700 cu.m)
Length: 485·6 ft (148 m)
Diameter: 45·9 ft (14 m)
Engines: Three 170 h.p. Maybach CX six-cylinder water-cooled
Useful load: 13,889 lb (6,300 kg)
Maximum speed: 48·5 m.p.h. (78 km/hr)
Operational ceiling: 5,250 ft (1,600 m)
Cruising range: 683 miles (1,100 km)

36 **Zeppelin LZ 18 (L 2)**

With LZ 18, Luftschiffbau Zeppelin reached a new development stage that represented several progressive steps in the field of airship construction. It was the first specimen of a series of ten airships which were to form the basis of the new building programme of long-range airships for which the Minister of Naval Affairs, Grand Admiral Alfred von Tirpitz, had been granted approval in January 1913. As early as 1910 the German Navy had sent one of its most skilled ship designers, Felix Pietzker, to the works on Lake Constance, to keep in close touch with the development of the Zeppelin airships. LZ 18 was designed to incorporate Pietzker's ideas of how to improve these aircraft, although the engineers at the Zeppelin works had certain reservations about several of these features. The German Admiralty had, as its minimum demand, stipulated that the new airships be able to reach the southern coast of England carrying a certain load of bombs. This called for a sizeable increase in the cubic capacity of the airship compared with previous Zeppelin designs. Thus LZ 18 was altogether the largest airship built prior to World War 1. It was equipped with four engines, installed in two gondolas, while there was a separate and enclosed control gondola about 50 ft (15 m) ahead of the forward engine gondola, and attached directly to the hull.

LZ 18, with the naval designation L 2, made its maiden air voyage on 9 September 1913. After some additional trial runs the airship was flown on 20 September to the Johannisthal flying field outside Berlin, where the navy could conduct its acceptance tests and familiarise the future naval crew with their new airship. On 10 October, L 2 started in the morning on its tenth flight to conduct an altitude test. Lieutenant-Commander Freyer was in command and, besides the regular crew (numbering 14 men), there were also some representatives from the Zeppelin works and from the German Admiralty on board, including Pietzker. Due to the great number of passengers thus carried, several members of the crew had to be left behind on the ground. One of the crew members not on board on this occasion was engineer C. Schönwälder who has, indeed, lived a charmed airship life and today resides in Copenhagen. He was one of the few survivors of the first naval Zeppelin airship L 1 (LZ 14) which crashed in the North Sea off Heligoland at the end of September 1913. On the day of the L 2 disaster he had been ordered by his superiors to represent the survivors of the L 1 crew at the funeral of one of the drowned naval officers. Quite briefly, Schönwälder was also a crew member of the German naval Zeppelin airship L 3 which in early 1915 was sent to the Skagerak to look for reported British submarines in that area, was caught in bad weather and, on the return trip to Germany, developed engine trouble. The airship was

unable to reach its home base and just managed to land on the southernmost tip of the Danish island of Fanoe, near to the German border, where the crew set fire to it on the beach and were interned in Denmark for the duration of the war.

But to return to L 2, which was delayed some hours by engine troubles before it eventually took off on what was to be its final flight. Shortly after the start the spectators on the ground witnessed an appalling sight. From the forward engine gondola a long flame was ejected and soon an explosion followed which engulfed the interior of the airship in an ocean of fire. Then the airship began to plunge to the ground like an enormous torch, and on the way down a second explosion occurred which blew in all the window-panes in the neighbourhood. By the time the wreck hit the ground only the burned-out framework remained. The last few bursts heard were caused by the exploding fuel tanks. From the sad remains of the airship, salvage crews pulled away three badly-burned persons, still alive, but they soon joined the ranks of their twenty-five dead comrades.

On behalf of the Zeppelin works, Dr Eckener now accused the German Admiralty in public of not heeding the warnings of the experienced airship designers against the 'improvements' which Pietzker had insisted upon. It was subsequently established that the disaster was caused by the large wind-screens which encased the front of the engine gondolas at Pietzker's request. They created a form of vacuum in the gondola as a result of which the engines were subjected to an explosive mixture of surplus hydrogen and air from the interior passageway.

When the victims of the L 2 disaster were being buried there was a bitter contention between Count von Zeppelin and Grand Admiral von Tirpitz. The airship builder blamed the disaster jointly on the dead Pietzker and the Admiralty, and their partnership almost ended there and then. Thereafter Count Zeppelin was only the figurehead of the Zeppelin airship company and began instead to take an active interest in the building of large aeroplanes. He was reported, shortly before his death on 8 March 1917, to have remarked that airships no longer interested him in the least!

Specification of LZ 18 (L 2)
Volume: 935,500 cu.ft (27,000 cu.m)
Length: 518·4 ft (158 m)
Diameter: 54·5 ft (16·6 m)
Engines: Four 180 h.p. Maybach CX six-cylinder
Useful load: 24,471 lb (11,100 kg)
Maximum speed: 49 m.p.h. (79 km/hr)
Operational ceiling: 9,200 ft (2,800 m)
Cruising range: 652 miles (1,050 km)

37 **The Royal Navy airship 'Mayfly'**

In July 1908 a proposal by the Admiralty to build a large airship was approved. With the increasing German predilection for such aircraft the Royal Navy was also interested in investigating whether this new type could be turned to good account. The order for the British naval airship HMA No. 1 (R 1) was placed with Vickers at Barrow-in-Furness, where a joint Navy–Vickers team was formed for this special task. This team drew mainly on its experience in building submarines, as the airship experience of the design staff was limited to a few flights which some of its members had made in German airships, which was no solid foundation for the work in hand. At the same time as the design drawings were

tackled a floating dock for the airship was built which, oddly enough, was termed a 'garage'. Right from the start it was planned to moor the airship at sea, so the bottoms of its gondolas were shaped like boats. Another feature was to be the provision of a mooring mast, which was a practice not yet conceived by the Germans at that time.

The terms of the contract stipulated that Vickers was responsible for the framework of the airship while the Admiralty would supply the gas cells and the covering. The rudder and elevator control arrangement closely followed the practice from submarines.

What followed was an endless sequence of changes, delays and difficulties. Vickers wanted to build the hull of wood, while the Admiralty steadfastly insisted upon the use of steel. This dilemma was solved by a compromise when the new metal alloy duralumin became available. It had originated in Germany, where some components for the Vickers airship were made, but the Germans had not yet gained much experience with this material and no fewer than 75 per cent of the parts supplied from Germany had to be rejected. The material for the gas cells was another difficult problem. Any number of modifications were called for, but finally, by the spring of 1910, work had progressed to the stage where a crew could commence training prior to the first trial flight. Concurrently, the shed at Barrow was heavily guarded.

On 13 February 1911 the engine tests began, but the actual trial ascent of No. 1 (or *Mayfly*, as this airship had by now been unofficially named) had to be postponed because of a political battle then being fought in Parliament. This concerned which country should be the approved supplier of hydrogen for the airship, since national production of that gas was insignificant at the time. Finally, on 24 May, tugs towed *Mayfly* out of its shed; it was then moored to a float in the Cavendish Dock, an operation which called for a helping hand from many tugboats and some three hundred mariners. It had been hoped that the maiden air voyage of *Mayfly* might become part of the naval coronation parade before King George V, but the airship had become slightly damaged while being hauled away from its shed and had also proved much too heavy, so it had to return to its shed for a stay of some several months. As events were to show, the name *Mayfly* was to prove all too prophetic, for the airship never did, in fact, fly at all. However, by 22 September 1911, the airship had been lightened

Specification of 'Mayfly'
Volume: 663,000 cu.ft (18,774 cu.m)
Length: 512 ft (156·1 m)
Diameter: 48 ft (14·63 m)
Engines: Two 160 h.p. Wolseley eight-cylinder
Lifting capacity (estimated): 44,800 lb (20,321 kg)
Maximum speed (estimated): 40 m.p.h. (64 km/hr)

to the extent that it was reported ready once more. The inflation with hydrogen from 1,762 tanks required 10½ hours to complete, and then the naval airship left its shed again. It had scarcely emerged before a strong squall caused it to heel right over, and although the airship soon righted itself, no sooner did the handling crew begin to turn it around, to point its nose towards the dock, than a crashing noise was heard from the centre section of the airship, whereupon the envelope fractured, and the long-suffering *Mayfly*, her back broken, gradually collapsed on to the water. The terror-stricken crew members in the rear gondola all jumped

overboard, whereupon the rear portion of the airship promptly rose vertically. The First Lord of the Admiralty at that time, Winston S. Churchill, was partly responsible for the fact that the findings of the investigating committee for this airship disaster were never published. The naval airship detachment was disbanded in January 1912, and *Mayfly* was left to its own resources, gradually deteriorating in its floating shed at Barrow.

38 Chalais-Meudon 'Fleurus'

When World War 1 broke out in August 1914, the French Army possessed about fifteen airships, most of them without any military value. The army aeroplane and airship forces comprised three groups: the first group, at Versailles, had combined airship and aeroplane bases at Saint-Cyr and Toul, and aeroplane-only bases at Buc, Châteaufort, Étampes, Villacoublay and Nancy. The second group, at Reims, had combined airship and aeroplane bases at Reims, Châlons, Verdun and Maubeuge and aeroplane-only bases at Douai and le Crotoy. The third group, at Lyons, had airship and aeroplane bases at Belfort and Épinal and aeroplane-only bases at Lyons, Ambérieu, Avord and Pau. However, this whole organisation was in a pretty miserable plight at the outbreak of the war. The build-up was partly incomplete and the activities of the army airship and aeroplane units were mainly of a sporting nature. Civilian firms such as Clément-Bayard and Zodiac dominated the airship field (see No. 29), and military production of airships was in an embryo state at the Chalais-Meudon establishment outside Paris, where it had all begun with the airship *La France* (see No. 19).

This military centre of aeronautical activities was of a similar nature to its British experimental counterpart at Farnborough and during the first three years of the war built airships exclusively for the French Army, all of them being of the non-rigid type. The first army airship, *Fleurus*, left the Chalais-Meudon workshops in 1912. It had an efficient shape, derived from wind tunnel tests carried out at the Eiffel laboratory in Paris. The Clément-Bayard factory built the engine for it, as well as its gondola and certain other components, which explains why this airship is often also referred to as the C.B. V. In the list of Clément-Bayard airships *Fleurus*, or C.B. V, is shown as a smaller sister-ship of the army airship *L'Adjudant Vincenot* or C.B. IV of 353,150 cu.ft (10,000 cu.m) capacity. *Fleurus* participated in the French Army manœuvres in 1913 and thereafter was stationed in a shed at the Pau base. On 23 September of that year the airship ascended again and headed for the Saint-Cyr base. This 422 mile (680 km) trip was completed in sixteen hours at an average speed of 33·6 m.p.h. (54 km/hr), the airship maintaining on this flight an altitude of between 2,625 and 3,280 ft (800 and 1,000 m).

At the outset of the war the French Army commanders directed the airships on bombing raids, but they were carried out at night due to the vulnerability of the airships. Under the command of Captain Tixier, *Fleurus* conducted the first airship raid of the war from Verdun on 9 August 1914. At the New Year of 1917 the French naval airship service was established, all the serviceable army airships serving as its nucleus. They were: *D'Arlandes*, *Champagne*, *Lorraine* and *Caussin*, as well as *Fleurus* and *Montgolfier*, the last two now serving as training airships. These airships now patrolled the seas and hunted submarines, particularly in the Mediterranean, and towards the end of the war from bases on the coast of

North Africa. Airship commanders and mechanics were trained at the Rochefort base. Here *Fleurus* was destroyed in June 1918 when a German aeroplane dropped a bomb which set the airship shed on fire and caused the airship school to be transferred to Saint-Cyr.

Specification of 'Fleurus'
Volume: 229,545 cu.ft (6,500 cu.m)
Length: 252·6 ft (77 m)
Diameter: 40·7 ft (12·4 m)
Engines: Two 80 h.p. Clément-Bayard four-cylinder
Maximum speed: 36 m.p.h. (58 km/hr)

39 **Zeppelin LZ 24 (L 3)**
Being a true copy of L 1 (LZ 14), except for its more powerful engines, the naval airship L 3 of the Zeppelin M-type made its maiden voyage on 11 May 1914. It later made an endurance flight of no less than 35 hours, and afterwards was approved and accepted by the German Navy and stationed in the Fuhlsbüttel airship shed near Hamburg. Before the outbreak of war it had participated in a number of fleet manœuvres and was the only naval Zeppelin available when hostilities began. It was, of course, an impossible task to patrol both the North Sea and the Baltic exclusively with L 3. The rented shed in Fuhlsbüttel was also the only available one on the North Sea coast, because although the shed at Nordholz, near Cuxhafen, had been started, it was not yet completed. The German Navy had already established an airship section under Commander Peter Strasser, but for some reason the German Admiralty did not, immediately upon the outbreak of war, bring pressure to bear on the Zeppelin works to build larger and better airship types. But this short-sightedness on the part of the German Admiralty in 1914 is undeniable, although different conditions prevailed in the airship division of the German Army, which then already had twelve units at its disposal.

Until the German Navy started its emergency programme, which comprised the building of a series of ten airships of the L 2 type (see No. 36), and before this programme really got going, the German Navy had to rely solely on L 3, which during the first months of the war did indeed fulfil a number of important reconnaissance tasks. During the night of 19–20 January 1915, L 3 and L 4 (LZ 27) carried out the first German naval airship raid against England, attacking industrial targets along the River Humber. On this occasion both airships carried fuel for thirty hours and a load of eight 50 kg bombs and ten or eleven 28 kg incendiary bombs. Each airship had a crew of sixteen men. A third airship, L 6 (LZ 31), took off the same night and headed for the Thames area. Peter Strasser was on board this airship to co-ordinate that night's air attacks on England, but L 6 had to turn back because it became weighed down by a coating of ice. A strong headwind drove L 3 off its course and it reached Great Yarmouth with only two of its three engines operating. The high-explosive and incendiary bombs were dropped haphazardly and caused little damage in the town, but two persons were killed, the first to die in an air raid. L 3 then disappeared in the fog and darkness and headed for home. L 4 appeared near Bacton, in Norfolk, about 78 miles (125 km) south-east of the Humber. The bombs dropped later by this airship did most damage in the town of King's Lynn. L 4 returned to Fuhlsbüttel at 10 a.m. on 20 January, arriving there seven minutes after L 3.

On 16 February 1915, Peter Strasser received orders from the naval staff

to despatch two airships to watch the activities of the British navy off the Norwegian coast.* Strasser entrusted two of his most experienced airship commanders, Lt-Cdr Hans Fritz (in charge of L 3) and Magnus von Platen-Hallermund (commanding L 4), with this task, and the two airships left Fuhlsbüttel the same evening. The next morning, 17 February, L 3 was off Blaavandshuk on the west coast of Jutland, battling a south-easterly snowstorm of increasing force. The irregular gusts proved harmful to the propellers, and through them indirectly also affected the engines. At 9 a.m. one engine broke down and two hours later one more ceased functioning. At 1 p.m. L 3 was abreast of Hanstholm, when Fritz decided to send a radio message that the airship was hard-pressed and would return, hugging the west coast of Jutland. The airship had to descend to 150 ft (50 m) above sea level because visibility was practically nil in the impenetrable snowstorm. With only one engine still running, the Danish city of Esbjerg was passed at 5 p.m. and the goal now was to reach the airship base at Tondern just beyond the Danish border. Then the last of the three engines stopped, and Fritz had only one choice left: to land before the airship was driven out to sea. Providentially, the northern tip of the Danish island of Fanoe was sighted, where L 3 was landed on the beach at 5.45 p.m. Left to its own devices, with no landing crew to assist, nor any sheltering facilities available, the airship rested on the wet sand with its back broken. After assuring himself that all his men were unhurt, Fritz destroyed his secret papers and then ordered the crew to leave the airship. He performed his last duty as commander of the airship by ordering it to be set on fire; then, with his crew, surrendered to the Danish authorities. They were all interned at some barracks in Odense where they spent the remaining war years.

L 4 likewise had its engines damaged, but was less lucky than its sister airship. It was forced down in the breakers off Blaavandshuk further north up the west coast of Jutland where eleven members of the crew escaped from the smashed control gondola. Relieved of this weight, the airship ascended again and disappeared forever out over the North Sea with the rest of the crew, comprising four mechanics, in the rear gondola. Theirs were the first lives to be lost in the war by the airship division of the German Navy. In time many more losses were to follow.

These twin disasters suffered by German naval airships demonstrated clearly how poor the German meteorological service then was. Extended German air voyages out over the northern open waters were not resumed until larger and more powerful airships became available.

* As reported by engineer C. Schönwälder, Copenhagen, who survived the disasters befalling both L 1 and L 3 and by chance missed being on board L 2 on the last trip of this airship.

Specification of LZ 24 (L 3)
Volume: 793,518 cu.ft (22,470 cu.m)
Length: 518·4 ft (158 m)
Diameter: 48·7 ft (14·85 m)
Engines: Three 200 h.p. Maybach CX six-cylinder
Useful load: 20,282 lb (9,200 kg)
Maximum speed: 53 m.p.h. (85 km/hr)
Operational ceiling: 9,200 ft (2,800 m)
Cruising range: 683 miles (1,100 km)

40 **Zeppelin LZ 40 (L 10)**
The German Admiralty had predicted in November 1914 that the first large airships of the Zeppelin P-type, with a gas content of 1,059,440 cu.ft (30,000

cu.m) would be ready in January 1915. They were L 10 (LZ 40) and L 11 (LZ 41), but did not in fact become available until 13 May and 7 June respectively. The German Navy was then able to compete on an equal footing with the German Army, which already had made determined air raids against England, and in particular the London region, with Z XII (LZ 26), LZ 37, LZ 38 and LZ 39 from bases in Belgium. The first naval attempt of that nature took place on 19 January 1915 (see No. 39) and was, as reported, not particularly successful. A previous categorical order from the Kaiser forbidding the bombing of the densely-populated quarters of London, and especially Buckingham Palace, had meanwhile been rescinded.

On 4 June 1915, L 10 left the Nordholz base near Cuxhafen at shortly past midnight, under the command of Lt-Cdr Hirsch. The airship had orders to attack the London region, for which purpose it carried two 100 kg and twenty 50 kg high-explosive bombs and 90 incendiary bombs. Delayed by an increasing headwind, Hirsch was unable to reach London, and instead dropped his bombs on Harwich and Gravesend, where the fire-bombs set the yacht club (used as a military hospital) on fire.

On 15 June L 10 set forth on another air attack on England, this time accompanied by L 11, which however experienced engine trouble and had to return. At nightfall L 10 had reached the coast of Northumberland when the lookout man on top of the hull reported an enemy aeroplane ahead. But this turned out to be a false alarm. However, the coastal batteries opened fire on the airship, which then dropped its bombs from an altitude of 7,550 ft (2,300 m) over an area with brightly-shining blast furnaces at South Shields. More damage was caused to the shipyard at Jarrow and to a chemical plant at Willington. Not once on this raid was the airship caught by the searchlights which were dreaded so much.

L 10 made a total of twenty-eight military flights, five of which were air raids over England. The final ascent was made in order to reconnoitre at sea on the afternoon of 3 September 1915. Shortly before making ready to land at Nordholz, the airship flew through a thunderstorm and was hit by lightning. It was then valving hydrogen in preparation for the descent and a violent explosion resulted. The airship plunged to the ground and the wreck burned for several hours in shallow waters just off the Neuwerk island. Hirsch and his crew of nineteen men perished.

Specification of LZ 40 (L 10)
Volume: 1,126,533 cu.ft (31,900 cu.m)
Length: 536·4 ft (163·5 m)
Diameter: 61·4 ft (18·7 m)
Engines: Four 210 h.p. Maybach CX six-cylinder
Useful load: 35,715 lb (16,200 kg)
Maximum speed: 59 m.p.h. (95 km/hr)
Operational ceiling: 12,800 ft (3,900 m)
Cruising range: 1,336 miles (2,150 km)

41 Zeppelin LZ 47 (LZ 77)

The airship division of the German Army during World War 1 made use of a total of thirty-five vessels of Zeppelin make. Sixteen of these airships were lost in action, four were wrecked, three made forced landings in home territory and one was carried away by a heavy storm. On all the different fronts a total of 282 bombing and reconnaissance trips were made, and 188 of

them can be considered successful. In all these activities only thirty-six crew members were lost. When the German Army ceased airship operations in 1917 it had thirteen or fourteen of these aircraft left which were either transferred to the airship section of the German Navy or were broken up. The German Army and Navy had different ideas about the engagement of airships in the war. The German Army right from the start of the war employed its airships for tactical, and later for strategic, tasks which were only feasible as long as the Allies were short of aeroplanes to engage the enemy airships. The German Navy on the other hand used its airships for bombing raids against England and as a parallel employed them on very important reconnaissance work. During the prelude to the Battle of Jutland in 1916 a score of airships thus kept the Chief of the German High Seas Fleet, Vice-Admiral Scheer, posted on the positions of the enemy by supplying important information, but in this respect the limitations of the airships were also apparent, as the prevailing weather conditions hindered their activities.

The Chief of the General Staff of the German Army, General of the Infantry von Falkenhayn, announced as early as October 1914 that he intended to launch bombing raids against England and asked for the co-operation of the German Navy. Immediately following the outbreak of war French aeroplanes had begun to bomb German cities in reply to German air raids following a false charge of their bombing a German town: a plan which the German Army decided would give it first precedence in the 'retaliation' bombing of French cities. A high penalty was paid for the first three German attacks of this character. They were made in late August 1914, in broad daylight, and cost the loss of four airships: Z V (LZ 20), Z VI (LZ 21), Z VII (LZ 22) and Z VIII (LZ 23). Not until these airships had been replaced did the German Army turn its attention to England; and, not being content to limit these activities to those nights when there was no moon, conducted a number of tests with LZ 77 (Zeppelin works number LZ 47) in the Cologne area in November 1915. The conclusions from these flights seemed to be that even at full moon an airship passing overhead was difficult to discern from the ground. This was later to prove a fatal deduction and one strongly questioned by the airship section of the German Navy, which contended that it was the industrial smoke prevailing above the Ruhr region which explained the veiling of the LZ 77 airship. The Navy conducted its own tests in this respect with L 16 (LZ 50), from The Hague base by the North Sea, and proved conclusively that the airship was visible from the ground in clear moonlight and could be kept in sight constantly by a fighter pilot sent up to look for it.

LZ 77 of the P-type was accepted by the German Army on 24 August 1915 and was based at Spich, near Düsseldorf, on 6 September. Only a week later, on 13 September, this airship made a raid on London in the company of LZ 74 (works number LZ 44) and the following month LZ 77 dropped a total of 14,771 lb (6,700 kg) of bombs over French territory. LZ 77 was to suffer the tragic consequences of the false deductions from the very tests it had previously conducted in friendly skies, and fell a victim to them in action over the Western front. On the evening of 21 February 1916, the day that the German Army began its massive attack on Verdun, LZ 77, commanded by Captain Horn, took off in company with three other army airships to bomb the railway junction at Revigny,

behind the front. The French anti-aircraft gunners made out the shapes of the airships clearly in the moonlight, and hit LZ 77 with an incendiary shell amidships. Engulfed in flames, it plunged to the ground at Brabant-le-Roi; another airship, LZ 95 (works number LZ 65), was also lost on this raid.

Specification of LZ 47 (LZ 77)
Volume: 1,126,533 cu.ft (31,900 cu.m)
Length: 536·4 ft (163·5 m)
Diameter: 61·4 ft (18·7 m)
Engines: Four 210 h.p. Maybach CX six-cylinder
Useful load: 35,715 lb (16,200 kg)
Maximum speed: 59 m.p.h. (95 km/hr)
Operational ceiling: 12,800 ft (3,900 m)
Cruising range: 1,336 miles (2,150 km)
Armament: Two 0·3 in Maxim machine-guns, mounted on a platform on top of the forward hull, as self-defence against enemy aircraft*

* This was standard armament equipment on almost all contemporary German airships.

At the beginning of 1917 the Zeppelin company halted the building of airships for the German Army. Thus the last army air attack with an airship was made on 16 February of that year by a single vessel, LZ 107 (works number LZ 77) of the Q-type. The airship started from Hanover and headed for Boulogne in France where 3,197 lb (1,450 kg) of bombs were dropped from an altitude of 9,350 ft (2,850 m). LZ 107 flew above the cover of clouds and was directed by an observer who hung in a lowered car below the clouds and communicated with the control gondola in the airship by means of a telephone cable. This particular hapless observer had to spend seven long and lonely hours in his small car because the winch that was to haul him back up jammed.

42 Zeppelin LZ 62 (L 30)

The third and most decisive stage in the development of the Zeppelin airships was the so-called 'Super-Zeppelin' that appeared in early 1916. The prototype of this formidable weapon was L 30 (LZ 62) of the R-type which made its maiden voyage at Friedrichshafen on 28 May. Under the command of Lt-Cdr Horst Baron Treusch von Buttlar-Brandenfels this airship was two days later transferred to Nordholz, near Cuxhafen, in which air voyage the old Count von Zeppelin also participated. This zeppelin had a gas content of 1,949,373 cu.ft. (55,200 cu.m) which meant a considerable increase in size over the previous types, and the hull was better streamlined. These airships were powered by six engines, two of them in the rear gondola which drove, through transmission shafts, a port and starboard propeller mounted on outriggers from the hull, a return to a former, somewhat clumsy arrangement. At one time these airships were equipped with ten machine-guns as a defence against attack from enemy aircraft. Three of these guns were installed on top of the forward hull. Most of the remaining Zeppelin airships to be built during World War I were of this type, but improved with further refinements.

The very large size of L 30 made it a difficult airship to handle on the ground. The assistance of many men was required each time the airship was hauled out from, or back into, its shed 'Nora', and might be rendered impossible even if there was only a relatively slight crosswind in relation to

the longitudinal axis of the shed. The Germans were handicapped by the availability of only one fairly small double-shed ('Hertha', later 'Nobel') of the turntable type at Nordholz, which could house two airships.

The driving force of the airship section of the German Navy, Captain Peter Strasser, and his staff investigated the potentialities of L 30 thoroughly, and this airship made five trial flights before 5 July 1916, when it took off on its first war assignment: reconnaissance over the North Sea. This airship was to complete thirty-one flights of this nature during its lifetime and, strangely enough, was not camouflaged. This style of war painting was first introduced with L 35 (LZ 80), and continued in the succeeding airships of the R-class up to and including L 41 (LZ 79), which was painted dull black on the underside of its hull.

The British intelligence service lost no time in procuring details about this new Zeppelin type, which was promptly nicknamed 'The Super-Zeppelin'. Its German designation was *Grosskampf-type* (large war type).

L 30 took part in nine important air raids on England, but in spite of von Buttlar's boasts to the contrary, never actually attacked London. That the airship failed in this respect can be ascribed mainly to the poor navigational facilities of that period, and to the bad weather encountered. L 30 was one of the units in the fleet of eleven naval and five army airships that during the night of 2–3 September 1916 conducted the largest German operation of its kind during the war. Most of the airships were under orders to bomb English cities, and mainly London, while a few of them were to carry out a distracting air attack on the Humber district. Fourteen of the sixteen airships reached the English coast, but two had to turn back. The army airship SL 11 of the Schütte-Lanz type had started from Spich, near Düsseldorf, and was the only one to cross the British capital, where the bombs dropped caused little damage. Shortly afterwards it was shot down in flames by Flight Lieutenant W. Leefe Robinson, piloting a B.E.2c biplane, who was awarded the Victoria Cross for accomplishing the first downing of one of the dreaded and despised 'Zeppelins' in British skies (very few then knew the difference between the two main types of German rigid airship). The sight of the burning airship frightened the rest of the attacking German airship force. All of these airships immediately turned around and scattered their bombs at random. L 30 stayed only briefly over English territory and unloaded its bombs over the town of Bungay on the east coast about 90 miles (145 km) from London.

On the night of 23–4 September, L 30 and its three sister vessels L 31 (LZ 72), L 32 (LZ 74) and L 33 (LZ 76), as well as a group of eight older airships, again raided England, and their attack orders were the same as those for 2–3 September. Once more it is questionable whether von Buttlar reached the city at all, as he maintained, but Naval Reserve Commander Alois Böcker did so, with L 31, as he had picked a more direct course than the other airship commanders. Shortly after midnight (on 24 September), he dropped two 300 kg, eight 100 kg and thirty-two 50 kg high-explosive bombs over east London from an altitude of 12,800 ft (3,900 m), but was caught in the beams from the searchlights and was subjected to heavy anti-aircraft fire. The airship was hit and forced to land at Little Wigborough, near the Island of Mersea on the east coast. Böcker managed to have his airship set on fire before he and his crew were taken prisoner.

In the spring of 1917, L 30 and L 37

(LZ 75), together with four of the army airships, were transferred to the Seerappen base on the Baltic, near the city of Königsberg. Here their main task was to watch the Russian fleet movements. They met with little interference from Russian army and naval pilots as the enemy military forces stayed quite inactive once the March revolution had broken out in Russia. Later the Germans ran short of fuel, and L 30 was laid up at Seerappen in August 1917. There was little more to report about L 30 until after the Armistice when, along with three more airships also laid up there, it was taken over by the Inter-Allied Control Commission, who handed it over to Belgium. This country had no facilities for housing an airship of that size, so asked for it to be broken up at the German base.

Specification of LZ 62 (L 30)
Volume: 1,949,373 cu.ft (55,200 cu.m)
Length: 649·6 ft (198 m)
Diameter: 78·6 ft (23·95 m)
Engines: Six 240 h.p. Maybach HSLu six-cylinder in-line
Useful load: 71,650 lb (32,500 kg)
Maximum speed: 64 m.p.h. (103 km/hr)
Operational ceiling: 17,700 ft (5,400 m)
Cruising range: 2,300 miles (3,700 km)

43 Zeppelin LZ 104 (L 59) – the so-called 'African' airship

In August 1917 the Zeppelin airship company brought out a new model which for more than a year was to remain the standard type of the airship section of the German Navy. It was the so-called V-type, which was to comprise ten airships. From the fourth of these, L 58 (LZ 105) onward, they had engines installed of the new 260 h.p. Maybach supercharged type. In service these 1,977,620 cu.ft (56,000 cu.m) airships established their high technical qualities.

At the same time the naval staff decided to come to the relief of General von Lettow-Vorbeck and his troops, who for three years had resisted Allied forces in German East Africa. The nearest base of the Central Powers from which an airship could take off for Mahenge in Tanganyika was Jamboli in Bulgaria. From there the distance to the German base in East Africa amounted to some 3,600 miles (5,800 km), and this airship voyage would last between four and five days. When the airship was also required to carry a useful load of some 16 tons, this called for an airship of about 2,366,080 cu.ft (67,000 cu.m) capacity, and there was then no such airship available. The German forces in East Africa had already been advised by radio that the airship would arrive here towards the end of October, so to save time it was decided to lengthen the still-unfinished L 57 (LZ 102) by the insertion of two extra gas cells, each of 49·2 ft (15 m) length. L 57 was of the W airship type and made its maiden voyage towards the end of September, but by misfortune was badly damaged in stormy weather on 7 October 1917. It was under the command of Lt Cdr Ludwig Bockholt, who was partly to blame for the mishap, yet he was placed in charge of the hurriedly-rebuilt replacement airship L 59 (LZ 104), since any further time delay would have jeopardised the successful accomplishment of this important expedition. On the morning of 3 November 1917, L 59 left the Zeppelin factory at Staaken, near Berlin, and headed for Jamboli. The airship carried in its hold an enormous assortment of munitions as well as thirty machine-guns with spare parts, sixty-one bags of

medical stores, a large quantity of mail and various tropical outfits. Due to the strong sun and heat in Africa, L 59 was without the usual black protective coating. It had also been taken into account that the airship would not return to Europe, but that the fabric covering of the framework of the hull could be turned to many uses in East Africa.

From Jamboli, Bockholt made two unsuccessful attempts to reach Africa, where the German colonial forces meanwhile were in desperate straits. They could no longer stand their ground against the British, who had received information of the impending arrival of L 59. On 21 November the airship made a third attempt at getting through to the African brothers-at-arms, unaware of von Lettow-Vorbeck's surrender the day before. The powerful radio transmitter in Nauen, near Berlin, tried to recall L 59, but in vain. The airship meanwhile crossed Turkey and at 6 p.m. was crossing the eastern tip of Crete, where a thunderstorm was brewing and rendered radio reception impossible. Early next morning L 59 reached the coast of North Africa near Mersa Matruh. The long stretch of barren Libyan desert faced the airship; the burning sun soon heated the gas cells so that the valves in each then automatically released hydrogen. The hull became as dry as a bone and nose-heavy as the airship, rolling and pitching in the heat waves, continued southward. At 3.30 p.m. L 59 passed over the luxuriant palm-tree groves of the Dakhilah oasis, with everything aboard still airship-shape. An hour later one of the five engines broke down; it was the one driving the generator for the radio transmitter and could not be repaired. This meant that the remaining engines had to be nursed in turn. At 10 p.m. the airship crossed the Nile at Wadi Halfa, providing evidence of how accurately Bockholt navigated by relying on his sun and stellar observations. With nightfall the airship cooled down and became heavy, and keeping it trimmed turned into a steady struggle. Shortly past midnight one of Nauen's numerous recall signals finally got through to the airship, and it thus began its long return trip to Jamboli, where it arrived on 25 November after an uninterrupted stay in the air lasting ninety-five hours. Under extremely difficult and trying conditions the airship had covered a distance of 4,040 miles (6,500 km), and all twenty-two members of the crew were utterly exhausted. Granted that L 59 did not see through what it set out to accomplish, this trip yet remains one of the proudest pages in the annals of the great airship achievements, and it remains only to add that upon the return of the airship to Jamboli there was still sufficient fuel left in the tanks for another sixty-four hours' flight.

There now followed an intense debate, in which even the German emperor became involved, regarding how to use L 59 to best advantage henceforth. The chief of the airship section of the German Navy, Captain Peter Strasser, wanted the airship recalled for reconnaissance use, but, by-passing his superiors, Bockholt addressed himself to the Navy staff directly, proposing that L 59 remain based at Jamboli to attack from there enemy targets in Italy and the Middle East. In January 1918, the German emperor finally decided in favour of Bockholt's proposition, after the airship had been rebuilt for that purpose at a works in Germany.

L 59 was back in Jamboli on 21 February 1918, and on 10 March attacked Naples from an altitude of 11,800 ft (3,600 m). On this occasion a total of 14,000 lb (6,350 kg) of bombs

was dropped on the naval base and important industrial establishments – with good effect, according to Bockholt.

An attack on Port Said on 20 March could not be carried through, as the airship crew was surprised at daybreak to meet a strong headwind. This happened again on an attempt to bomb the British naval base in the Bay of Suda on Crete. On 7 April 1918, L 59 ascended from Jamboli for the last time. This time the airship was headed for Malta, and crossed the Balkan peninsula and the Strait of Otranto behind the heel of Italy. Here the German submarine U-53, at 9.30 p.m., observed some glimpses of light followed by a sea of flames that lit up the whole horizon. Simultaneously, the echo of an explosion resounded through the strait. L 59 had finally come to its end, with the roaming submarine as the only eyewitness of the disaster. Some oily patches and a few pieces of wreckage substantiated to the investigating U-53 the spot where the airship and its crew had found their watery graves. Neither the Italians nor any other allied forces ever claimed to have brought down L 59, so it can only be surmised that the accidental cause occurred on board the airship.

Specification of LZ 104 (L 59)
Volume: 2,419,057 cu.ft (68,500 cu.m)
Length: 743·1 ft (226·5 m)
Diameter: 78·6 ft (23·95 m)
Engines: Five 240 h.p. Maybach Mb IVa six-cylinder
Useful load: 114,860 lb (52,100 kg)
Maximum speed: 67 m.p.h. (108 km/hr)
Operational ceiling: 26,900 ft (8,200 m)
Cruising range: 4,970 miles (8,000 km)

44 Zeppelin LZ 112 (L 70)

The final version of the 'Super-Zeppelin' was an outstanding airship. Its ability to climb to high altitudes was now the most important performance feature, in order to outclimb attacking aeroplanes over the North Sea and Great Britain. These Zeppelins of the X-type now carried more than thirty tons of fuel, enabling them to enter the Atlantic by a circular route, rounding the north of Scotland and then staying at sea for several days in support of the German submarines.

By now it was evident that the war was fast drawing to an end, but the Zeppelin works managed to finish two of the planned total of four airships of this type. The third of them, L 72 (LZ 114) was completed after the Armistice and was delivered to France under the name of *Dixmude* (see No. 55). These X-type Zeppelins were only to have been a transition stage to a series of airships with the designation L 100. They were to have had a gas capacity of 3,813,990 cu.ft (108,000 cu.m), a length of 780·8 ft (238 m) and a minimum useful load of 180,780 lb (82,000 kg).

L 70 was the prototype of the Zeppelin X-type, and the only one of these airships equipped with seven engines; L 71 (LZ 113) and L 72 were fitted with six engines. L 70 made its maiden air voyage from Friedrichshafen on July 1918 under the command of the dashing, but still relatively inexperienced, Lt Cdr Johann von Lossnitzer. This trial flight and the succeeding ones confirmed that the airship would be able to carry its designed bomb load of 8,000 lb (3,630 kg) on raids over Great Britain.

The first war engagement of L 70 was on August 1918 when, accompanied by two other German airships, it was sent in the early morning hours on a routine reconnaissance assignment

over the Dogger Bank area. Simultaneously, a British naval force comprising light cruisers and destroyers left Harwich. It was L 56 (LZ 103), the most westbound of the three airships, which, through holes in the pretty solid banks of clouds, detected and reported the British fleet units, but otherwise kept its distance. L 70 on the other hand, immediately upon picking up this report, headed for the position and von Lossnitzer managed to sight the enemy. Daringly, and undisturbed by the heavy anti-aircraft fire from the warships, he ordered ten 100 kg bombs to be dropped, but could not observe the result. He sent a radio report home about the engagement, then continued his disrupted patrol work. This determined air attack had taken the British by surprise, and they regretted bitterly that they had not stored a couple of fighter aircraft on one of the cruisers before heading out to sea.

Although the Germans were then already in sight of losing the war, their naval airship section launched one final air raid against the British mainland. It was carried out on the evening of 5 August by an airship fleet composed of L 53 (LZ 100), L 56 (LZ 103), L 63 (LZ 110), L 65 (LZ 111) and L 70 (LZ 112). Captain Peter Strasser, the chief of the German naval airship division and its driving force throughout the war years, was in personal charge and stayed aboard the L 70, his latest airship. Von Lossnitzer still commanded L 70, which on this raid stored eight bombs of each of three sizes: 50, 100 and 300 kg.

This airship force flew to the attack in V-formation and planned to cross the British coast at an altitude of 16,400 ft (5,000 m), but was observed before it had grown completely dark, and a number of British aeroplanes immediately took off to engage the airships. A de Havilland D.H. 4 biplane, piloted by Major Egbert Cadbury and carrying Captain Robert Leckie as observer, closed with L 70 at 9.45 p.m. and attacked at once. The explosive Pomeroy shells fired by the machine-guns of the British aeroplane set the airship on fire in a short while. Its nose first pointed upwards, then the airship plunged thousands of feet into the sea, engulfed in flames. As had happened so often before, when the rest of the attacking airship force saw the lead ship afire they gave up their intentions, turned around, and dropped their bombs over open water. The airship attacks on Great Britain had ended with the loss of their organiser, Peter Strasser.

This is a fitting place for a review of their influence on the war of 1914–18. The real damage caused by the bombs dropped on British territory by the German airships was not substantial, but British war production was slowed up to some extent by their actual or reported appearance in British skies and the airships tied down anti-aircraft units and aeroplanes to fight them on the home front that otherwise could have been sent, along with the personnel manning them, to the battle lines of the actual theatres of war. 'The Zeppelins' also made the British people very 'air-conscious', as they drove home to the population that its island isolation no longer afforded any effective protection. Could the Londoners and others in the United Kingdom then have gazed into the future, these few airships would have been found to be harbingers of intensive developments on a much larger scale a quarter of a century later.

When World War I ended, a total of one hundred and fifteen Zeppelin airships had been built. A compilation of their fates reads as follows: 22 obsolete and broken up

after extended, useful service; 9 handed over to the Allies after the Armistice (including L 71 awarded to Great Britain); 7 deliberately damaged by their own crews; 17 destroyed in the air by enemy aircraft or anti-aircraft guns; 19 damaged in the air and thereafter wrecked in landing; 7 landed in enemy or neutral territory; 8 destroyed in their sheds by enemy attack; and 26 lost as a result of pure accidents sustained either in the air or on the ground. Expressed in human lives, about 40 per cent of the 50 or so airship crews trained by the airship section of the German Navy, more than three hundred and eighty souls in all, were killed on active service.

Specification of LZ 112 (L 70)
Volume: 2,196,573 cu.ft (62,200 cu.m)
Length: 693·9 ft (211·5 m)
Diameter: 78·6 ft (23·95 m)
Engines: Seven 260 h.p. Maybach Mb IVa six-cylinder
Useful load: 95,900 lb (43,500 kg)
Maximum speed: 81 m.p.h. (130 km/hr)
Operational ceiling: 22,970 ft (7,000 m)
Cruising range: 3,730 miles (6,000 km)

45 **Schütte-Lanz SL 3 (C 1)**

Luftschiffbau Schütte-Lanz (The S-L Airship Company) was founded in Mannheim-Rheinau in 1909, by shipbuilding Professor Johann Schütte of Danzig, with the financial support of a number of local industrialists, the foremost being members of the Lanz-Röchling family. An additional works was founded in 1916 at Zeesen, near the Berlin suburb of Königswusterhausen. This concern was to build a rigid airship with a wooden framework of plywood, which in Professor Schütte's view was both lighter and more flexible than the aluminium and duralumin used by Count Zeppelin.

The first Schütte-Lanz airship, SL 1 (A-type) had a gas capacity of 688,637 cu.ft (19,500 cu.m) and made its maiden voyage on 17 October 1911. It was allotted to the German Army, as was SL 2 (B-type), completed in February 1914, which incorporated many novel features that were revolutionary for their time. Thus the hull was carefully streamlined and the stabilising fins, rudder and elevator alike were of a clean design. The enclosed and well-equipped control gondola was a separate unit, and the four Maybach engines drove the propellers directly. The triangular keel arrangement was placed inside the hull.

The Schütte-Lanz company always felt the keen competition of the dominant airship concern in Friedrichshafen and the tangible goodwill of high esteem unfailingly extended to Count Zeppelin and his activities by the German nation. It was also a misfortune for the Schütte-Lanz concern when during the war airship operations became the exclusive domain of the German Navy, for it looked upon wooden airships with much disfavour. It had good cause for this attitude, as the wooden framework of the Schütte-Lanz naval airships absorbed much moisture on their voyages over the North Sea and thus became heavier, resulting in a poorer performance. It must not be forgotten, either, that the glues employed at that time did not have the waterproof qualities of modern glues. Thus, of the total of twenty-two Schütte-Lanz airships built, the German Navy ordered and used only eight, and Professor Schütte with Teutonic stubbornness stuck to his wood principle for too long. When he finally developed a metal framework of his own, made up of components of duralumin tubing,

it was too late. This airship was not completed before the war ended. The other Schütte-Lanz airships were employed by the German Army, and even here this airship-building concern ran into ill luck, for two new designs were destroyed in the construction stage when the shed housing them caved in. On the other hand, as the German Navy gained practical experience from the airships it operated, its engineers reported defects and suggested improvements to the Zeppelin company in Friedrichshafen, who also adopted many of the features and practices first introduced in the Schütte-Lanz airships.

Returning to SL 2 of the German Army airship division, early in the war it made a reconnaissance trip on the eastern front for the Austrian headquarters at Przemysl in Poland. On 20 March 1915 SL 2 participated with two more army airships, Z X (LZ 29) and LZ 35, in a planned air attack on Paris. SL 2 was damaged by French anti-aircraft fire, so her captain elected instead to attack a French Army headquarters close by in Compiègne, where the airship dropped 1,984 lb (900 kg) of bombs.

SL 3, of the C-type, was ready for service in February 1915. It was the German Navy's first Schütte-Lanz airship and the largest airship then built. The naval order comprised SL 4 and SL 6 as well.

SL 3 appeared for the first time over British territory on 4 June 1915, together with L 10 (LZ 40). SL 3 was commanded by Lt Cdr Fritz Boemack, who had orders to attack Hull. Shortly after midnight he dropped three bombs on what he took to be a railway junction in the region of his target, but they actually fell in open country, causing no damage. On this raid the airship could not carry a bigger bomb load because it had become heavy from absorbing moisture at sea and could only rise to an altitude of 6,560 ft (2,000 m).

In the evening of 3 July 1915, a British naval force consisting of three light cruisers, sixteen destroyers and two seaplane tenders headed out to sea from Harwich. Its destination was the German Bight, and its aim to act as decoy for enticing the German airships to ascend and reconnoitre the force, whereupon it was conceived that floatplanes of the Sopwith Schneider type, carried by the British surface vessels, would attack the airships. Other British seaplanes would at the same time bomb the German naval ports located along the Bay of Heligoland. Six German naval airships, SL 3 being one of them, swallowed the bait. The Schütte-Lanz airship spotted and reported one of the cruisers and twelve of the destroyers. The British scheme failed completely, however, because none of the fighters was able to take off from the rough sea, and the bombers either had engine failures or were repulsed by German aircraft. The German airship units felt good about the events of 3–4 July, which they considered to be 'their own show', since none of the German Navy's surface forces had been involved in the encounter.

On 7 August, SL 3 was in the air again, this time acting as a lookout for a German minelayer. Off Blaavandshuk, on the west coast of Jutland, the airship turned homeward again and became so heavy in the rainy weather that it failed to respond properly to the controls and was badly damaged while landing at the Nordholz base near Cuxhafen.

SL 3 made about 70 flights in all as a naval airship and shared the fate of most of the other Schütte-Lanz airships. At a fairly early stage of the war it was stationed at the Baltic base of Seddin, near Stolp in Pomerania, which

was a relatively secondary theatre of war. Here it met its fate on 1 May 1916 when it plunged into the sea between the Swedish island of Gotland and the town of Kurland in Russia. The crew was rescued, but the airship was completely wrecked.

The last design with a wooden hull from the Schütte-Lanz airship works was SL 22, with a gas content of 1,988,214 cu.ft (56,300 cu.m). It was completed in June 1918, but the German Navy declined to accept it. This airship was dismantled after the Armistice and various parts were distributed among the Allies for further examination.

Specification of SL 3
Volume: 1,147,727 cu.ft (32,500 cu.m)
Length: 502 ft (153 m)
Diameter: 64·8 ft (19·75 m)
Engines: Four 210 h.p. Maybach CX six-cylinder
Useful load: 30,865 lb (14,000 kg)
Maximum speed: 53 m.p.h. (85 km/hr)
Operational ceiling: 7,875 ft (2,400 m)

46 The Caquot captive balloon

The French general staff decided in 1912 to discontinue altogether the use of captive balloons for observation purposes. By the end of 1914 it became evident that the Germans were using kite balloons in ever-increasing numbers for artillery observation on the western front. The French – and later the British – reacted quickly, but for a while countered this threat with spherical balloons that were completely unsuited for this purpose in windy weather.

A French officer, Captain Albert Caquot, came to the rescue of his general staff. Basing his plans upon the German kite balloon style, he designed a new and better-shaped type equipped with three stabilising fins spaced 120° apart. This arrangement rendered these balloons very steady in the air even if strong winds were blowing. The first two Caquot observation balloon types were designated 'L' and 'M' respectively. In their final form they were built in four standard sizes: 26,486 cu.ft (750 cu.m) (P); 28,958 cu.ft (820 cu.m) (P.2); 32,843 cu.ft (930 cu.m) (M.2) and 35,315 cu.ft (1,000 cu.m) (R). The French Navy used the P and P.2 sizes on board smaller vessels as protection against German submarine attacks, while large fleet units carried the R size to direct their gunfire. Balloons of the P size could carry two observers to an altitude of 1,640 ft (500 m), while the R size could carry three observers to this altitude or two observers to an altitude of 3,380 ft (1,000 m). On 1 July 1917 the French Navy possessed a total of 10 Caquot balloons. Twelve months later this number had increased to 200, and 24 naval vessels had special equipment for the handling of these balloons.

The French Army likewise used Caquot balloons extensively. Gradually 76 companies were formed to guard the various sectors of the front by day and night by means of these balloons. This task could scarcely have been performed satisfactorily by means of ordinary aeroplanes. Life in the open basket was far from being pleasant. Not only were the observers exposed to the capricious weather, but often they also had to jump hurriedly by parachute to save their lives, when attacking enemy aircraft turned the balloon envelope above their heads into a sea of flames. Certain fighter pilots on both sides specialised in attacks on these captive balloons. For instance, the German 'ace', Captain Heinrich Gontermann, towards the end of World War 1 had 18 Caquot balloons –

besides 21 aeroplanes – to his credit. Therefore it was of the utmost importance that an observation balloon could be hauled down quickly when warned of an impending attack on it. To this end the French in 1915 and 1916 used a motor winch of the Saconney type, driven first by a 32 h.p. and later by a 60 h.p. Delahaye engine. From 1917 onwards the motor winch was of Caquot's own make and driven by a 70 h.p. de Dion-Bouton engine which hauled the observation balloon down at a speed of about 20 ft (6 m) per second.

47 Barrage balloons in World War 1

In 1917 the Germans began attacks against England by day and night with large aeroplanes after the airship had proven unsuited as a weapon of offence. The British counter-measures were searchlights, anti-aircraft guns and fighter aircraft, to which a quite new form of passive defence was added in the form of balloon barrages. They were preceded by many experiments before proving their value and influencing the conduct of aerial warfare to a certain extent.

There was a 51-mile-long (82 km) balloon barrage established around London by the middle of 1918. It was of the so-called net type, where the balloons were arranged in groups of three which were interconnected by means of a steel cable from which a number of light cables of about 1,000 ft (300 m) length hung vertically. This net barrage, or 'apron' as it was also termed, was mounted so high that enemy aircraft arriving to attack would have difficulties in flying above it. German pilots taken prisoner, on being interrogated, expressed great fear of these barrages, so evidently their psychological effect alone was important. Although the balloon barrages generally were placed in densely-populated areas, they remained very much a secret weapon and the general public learned little about their true purpose.

Other nations soon followed suit. Italy had already hung balloon barrages to an altitude of 9,840 ft (3,000 m) around Venice from 1916 onwards, but there the balloons were not interconnected. France planned the formation of 150 barrage balloon detachments with 10 balloons each, but had only established a total of 750 balloons when the war ended. The Germans, who never left anything untried in the field of new ways of active and passive warfare, adopted this procedure in January 1918, and soon had 10 balloon detachments, numbering 50 balloons each, primarily for guarding industrial installations.

Balloon barrages were one of the few protective measures that were re-established almost unchanged when World War 2 broke out in September 1939. It was soon found that these barrages could be used and compounded in many more ways than during World War 1 (see No. 74).

48 The SS or 'Sea Scout' class airships of the Royal Navy

On 1 January 1914, seven months before the outbreak of World War 1, all government-owned British airships were turned over to the Admiralty. They included *Willows IV*, a Parseval airship designated 'No. 4' and the three experimental airships *Delta*, *Eta* and *Gamma* which had been built at Farnborough. The British Admiralty quickly realised the value of airships for patrolling at sea. The problem, however, was how to initiate a production of really suitable types for this special purpose. The non-rigid airship, in which the shape of the balloon envelope was maintained by pressure

exerted inside the envelope, was selected as the most expedient type.

The prototype of these small and simple-to-build airships was ready for its first test flight in March 1915. It was a composite of the envelope from *Willows IV* (see No. 34) and the fuselage of a B.E.2c aeroplane slung underneath, complete with its engine and propeller. During the war some one hundred and fifty of these airships were built in three different forms, with a number of them going to France and Italy. They were termed the SS class, the initials standing for 'Sea Scout' or 'Submarine Scout'. Colloquially they always were referred to as 'Blimps'. Over the years several explanations have been advanced about the origin of this word. The most common one is that in the military vernacular the Type B was referred to as 'limp bag', which was simply abbreviated to 'blimp'. An alternative explanation is that on 5 December 1915 A. D. Cunningham, R.N., who designed the SSZ type, flipped the envelope of a non-rigid airship with his fingers during an inspection, which produced a sound that he pronounced as 'blimp'; and that the word then caught on as the nickname for all small non-rigid airships.

The first airships of the SS class had a gas content of only 20,500 cu.ft (580·5 cu.m); in later types this was increased to 60,000 and 70,000 cu.ft (1,699 and 1,982 cu.m). In 1917 the original type was succeeded by the SSP (P standing for pusher propulsion), with a somewhat improved performance. A variation of this was the SST (T for Twin, with two engines.) Neither the SSP nor SST airships were particularly successful, so only six and two respectively were built. Shortly after the SSP type the SSZ (Z for Zero) was produced. A total of ninety-three of them was ordered, but only sixty-six were delivered to the Royal Navy. Of the six 'Blimps' transferred to the U.S. Navy in 1918, two were of the SSZ type, numbered SSZ 23 and 24. Only the latter airship reached America, where it bore the designation A5472. SSZ 21 and 22 went to France.

The SSZ airships rendered good service in 1917 and 1918. Their envelope was made of layers of fabric reinforced with rubber. The inside pressure was maintained by means of two air-filled ballonets, the pressure of which was regulated with intake nozzles mounted in the slipstream of the propeller. Viewed from the bow, the gondola, strongly built and shaped like a boat, seated – from front to rear – the wireless operator, the pilot, and a mechanic. The rudder was operated with foot pedals and the elevator was manipulated by means of a wheel mounted on the port side of the cockpit. The armament was a Lewis machine-gun. The bomb load could vary, but normally comprised three 100 lb bombs. The airship was even provided with a listening device which, fastened to a line, dragged in the water (the forerunner of the sonobuoy).

The airships of the SSZ type were built at the R.N.A.S. Capel air station near Folkestone. The first specimen was, as an experiment, towed by one of the smaller naval surface vessels to the vicinity of the Belgian coast, from where the airship continued under its own power. Non-rigid airships were at first not too well adapted to this procedure, but with improved technique good results were later achieved by thus increasing the range of the airships.

The scouting British airships joined in battling the German submarines in the Channel and in the Bay of Biscay. They also served as convoy escorts and thus released a large number of light cruisers and destroyers that could be ill spared for such duty. Bad weather

seldom prevented these small lighter-than-air craft from performing their work. In the period from 1 January 1918 until the Armistice, there were only nine days on which the airships were unable to undertake their tasks. In these ten and a half months they were in the air for a total of 53,354 hours. The records in the archives of the Admiralty reveal that in the course of the whole war period the various types of 'Blimp' spotted a total of forty-nine enemy submarines, and it has been established that they were responsible for twenty-seven of them being attacked and a goodly number of these sunk. A type like the SSZ airship could indeed stay in the air for a long time. Seven hours was its normal flying duration, but flights lasting twelve or even twenty-four hours were not uncommon occurrences. The record was held by SSZ 39 which, in the summer of 1918, flew with full war equipment uninterrupted for fifty hours.

Specification of the SSZ type
Volume: 70,000 cu.ft (1,982 cu.m)
Length: 143 ft (43·6 m)
Diameter: 32 ft (9·75 m)
Engine: One 75 h.p. Rolls-Royce Hawk
Useful load: 7,275 lb (3,300 kg)
Maximum speed: 48·4 m.p.h. (77·8 km/hr)
Cruising speed: 34·5 m.p.h. (55·6 km/hr)
Normal endurance: approx. 7 hours

49 **The 'NS' or 'North-Sea' class airships of the Royal Navy**

The last and most advanced type of small non-rigid airship used by Great Britain was the 'NS' class (the initials standing for North Sea), developed both for co-operation with naval surface units and for convoy duty. It had a minimum endurance of twenty-four hours. The envelope was composed of 2,500 patches coated with silver (aluminium pigment) colour, after the Astra-Torrès fashion, resulting in a trefoil cross-section. The previous types had been improved upon by the provision of separate control and engine gondolas. The control gondola was enclosed and housed the crew of ten men who worked in two shifts. This division of gondolas and equipment also meant a better distribution of the weight over a greater area of the envelope. The gondolas hung suspended by lines attached to the envelope by a number of patches.

This airship type first entered naval service in February 1917. By June of the same year NS 1 left the Pulham base in Norfolk and completed an endurance trip of forty-nine and a half hours' duration. On this occasion the twelve fuel tanks were installed inside the envelope, and each time the fuel supply was required to be switched to another tank, a mechanic had to climb on top of the envelope to perform the change. On later airships of the class the fuel supply change could be made from the control gondola.

Due to certain engine troubles originally experienced, only twelve of these airships were built initially, and from July 1917 onwards all were stationed at the East Fortune base in the Firth of Forth. However, after the end of World War 1 a total of about two hundred of these airships had been built, including NS 14, completed in November 1914, which was handed over to the U.S. Navy and renumbered A5580.

One hundred and three of these 'Blimps' saw service during the war. They performed their last task on 21 November 1918. On this date the British fleet left the Firth of Forth for a rendezvous with the German naval forces that

were to surrender to the Allies in accordance with the terms of the Armistice. The cruiser *Cardiff*, with Rear-Admiral Sinclair on board, was the flagship of the sixth light cruiser squadron which had the task of establishing the first contact with the German naval forces, comprising sixty-nine large and small vessels. Overhead was *Cardiff's* own captive balloon, with NS 7 on guard to starboard. In addition, NS 8 was positioned above the centre of the British main force, and this dramatic encounter passed without any untoward incidents.

It may finally be recorded that airships of the 'NS' class on several occasions made particularly long-lasting individual flights. NS 11 at the beginning of 1919 set an endurance record of one hundred and one hours 50 minutes, covering a distance of more than 3,000 miles (4,828 km). In July of the same year this airship was lost and its crew perished when it was hit by lightning and plunged into the sea off Salthouse, on the east coast, while out looking for mines.

Specification of the 'NS' class
Volume: 360,000 cu.ft (10,194 cu.m)
Length: 262 ft (79·9 m)
Width: 56 ft 9 in (17·3 m)
Engines: Two 260 h.p. Fiat A. 12 six-cylinder
Useful load: 8,400 lb (3,810 kg)
Maximum speed: 57·6 m.p.h. (92·7 km/hr)
Cruising speed: 42·6 m.p.h. (68·6 km/hr)

50 23 and 23X class rigid airships of the Royal Navy

Even though the British non-rigid airships were successful in World War 1, and in spite of the failure with the naval No. 1 *Mayfly*, the idea of building rigid airships had not been abandoned in England. In 1914 the British government ordered the rigid HMA (His Majesty's Airship) No. 9 from Vickers, but as a result of subsequent cancellation and re-ordering this airship was already virtually obsolete by the time that it eventually made its maiden voyage on 16 November 1916. It was broken up in June 1918 after having flown for only 198 hours and 16 minutes.

After many protracted political discussions the Admiralty succeeded in having the building of four airships of the so-called 23 class, a modified version of the No. 9 design, approved. Vickers was to build No. 23, Beardmore No. 24, Armstrong Whitworth No. 25 and Vickers again to build R 26, the first rigid airship to be designated with the letter 'R' denoting 'Rigid'. This series was originally to have totalled ten airships, but only six of them were built. The last two, Beardmore's R 27 and Armstrong Whitworth's R 29, were of a somewhat changed and improved design, known as the 23X class. The visible difference between the two classes was mainly that the 23X airships lacked the distinctive exterior keel arrangement which on the 23-class airships mainly served the purpose of distributing the weight. In the 23X design this was achieved by means of interior, circular cross-frames.

The 23 class can best be described as a 'fattened' edition of the No. 9 airship and really was not a bad design at all, but unfortunately it was well behind the times. Plain evidence of this was provided when, two months before the first airship of the 23 class made its maiden voyage, the German Zeppelin airship L 48 (LZ 95) was shot down on English territory and turned out to represent a class of vessel capable of carrying a useful load nine times larger than that of Great Britain's newest rigid airship. This surprising reality was a contributing factor in once more almost shattering a British airship building programme.

The design work on No. 23 started in June 1916 and the maiden voyage was planned for the autumn of that year, but the selected engines soon turned out to be 4,400 lb (2,000 kg) too heavy and various alterations to the airship had added another 3,300 lb (1,500 kg) of excess weight. The airship was not ready until August 1917 and it was established during the first trial trip on 19 September that, with the four Rolls-Royce engines installed, there was a lifting capacity of only a little more than 11,000 lb (5,000 kg) left, which called for new and drastic changes.

No. 23 carried out a number of patrols over the North Sea, participated in some victory parades in November 1918, and later that month acted as flagship when the German submarines arrived off Harwich to surrender. Most of the time No. 23 served as a training airship. For a time towards the end of the war the Admiralty feared that the British airships might be attacked by the German Zeppelins and were insufficiently protected with the guns mounted on the platform on top of the forward hull, so in the summer of 1918 a number of experiments were made in turning No. 23 into an aircraft carrier in a limited way by suspending two Sopwith Camel fighters from the keel below the airship. They were to defend it after being released, but could not return to the airship. However, it was realised that the superior German airships would probably adopt the same practice, and then nothing would have been gained. In the spring of 1919 the bow of No. 23 was reinforced prior to conducting some tests with a mooring mast, and in September of that year the airship was finally broken up.

Landing tests of attachment to, and release from, a mooring mast were also made with No. 24, which also wound up as a training vessel for new airship crews. The most noteworthy air voyage of No. 26 was an extended flight of over forty hours' duration on 4–5 June 1919.

Specification of the 23 class
Volume: 942,000 cu.ft (26,675 cu.m)
Length: 525 ft (163·1 m)
Diameter: 53 ft (16.15 m)
Engines: Four 250 h.p. Rolls-Royce Eagle twelve-cylinder
Useful load: 13,228 lb (6,000 kg)
Maximum speed: 52 m.p.h. (84 km/hr)
Cruising speed: 40 m.p.h. (64 km/hr)
Operational ceiling: 3,000 ft (914 m)
Bomb load: Four 100 lb bombs
Crew: 17 men

Specification of the 23X class
Volume: 990,600 cu.ft (28,050 cu.m)
Length: 539 ft (164·3 m)
Diameter: 53 ft (16·15 m)
Engines: Four 250 h.p. Rolls-Royce Eagle III twelve-cylinder
Useful load: 19,000 lb (8,618 kg)
Maximum speed: 55·3 m.p.h. (89 km/hr)
Cruising speed: 42·6 m.p.h. (km/hr)
Operational ceiling: 6,900 ft (2,100 m)
Bomb load: Four 220 lb bombs
Crew: 17 men

R 27 was built at the works of Beardmore in Scotland and was completed by early summer 1918. After having been in the air for a total flying time of 89 hours and 40 minutes, it was destroyed in its shed at the Howden

base in Yorkshire on 16 August 1918. This accident was caused by a small non-rigid airship, SSZ 23, which was being packed in the same shed for shipment to the United States (see No. 48). Its American crew was cleaning the airship gondola with petrol, when the wireless operator began at the same time to test his equipment, which evidently created some sparks that ignited the petrol fumes. Instantly the shed was an inferno, but all except one man managed to escape.

R 29 was built at the works of Armstrong Whitworth at Selby in Yorkshire. It was the only completely successful airship of the whole series, as its excess lifting capacity amounted to 18,000 lb (8,165 kg). It also became the sole British rigid airship to engage German submarines in battle, and this on no fewer than three occasions. The first submarine escaped, the second hit a mine and sank. The third encounter between R 29 and a German submarine, this time the U-115, took place on 29 September 1918. One of the smoke bombs from the airship marked the spot where the submarine dived, and it was then sunk by British naval surface vessels. R 29 was broken up in October 1919.

51 The R 34 airship of the Royal Navy

In 1919 two rigid airships ordered by the Admiralty were completed. They were R 33 and R 34 built by Armstrong Whitworth and Beardmore respectively. This class of airship was based upon the German Zeppelin L 33 (LZ 76), shot down at Little Wigborough in Essex on 24 September 1916, and incorporated other improvements as well, which had been found in the L 49 (LZ 96) airship which made a forced landing in France in 1917 and was captured almost intact. Except for the gondola arrangement these two British airships followed the German pattern closely, but it was a mere coincidence that the German '33' figure was repeated in the Royal Navy rigid airship sequence.

The hull of the R 33 class airships can be described as semi-streamlined inasmuch as only a minority of the cross-frames were of the same size. There was a slight space between the control gondola and the forward engine gondola, but viewed from a distance they appeared to be a single unit. About 'midships two single engine gondolas were mounted side by side. Here the propellers were reversible and their braking effect would thus slow up the airship when landing. In the rear gondola three engines were installed originally, but one was later removed. These engines drove a single two-blade wooden propeller.

R 33 and R 34 were planned primarily for reconnaissance at sea, but undoubtedly their ultimate commercial use had also been considered. R 33, at least, was at one time fitted with two gun platforms, on top of the forward hull and in the tail cone.

R 33 was in service for a long time and conducted many interesting experiments. When dismantled in 1928 it had accumulated 800 hours of flying time.

R 34 gained the world's renown for its double crossing of the Atlantic, but came close to being wrecked on its maiden flight when the elevators became stuck in the downward position.

At the end of 1918 the Admiralty came forward with the proposition that the Air Ministry could take over its airships and their ground facilities on a loan basis. The purpose was that the airships be afforded an opportunity to prove their suitability as passenger carriers by making a number of long air voyages. A special invitation was received from the United States, so it

was decided that R 34 would pay a visit there during the summer of 1919. In the spring of that year this airship made a number of training flights especially to test its navigational equipment. One of these voyages was a cruise to the Baltic via Copenhagen.

The airship departed for New York from the East Fortune base on the Firth of Forth at 1.42 p.m. on 2 July 1919. Major G. H. Scott, R.A.F., was in command of the airship and its crew of thirty men. The seventy fuel tanks held a total of 4,900 gallons (22,275 litres) of petrol besides 2,300 gallons (10,455 litres) of oil and 3 tons of water ballast and other required equipment. Thus the useful load of the airship amounted to almost 34·5 tons. To retain the maximum amount of hydrogen in the eighteen gas cells of the R 34, Scott had right from the start to fly as close to the ground as possible, so most of the time the airship stayed in the clouds or in fog. All five engines of R 34 were operated for more than thirty hours, then the fifth was stopped to save fuel. Just about that time a stowaway reported at the bridge to give himself up. It was a former crew member, Private W. Ballantyne, who had been scratched from the list to save about 200 lb (91 kg) of weight and instead carry that additional amount of precious fuel. Events were later to prove how foolishly this man had behaved; for, as a matter of fact, he came close to having this east-to-west air crossing of the Atlantic end in failure. One more unaccounted-for passenger was to turn up, but caused less concern as it was only a small cat. There were two more animals on board, in the form of carrier pigeons, but they were true 'members of the crew'.

Up until that time everything was to schedule, except for some bad weather encountered about 300 miles (480 km) east of Newfoundland which forced the airship to climb higher. There also occurred the unforeseen incident when the total supply of chewing gum on board the airship was consumed in plugging a leaking cooling connection on one of the engines. In the evening the situation grew so critical that Scott pondered the alternatives of having an American destroyer take the airship in tow or of making an intermediate landing in Montreal to refuel. However, on the morning of 6 July he decided to go for the Montauk naval base on Long Island, and as the headwind had also diminished he finally gambled on reaching New York itself. Then the R 34 at 1.20 p.m. hovered above Hazelhurst and prepared to land at the Roosevelt flying field in Mineola. One last, serious problem remained to be solved. Earlier, when R 34 had radioed that it was in trouble and would probably head for Boston, the awaiting landing party was hurriedly despatched to that city. Thus there was only a small and anxious, but untrained staff left at Roosevelt Field. The difficulty was solved by an officer on board R 34, Flt Lt J. E. M. Pritchard, who jumped by parachute from the airship and took charge on the ground. Half an hour later R 34 was safely anchored, having taken 108 hours and 12 minutes to complete the first east-to-west air crossing of the Atlantic. The airship then had barely enough fuel left in its tanks for another two hours' flying. Had the stowaway not been on board there would not have been any doubt about the ability of the airship to reach New York, which was a prestige question of no little importance.

The R 34 and its crew were duly applauded by New York, and then on 10 July the airship began its passage home to Great Britain. The forward engine of the two in the rear gondola broke down completely on 11 July, but otherwise nothing untoward happened

en route and at 8 a.m. on 13 July the airship landed at the Pulham base in Norfolk 75 hours after leaving New York. The return to Pulham, instead of East Fortune, was at the request of the Air Ministry. The R 34 had become the first airship – indeed, the first aircraft of any kind – to cross the Atlantic in both directions.

The career of R 34 came to an end eighteen months later, for on 28 January 1921 it maintained too low an altitude and was badly damaged when it hit a range of hills in Yorkshire. The crew managed to return the airship to the nearby Howden base, where it was damaged still more, fortunately without the loss of any lives.

The achievement of the R 34 had no lasting effect on trans-Atlantic air travel, as it was evident that neither from the economical nor the safety angle could airships of the R 33 class cope with such a long route; it would at least necessitate several intermediate landings, for instance in Iceland, Newfoundland or the Azores. In 1919 the equipment simply was too costly and too unreliable to be used on regular air schedules.

Specification of the R 33 class
Volume: 1,950,000 cu.ft (55,218 cu.m)
Length: 643 ft (196 m)
Diameter: 78·75 ft (24 m)
Engines: Five 250 h.p. Sunbeam Maori twelve-cylinder
Useful load: 58,430 lb (26,500 kg)
Maximum speed: 62 m.p.h. (100 km/hr)
Cruising speed: 45 m.p.h. (72 km/hr)
Crew: 22 men

52 **R 36 – Great Britain's first passenger airship**

The R 35, R 36 and R 37 were the last rigid airships ordered by the Admiralty during World War 1, but R 36 was the only one of these so-called R 35-class airships to be completed and to fly. This design was originally based upon the German Zeppelin L 48 (LZ 95), but at a fairly early stage it was decided to lengthen R 36 and R 37 to achieve a greater lifting capacity and a higher ceiling. When the war ended other uses had to be found for the airships already built or then being built. The only sensible solution seemed to be to have them carry passengers as well as cargo. A route between London and Cairo was being considered, but sightseeing trips to the battlefields were also proposed, as well as tourist excursion flights to the Riviera, Denmark and Sweden. The British government felt unequal to this task financially, and hence offered all its available large airships, and the ground facilities for them, for sale. No buyers immediately came forward, however.

In these circumstances, and in spite of the anything but promising prospects for airships in the future, the decision was made to adapt R 36 to carry passengers. The civil air authorities estimated that R 36, or G-FAAF to give it its civil registration, should be able to carry thirty passengers and one ton of cargo from England to Egypt in 72 hours. As it turned out, these expectations were far too optimistic.

R 36 was built at the Inchinnan works of Beardmore in Scotland. Work on this airship commenced in 1918, but its maiden voyage did not take place until April 1921. Much was expected of this first passenger airship in Great Britain, even though it was not a completely new design. A total of fifty passengers could be carried in the 130 ft (39·6 m) long centre-section right below the hull, aft of the control gondola. The passenger saloon was furnished with wicker chairs and tables; there were cabins with berths, toilets and a galley. The crew comprised four officers and thirty-four other ranks. Their quarters were inside the hull, just above the gondola. The crew of the R 36 worked in watches, as on large passenger ships.

On 5 April 1921, R 36 was almost involved in disaster. The airship was on a coast-to-coast trip and, when off Bristol, the top stabilising surface and the starboard section of the tail surface suddenly folded up. Contrary to the practice on the R 33 class, for instance, these components were not supported by stay wires. The airship dived quickly from an altitude of 6,500 ft (1,980 m) to 3,000 ft (914 m). The well-known Major Scott was in command of the airship on this occasion, as he had been on the two trans-Atlantic trips with the R 34. He had all engines stopped at once and ordered the whole crew aft, which restored the equilibrium. Then the R 36 managed to return slowly to its base with the engines operating at low r.p.m. This mishap made a strong impression on various staff members of the Air Ministry, who participated in this flight and thus learned at first hand the risks run with airships. The R 36 was not really used to any great degree, and the uncertainty prevailing about how to use such a large airship to good advantage is perhaps illustrated best by mentioning that, on 14 June 1921, it was filled with newspaper reporters and then sent aloft to help the police direct traffic to and from the Ascot races. The newsmen were perhaps unimpressed, but commented favourably on the steady and quiet ride of the airship. They all however had one complaint in common: the lack of a lift in the 120 ft (36·6 m) tall mooring mast, by which means all passengers boarded the airship.

This very mooring mast caused much damage to R 36 on 17 June. During a landing manœuvre the mooring cable from the airship became jammed in the winch at the base of the mooring mast, which then overturned as a result, and pulled the airship forward and downward against the mast, thereby bending its bow badly. A storm was brewing, so it was imperative that the airship be got quickly under cover. However, the only suitable shed available already housed the German Zeppelin L 64 (LZ 109), which had been commandeered as war booty. The unoffending German airship became an unfortunate victim of circumstances, for although it must be acknowledged to have been a superior vessel to R 36, no time was lost in pulling it out of the shed and attacking it with axes and other weapons of destruction, in order to effect a positive grounding. To perfect the madhouse, the ground crew managed to further damage the R 36 while it was being pulled inside the shed, as it was knocked against the abutments of the entrance doors.

Specification of R 36
Volume: 2,100,000 cu.ft (59,465 cu.m)
Length: 663 ft (202·1 m)
Diameter: 80 ft (24·4 m)
Engines: Two 260 h.p. Maybach Mb IVa* six-cylinder in the forward gondola, and three 350 h.p. Sunbeam twelve-cylinder in the rear gondola
Useful load: 36,380 lb (16,500 kg)
Maximum speed: 65 m.p.h. (105 km/hr)
Cruising speed: 51 m.p.h. (82 km/hr)

* These engines were from L 71 (LZ 113) which was acquired as war booty.

The repair work on R 36 was not started until August 1925 because the whole British airship situation was

being deliberated anew. Meanwhile the R 38 had crashed, which was to have been supplied to the U.S. Navy as the ZR-2. This had happened on 24 August 1921, when on a test flight it broke in two over the Humber estuary and forty-four crew members, including sixteen from the U.S. Navy, lost their lives. Only five of those on board survived the disaster. The R 36 was finally restored, but did not fly again and was broken up at the end of the twenties. There was now only one giant airship left, the R 80 (see No. 53), of the various designs planned during World War 1.

53 R 80 of the Royal Air Force

The R 80 was the last British rigid airship to be planned before World War 1 ended, and was in many respects an interesting and advanced design. R 80 was built by Vickers and was designed by B. N. (now Sir Barnes) Wallis, the engineer and scientist of later World War 2 renown. It is noteworthy how well streamlined both the hull and the gondolas of R 80 were, compared with earlier designs: for instance, the head resistance was only one-fifth of that of the 23 class. R 80 was indeed the first truly streamlined airship; the hull was shaped like a torpedo, without any parallel or straight sections to cause vortex formations. The combined control and forward engine gondola was placed well forward and was, like the two rear engine gondolas, built of aluminium with an asbestos bottom covering. The window glazing was either Triplex safety glass or celluloid. The fuel tanks were installed in the hull below the fifteen gas cells, and a passageway in the keel extended throughout the full length of the airship.

On top of the forward hull, a platform was planned on R 80 for the mounting of a rapid-fire two-pounder gun and for two Lewis machine-guns. Two more Lewis machine-guns were mounted in the stern tip and an additional number of machine-guns in the various gondolas. Provision was made to carry eight 230 lb bombs in the keel.

Conditions prevailing at the time of the Armistice delayed the completion of the R 80 so that it was finally towed out from its shed on 20 June 1920. The maiden air voyage started out dangerously, as the airship rose very rapidly because it had stood exposed to the broiling sun for a long time, which created too high a pressure in the gas cells. Several test flights were made in January 1921 before it was handed over to the Royal Air Force. In terms of size the R 80 was not a big airship, yet it was fast, even though the fabric covering on the hull was not tight. Unfortunately for the designers both the military and civilian authorities showed a lack of interest, not knowing how to employ this airship. It seems to have been threatened with the fate of being broken up almost from the start, but this little-used airship enjoyed a brief respite when placed at the disposal of the personnel

Specification of R 80

Volume: 1,250,000 cu.ft (35,396 cu.m)
Length: 534 ft (162·8 m)
Diameter: 70 ft (21·34 m)
Engines: Four 230 h.p. Wolseley-Maybach six-cylinder
Useful load: 37,480 lb (17,000 kg)
Maximum speed: 65 m.p.h. (105 km/hr)
Cruising speed: 50 m.p.h. (80·5 km/hr)
Ceiling: 16,400 ft (5,000 m)
Maximum range: 6,400 miles (10,300 km)

from the U.S. Navy who had previously trained with the R 32 which was then being retired, and who were waiting to accept the ill-fated R 38 (see No. 52).

The R 80 made its last brief flight, from Howden in Yorkshire to Pulham in Norfolk, on 20 September 1921, and had then only been in the air for a total of 75 hours. The airship was finally broken up in 1924, but parts of the hull were kept intact to serve as exhibits in the investigations of the R 38 disaster.

54 Zeppelin LZ 120 'Bodensee'

On 21 June 1919, the many German naval vessels that since the Armistice had been kept interned at the British naval base at Scapa Flow, in the Orkney Islands, were scuttled by their own crews. This act was also the signal for personnel at the German naval airship bases at Nordholz and Wittmund, on the North Sea coast, to enter the sheds there undetected and remove the supports from under the stored airships. The huge hulls collapsed to the accompaniment of gigantic crashing noises and settled on the floor as worthless heaps of metal and fabric. The Allies were thus deprived of seven airships in this fashion, and there now were only a few wartime Zeppelins left. These were at the Ahlhorn airship base near Oldenburg where, for some reason or other, similar destructions did not take place.

The Inter-Allied Control Commission promptly responded with reprisals for these deliberate acts of destruction by demanding that all German airships left should be handed over. They included two small Zeppelin passenger airships, LZ 120 *Bodensee* (Lake Constance), and LZ 121 *Nordstern* (North Star), which had been built for the revived DELAG airline after the Armistice. To arrive at a rigid airship type that was both relatively fast and capable of carrying a profitable payload, these new Zeppelins were much smaller than their forerunners. The hull amidships was of large diameter, but was well streamlined. In the beginning there were some problems of stability and control to overcome, but these sister airships soon established themselves as a very successful design.

The LZ 120 *Bodensee* made its maiden voyage at Friedrichshafen on 20 August 1919. It began regular operations between the two Zeppelin works at Friedrichshafen and Staaken, near Berlin, on 24 August, covering the 376 mile (605 km) journey between the Swiss border and the German capital during one day and making the return trip the next day. *Bodensee* had a seating capacity for twenty passengers and by 1 December, when operations ceased for that season due to lack of fuel, a total of 4,050 passengers and crew had been carried on 103 trips. The company had not expected to fill every seat, but the German railways were in a deplorable state and the service was poor in the aftermath from the war, so these long-distance air tickets were in great demand by European travellers on the Continent, and often one supplementary seat, or more, was provided in the form of an extra wicker chair. This was no great problem during the autumn and winter months with the greater carrying capacity possible in the cooler air, but for the following year *Bodensee* was to be lengthened with one 32·8 ft (10 m) section, and more lift was provided by the addition therein of an additional gas cell of 90,050 cu.ft (2,550 cu.m) capacity. This would bring *Bodensee* into line with its new sister airship *Nordstern* which, based upon the operational experience gained with *Bodensee*, was right from the start

built to this increased capacity. As the *Nordstern* name hints, this airship was destined for northern skies as a Swedish airline company planned to order it for service between Stockholm and Berlin. To this end *Bodensee* made a commercial demonstration round trip between the two European capitals.

These plans were upset when the Inter-Allied Control Commission reacted on the German sabotage committed at the North Sea airship bases. The official justification advanced for the demand that the two civilian airships also be turned over was that they had been built of surplus material from the war production of airships.

The remaining Zeppelin airships were distributed among the Allies as follows: France received the army airship LZ 113 (LZ 83), the passenger airship LZ 121 *Nordstern* (which it renamed *Méditerrannée*) and the naval airship L 72 (LZ 114) (see No. 55). Great Britain was allotted the naval airships L 64 (LZ 109), and L 71 (LZ 113). Italy received the passenger airship LZ 120 *Bodensee*, and the naval airship L 61 (LZ 106), which was subsequently wrecked the first time it landed during Italian service. Belgium was given the naval airship L 30 (LZ 62) (see No. 42), and the naval airship L 37 (LZ 75) was allocated to Japan, but both of these countries had their airships broken up at once.

Bodensee left Friedrichshafen destined for the Ciampino air base on 3 July 1921, and completed the 826 mile (1,329 km) trip in 12½ hours. Here the Italian Army took delivery of it and renamed it *Esperia*. It subsequently made some long air voyages; among them, one from Rome to Barcelona and return may be mentioned. This airship participated in the Italian fleet manœuvres of 1927, and thereafter there were no further records of the former *Bodensee*.

LZ 121 *Nordstern* made its maiden voyage on 8 June 1921, and was then immediately handed over to the French Navy, with which it served as a training airship.

Specification of LZ 120 'Bodensee'

Volume: 725,713 cu.ft (20,550 cu.m)
Length: 429·1 ft (130·8 m)
Diameter: 61·35 ft (18·7 m)
Engines: Four 260 h.p. Maybach Mb IVa six-cylinder
Useful load: 22,045 lb (10,000 kg)
Cruising speed: 81 m.p.h. (130 km/hr)
Operational ceiling: 6,560 ft (2,000 m)
Range: approx. 1,243 miles (2,000 km)

55 **Zeppelin LZ 114 'Dixmude'**

The naval airship L 72 (LZ 114), of the Zeppelin X-type, was a sister airship of L 70 (LZ 112) and L 71 (LZ 113). It had just been completed when the Armistice was effected in November 1918, but had not then received its military equipment. Therefore the Germans maintained that as this airship had not yet officially been turned over to the German Navy it must be considered the private property of the Zeppelin company, and not war booty to be delivered to the Allies in accordance with the Armistice terms. The Inter-Allied Control Commission decided otherwise, and handed L 72 over to France, along with the army airship LZ 113 (LZ 83), and the passenger airship LZ 121 *Nordstern*, as part of the war reparations.

Thus on 10 July 1920, L 72 left its base at Friedrichshafen at 10 p.m. and, manned with a German crew, headed for France. At 11 a.m. on 11 July the airship arrived at the Maubeuge base and was handed over

to the French military authorities. The airship was renamed *Dixmude*, and after some short trial flights left for its permanent base at Cuers-Pierrefeu, near Toulon. In the spring of 1922 the French government allocated 2 million francs for repairs to the gas cells of the airship, which became a long-drawn-out affair, so that the airship was not back in service until the summer of 1923.

Dixmude then entered upon an active career. On 2 August 1923 the airship made a cruise of 18 hours' duration, across southern France extending from the Italian to the Spanish border. On 9 August *Dixmude* covered the distance Cuers-Port Vendres-Ajaccio and return to Cuers in 24 hours. Next the airship headed out over the Mediterranean on 30 August, and flew via Algiers, Sousse, Tunis, Bizerta, Sardinia and Corsica before returning to its base on 2 September, having then covered 1,740 miles (2,800 km) in 60 hours. On 25 September it began a truly long-distance trip, as usual under the command of Lt Cdr Jean du Plessis de Grenedan. The airship first headed for the Sahara desert region and on 30 September wound up the cruise with a circuit over Bordeaux and Paris. When it landed again in Cuers the airship had stayed in the air continuously for 118 hours 41 minutes, thereby establishing a world's endurance record. *Dixmude* made another circuit over France proper, lasting 44 hours, covering the period from 17–19 October, and on this occasion also participated in some manœuvres of the French Navy off Toulon.

These various performances seemed to bring out that *Dixmude* was a 'lucky ship', as the saying goes in airship circles. This view was borne out again when *Dixmude* pulled through well on a flight lasting from 21–24 November, in spite of a raging storm encountered off Cap Ferrat on the southern coast of France. On that occasion the airship absorbed almost nine tons of rain water, but still the crew managed to return the airship to its base safe and sound.

On 22 December, however, fate finally caught up with this by now famous airship. It had left its home base on 18 December and had once more headed for the Sahara region. There was a total of 52 people on board. During the night of 21–22 December *Dixmude* was on the return leg when it ran into a bad storm out to sea over the Mediterranean. The last position reported by the airship was halfway between Sciacca, on Sicily, and the island of Pantelleria, off Tunis, at 2 a.m. on 22 December. About 20 minutes later a flash was noticed in the sky followed by an explosion. A stroke of lightning was assumed to have caused the disaster. An extensive search for possible survivors was initiated promptly, but in vain: all had perished. On 29 December some Italian fishermen picked up a body which they found floating amongst bits of wreckage. It turned out to be the remains of the youthful commander of the *Dixmude*.

No other trace of the lost airship was ever found and many conjectures were advanced about the outcome of this disaster. One, a highly unrealistic one, was that only the control gondola had dropped into the sea, while the rest of the airship with the remaining crew drifted southwards towards the wide African desert regions, where survivors might still be found.

More sober reflection led to the conclusion that after this disaster France had better abandon any further ideas of large rigid airships, and both LZ 113 (LZ 83), and *Méditerrannée* (the former LZ 121 *Nordstern*, see No. 54) were broken up.

The specification of LZ 114 *Dixmude*

is to all practical intents identical to that of LZ 112 (see No. 44).

56 **Italian Army and Navy airships of the M class**

Most of the Italian airships from the World War 1 period were built at the government arsenal for aircraft equipment in Rome: Stabilimento Construzioni Aeronautica. The airships were divided into four categories: 'Piccolo' (P), meaning small; 'Medium' (M), the intermediate size; 'Velore' (V), the fast type; and 'Grande' (G), meaning large.

The semi-rigid, M-class airships were modified extensively during the war. They were successively powered by two, three or in some instances by four engines. Separation walls divided the envelope into six gas sections, each of them having two control valves. The ballonet inside the envelope extended through the full length of the envelope. The forward end of the interior keel was joined to a reinforcement of the bow, while mounted at its rear end were the stabilising fins, with their split rudders, and the fixed tail surfaces. Attached to the aft end of the envelope were also two small horizontal fins, one each on the port and starboard side; and, somewhat further forward on top of the envelope, a larger vertical fin. A gun mounting was provided forward on top of the envelope. The gondola was short and thick. The two engines were mounted on outriggers on the sides of the gondola. The variable-pitch propellers were shaft-driven, and the blades were also reversible.

The Italian Army possessed three airships of the standard version of the M class, while the Italian Navy used an equal number of a special version for bombing purposes. The Italian Army had altogether six airships at its disposal, while the Italian Navy had twenty of these aircraft and both armed forces used them extensively and actively. These ships made a total of 650 wartime flights of 2,200 hours' duration adding up to a collective distance of 86,990 miles (140,000 km). On 258 of these cruises 440,920 lb (200,000 kg) of bombs were dropped. The main targets attacked included the Austrian–Hungarian naval base at Pola, the St Marco docks, railway junctions and other important installations behind the Austrian lines. It was imperative that the Italian airships should be able to attain high ceilings because they were subjected to very intense Austrian anti-aircraft fire, whereas in their case speed and endurance ranked as qualities of less importance, because they seldom had to cover long distances on their war trips. Yet M-2, M-3, M-4, M-8, M-13 and P-10 were all lost due to enemy air attacks, while M-5 crashed as a result of mechanical failure.

In 1918 the British Admiralty ordered an airship of the M class from Italy. It was flown to England on 28 October that year, and there designated SR-1. This airship became part of the rather costly and much criticised experimental programme conducted by the Royal Navy with small non-rigid airships, the so-called 'Blimps'.

Specification of the M class

Volume: 441,437 cu. ft (12,500 cu. m)
Length: 272·3 ft (83 m)
Diameter: 55·8 ft (17 m)
Engines: Two 250 h.p. Itala-Maybach four-cylinder
Useful load: 8,377 lb (3,800 kg)
Cruising speed: 43·5 m.p.h. (70 km/hr)
Operational ceiling: 6,560 ft (2,000 m)
Endurance: 6 hours with a bomb load of 2,205 lb. (1,000 kg); 12 hours for scouting at sea

57 **The U.S. Navy airship ZR-1 'Shenandoah' ('Daughter of the Stars')**

The design of the first rigid airship of the U.S. Navy dates from 1916. The framework was to be of wooden construction while the choice of incombustible helium as lifting gas, instead of hydrogen, was more far-sighted. However, these plans were dropped in favour of a more conventional design to be patterned on the German Zeppelin airship L 49 (LZ 96), which had been forced down in France in October 1917, and had been captured almost undamaged. Thus aluminium was selected as the final building material for the framework, and hydrogen as the gas to be used for filling the airship, since helium at that time was still only available in the United States in very limited quantities.

The drawings for ZR-1, later to be named *Shenandoah*, were produced by the U.S. Navy's Bureau of Aeronautics. Construction of the components took place at the Naval Aircraft Factory in Philadelphia, and these were then transported to the Naval Air Station at Lakehurst, New Jersey, for assembly, since this was the only place where a shed of the required size was available. ZR-1 made its maiden voyage on 4 September 1923, but proved heavier than estimated because the airship on this occasion was filled with helium, which does not have so high a lifting capacity as hydrogen. The performance figures therefore did not come up to specification. So with an eye to the use of helium for filling the airship at a future date, the decision was made to lengthen the hull of ZR-1 by 33 ft (10 m). A novel feature of the airship was its reinforced bow enabling it to be left out in the open moored to a mast.

On later occasions ZR-1 was moored experimentally to the Navy depot vessel *Patoka*, which had been specially fitted with a mooring mast for this purpose. (It is surprising indeed that in spite of all the enterprise displayed by Germany in the airship field, mooring masts had never been tried out in that country.)

During its two years of service *Shenandoah* made a total of 37 flights including a transcontinental crossing in both directions. Most of these air voyages were accomplished with minor mishaps only, though on some perilous occasions the airship ran into thunderstorms and other very rough weather, ranging from heavy snowfalls to, in hot climates, wind-raised sandstorms. On 16 January 1924 the airship tore away from its mooring mast at Lakehurst when a storm came up suddenly. Some of the gas cells were also damaged and leaked. Only a proportion of the crew was on board the airship at the time. By and by the engines were started, yet it was almost impossible to keep the airship under control. At one time during the night *Shenandoah* passed over New York City, where the red and green warning lights of the airship could now and then be seen through the clouds by onlookers on the ground. Gradually the storm abated and the officer of the watch on board, Commander M. R. Pierce, who by now had charge of the airship, was able to radio the report that all danger was over.

But a less happy incident was to follow. On the night of 3 September 1925, ZR-1 was flying from Lakehurst to Scott Field in Illinois when, above Byesville in Ohio, it passed through a violent storm. The updraught of a squall lifted the airship beyond the safe pressure altitude, resulting in some of the 19 gas cells bursting as their safety valves had been deliberately closed in an endeavour to avoid any waste of the costly helium with which *Shenandoah* was filled at the time. *Shenandoah* alternated with the other rigid airship of the

U.S. Navy, ZR-3 *Los Angeles* (see No. 58) in using the available supply of this safe gas. The captain of *Shenandoah*, Commander Zachary Lansdowne, and his navigating officer, Commander Charles E. Rosendahl, made every effort to save their airship, but did not succeed. With a great struggle *Shenandoah* had been lowered to an altitude of less than 6,000 ft (1,830 m) when it began to roll and pitch, soon to break into three parts. The navigating officer was in the bow of the airship along with six other members of the crew and decided to handle this part as a free balloon. An hour later they succeeded in making a safe landing. The rear part of the airship, with 22 crew members, likewise made a safe descent, even though it was a rough landing. The rest of the crew, numbering 14 men including the captain of the airship, did not stand a chance. Their stations were either in the control gondola or in the engine gondolas, all of which tore from the centre section and plunged to the ground. When the new day dawned the inviting, but hilly, Ohio landscape lay strewn with broken parts of the 'Daughter of the Stars', the proud Indian name that the airship had borne.

Specification of ZR-1 'Shenandoah'

Volume: 2,115,000 cu.ft (59,890 cu.m)
Original length: 680 ft (207·3 m)
Diameter: 79 ft (24·1 m)
Height: 93·5 ft (28·5 m)
Engines: Six 300 h.p. Packard
Maximum speed: 60 m.p.h. (96·6 km/hr)

The cause of this disaster has already been touched upon briefly. Ten of the 18 automatic safety valves regulating the pressure in the gas cells, and seven of the 15 manœuvring valves, had been removed prior to the flight. The remaining valves, altered to manual manipulation, were unable to release sufficient gas fast enough. The airship had been deprived of unimpeded 'free breathing', so to speak.

58 The U.S. Navy airship ZR-3 'Los Angeles'

The United States of America was the only one of the great Allied Powers not to receive anything in the way of booty when the German airships were distributed after World War 1 ended, although original plans had included the allocation of two wartime Zeppelins to the U.S. Navy. The U.S.A. was, however, to be compensated in a different way, although it did finally receive an airship. After protracted negotiations and deliberations among the Allies, it was finally decided to have the Zeppelin works in Friedrichshafen design and build an airship of a size corresponding to LZ 70 (L 70) of the X-type (see No. 44) for the American government. This solution also meant the survival of the Luftschiffbau Zeppelin, as this activity enabled the airship works to keep together, and have work for, an experienced staff in spite of the severe financial strains following the war. In 1923 it further led to a partnership with the Goodyear Tire & Rubber Co. in America, as the two concerns formed the joint Goodyear–Zeppelin venture. The Germans were more or less obliged to accept this arrangement because of the aircraft building restrictions imposed upon Germany by the Versailles treaty. Besides the transfer of the patent rights, the chief engineer of the Zeppelin Works, Dr Karl Arnstein, and twelve other technical experts were employed by the American airship company.

It is to the credit of the German Zeppelin company that in LZ 126 they painstakingly built the best airship of which they were capable. Incidentally, there was a clause restricting it to civilian use exclusively, even though the U.S. Navy had placed the order.

LZ 126 made its maiden voyage at Friedrichshafen on 27 August 1924, and three more trial flights were undertaken on 11 and 24–25 September respectively. Then the 4,660 mile (7,500 km) long delivery flight, from Friedrichshafen to Lakehurst, New Jersey, U.S.A., was accomplished during the period from 12–15 October, and on this occasion the airship was commanded by Dr Hugo Eckener who was also by this time chairman of the board of Luftschiffbau Zeppelin. This was only the second west-bound air crossing of the Atlantic, and the airship carried a total of 32 persons. The flight lasted 81 hours 17 minutes. Shortly after the airship had been housed in the shed there it was transferred to U.S. government ownership, and about the first action the new American crew undertook was to drain the gas cells of their hydrogen, and await the arrival of ZR-1 *Shenandoah* at Lakehurst, as this airship contained practically the total supply of helium available at that time. The precious gas was then transferred to the fourteen gas cells in LZ 126. As a result, ZR-1 remained earthbound for the next eight months while ZR-3 *Los Angeles*, as LZ 126 had now been named, made a number of flights, two of them as far as Bermuda.

The loss of the *Shenandoah* (and the only supply of helium) in early September 1925 (see No. 57), was a great blow to the American public, yet most circles generally remained in favour of further support for airships. At an extremely high cost a new supply of helium was produced for *Los Angeles*, which soon flew again under the command of the hero from the *Shenandoah* disaster, Captain Charles E. Rosendahl. During the next three years Rosendahl restored confidence in airships based upon the strength and reliability and the fine performance of ZR-3.

This airship demonstrated in 1926 that it could be moored to the mothership *Patoka*, which had been fitted with a special mooring mast. A further step was taken in 1928 when *Los Angeles* settled at ease on the flight deck of the aircraft carrier *Saratoga*. On 3 July 1929, the *Los Angeles* in turn became an aircraft carrier of a different kind. While the airship cruised in the air at a speed of about 78 m.p.h. (125 km/hr), a naval Vought UO-1 scout biplane, piloted by Lt A. W. 'Jake' Gordon, cautiously approached the underside of the hull and engaged a hook to a trapeze fixed to the airship hull. The first of a long line of so-called 'trapeze artists' had thus passed 'the test' with flying colours. The U.S. Navy's interest in joint air manœuvres of aeroplanes and airships dated back to the end of World War 1. It was not a novel concept, as the idea had been tested previously, in Germany and Great Britain, and the U.S. Army had also conducted some successful experiments along these lines in 1924, when an aeroplane hooked itself on to a 'Blimp'.

Los Angeles was later commanded by Captain Herbert V. Wiley, who in 1930 was succeeded by Captain Alger H. Dresel, and the experiments with hooking aeroplanes on to the airship and then releasing them again continued throughout 1932, with different 'artists' and types of aeroplanes, such as the Consolidated N2Y-1 and the Curtiss XF9C-1. The military value of these experiments had been established by now and this display always made a hit at the various air meetings held around the country. *Los Angeles* and its attendant small aeroplanes must have reminded the spectators of a huge sow with her thirsty sucklings.

In the summer of 1926 *Los Angeles* added another 'first' to its credit, but this sensational novelty only became generally known at a later date. It became the one and only airship ever to stand on its nose on top of the mooring mast. A gentle breeze suddenly gained force and then blew directly from the opposite way. *Los Angeles* had been swinging leisurely at the mooring mast and now tried to follow the wind like a weather-cock, but instead of swinging sideways the airship chose to make the change upward instead. The crew on watch was caught napping and after a long slide soon found themselves in the nose of the airship along with all kinds of unfastened gear. The perplexed and astonished personnel on the ground watched helplessly what was going on. After standing on its nose for a brief instant the 658 ft (200·6 m) long hull turned gracefully around its axis and then gradually settled in its former position on the leeward side of the mast. Aside from a few tears in the fabric of the hull, neither the airship nor the crew on board had suffered any damage or injuries.

In spite of this incident and other minor adventures the *Los Angeles* enjoyed a long and distinguished service. For many years this airship flew a great number of outstanding people to important events in many of the states, while numerous new crews simultaneously received their training in the handling of airships. Only once did ZR-3 play the part of a military aircraft, the former Allies granting their special permission on this occasion. This was during the American naval manœuvres in 1931. The airship operated from the mother-ship *Patoka* off the west coast of Panama, serving as a scouting aircraft of the fleet force defending the Panama Canal.

Other extensive flights besides those already mentioned included one from Lakehurst to Panama, of 39 hours 45 minutes duration, on 26 February 1928 Two days later the airship continued from Panama to Cuba where it was moored to *Patoka* before returning to Lakehurst.

On 30 June 1932, *Los Angeles* fell victim to the depression which hit the United States economy in a serious way. Laying-up of the vessel was considered only a temporary expedient, but the proud airship was never to take to its true element again. On its 331 flights, *Los Angeles* had spent a total of 4,398 hours in the air, to which must be added another 2,000 hours moored to its mast out in the open. The final breaking-up of this airship did not occur until early 1940.

Specification of ZR-3 'Los Angeles'

Volume: 2,472,000 cu.ft (70,000 cu.m)
Length: 658 ft (200·6 m)
Diameter: 90·5 ft (27·6 m)
Engines: Five 400 h.p. Maybach VL I twelve-cylinder water-cooled
Useful load: 101,415 lb (46,000 kg)
Maximum speed: 76 m.p.h. (122 km/hr)
Cruising speed: 70 m.p.h. (113 km/hr)
Range: 7,770 miles (12,500 km)

59 **With Roald Amundsen across the North Pole in N 1 'Norge'**

The two Zeppelins allotted to Italy as part of the World War 1 reparations had no glorious careers in that country. L 61 (LZ 106) was soon wrecked while landing at the Ciampino air base near Rome, and the experiences gained with *Esperia*, the former LZ 120 *Bodensee* (see No. 54), were conducive to Italian concentration on airships of the non-rigid type. This led to the interesting cross-breed, the so-called semi-rigid

type, which consisted of a hydrogen-filled envelope with a full-length, flexible keel built in several sections. Due to this flexibility the gas pressure in the envelope could maintain the required shape and yet the spine-like keel was rigid enough for the mounting of a combined control gondola and a passenger compartment.

In 1923 a semi-rigid airship of this type was built at the airship works of the Italian government near Rome, under the direction of Colonel Umberto Nobile. The first trial flights were made in March 1924, and proved so successful that they called for no changes in the design. In 1926 this airship, N 1, was chartered to the famous Norwegian Arctic explorer Roald Amundsen and his partner and financial backer, the American Lincoln Ellsworth. The terms of the Italian transaction were a reasonably low sale price, with an offer to buy back the airship after the expedition provided that it was still in a reasonably good state. The deal was also conditional upon five of the Italian members being signed on for the Polar flight. Amundsen, who was then 53 years old, had been in 1911 the first man to reach the South Pole. In 1925 he had tried to get to the North Pole by aeroplane, but had to abandon the attempt. Now he felt that he stood a better chance of succeeding with his recently-acquired airship which he named *Norge* (Norway). The reason why this Italian airship was placed at Amundsen's disposal on easy terms may well be that Italy's 'strong man' of that period, the Fascist leader Benito Mussolini, saw a chance to gain glory for his country, although he had to drop his demand that the airship fly the Italian colours on this polar trip. Amundsen was on this occasion accompanied by several countrymen of his, one of them being Lt Hjalmar Riiser-Larsen, who was the only Norwegian on board with any actual airship experience, and was appointed the navigational officer. Of the 16-man crew, six (including Nobile) were Italians; Nobile, although nominally captain of the vessel, felt and objected to the fact that he too was considered a 'hired hand'. This caused friction between Amundsen and Nobile, and their controversies during and after their joint air voyage looked as if they would carry beyond into future years until later on with the death of one of them, all antagonism dramatically departed.

Norge was ferried from Rome to King's Bay, Spitsbergen, via Pulham in England, Oslo and Leningrad. The airship arrived at its starting point for the Polar trip on 7 May 1928, just in time to see the American naval pilot, Commander Richard E. Byrd, return from his flight to the North Pole by aeroplane, a tri-motored Fokker monoplane named *Josephine Ford*, having taken off from the Norwegian island two days before. This undoubtedly was a disappointment to Amundsen, who nevertheless showed good sportsmanship, and the members of the two expeditions jointly celebrated the American success. Amundsen may also have reflected and consoled himself that his coming venture was more ambitious, as he not only planned to cross the North Pole in his airship, but then also continue to Nome in Alaska.

Norge ascended from its snow-covered base at 8.55 a.m. local time on 11 May. The silvery airship circled its starting point once, then headed north across the wide frozen expanses. At 2 a.m. the following day the airship had arrived over the North Pole, where the Norwegian, Italian and American flags were dropped. Then the course was set for Point Barrow in Alaska, and this turned out to be by far the most difficult stage. The airship encountered a dense Arctic fog during the day and the first

ice formations on the gondolas and wires made themselves felt by the weight increase. The two magnetic compasses on board also began to behave erratically, flickering without purpose, and it was a credit to the navigational skill of Riiser-Larsen that the course was maintained through the next night. The morning of 14 May gave landfall not far from Point Barrow, from where the coast was hugged southward while a brewing storm gained in force. In the neighbourhood of the Eskimo village of Teller, not far from the destination city of Nome, the airship was no longer equal to battling the storm, making no headway although all three engines were operating at full r.p.m. Amundsen then ordered a landing, which was accomplished successfully and the airship crew managed to convey to the excited Eskimos why the landing ropes were lowered and how they should go about handling them. As the main gondola touched the ground the ripping panels of the envelope were pulled. Shortly afterwards *Norge* rested, empty of gas, across the keel and gondolas, flapping in the strong wind. A distance in the air of 3,417 miles (5,500 km) had been covered and the *Norge* airship and its crew had accomplished exactly what they had set out to perform.

This achievement was acclaimed by the whole world, but the ensuing bickering and renewed dispute of competence between Amundsen and Nobile was very trying and most unbecoming to either of them. Both antagonists were outstanding characters and aired their differences in a series of articles in newspapers and magazines which bewildered the general public. Amundsen accused Nobile of nothing less than incompetence. It was Amundsen who had originated and planned this Arctic expedition, but Nobile countered that only his clever airship had made it possible to see it through, and maintained in turn that Amundsen had only played an inactive part in the expedition by occupying a chair in the airship. It may be difficult to say that either of them was entirely right, but it is certain that here the seed was planted which was shortly to shape the destiny of both men, dramatically and fatefully.

Specification of N 1 'Norge'
Volume: 670,980 cu.ft (19,000 cu.m)
Length: 347·8 ft (106·0 m)
Diameter: 64 ft (19·5 m)
Engines: Three 245 h.p. Maybach Mb IVa six-cylinder
Useful load: 18,243 lb (8,275 kg)
Maximum speed: 70 m.p.h. (113 km/hr)

60 **The airship N 4 'Italia' and the disaster in the Arctic Ocean**

As a result of his quarrels with Amundsen following the crossing of the North Pole in the *Norge* airship (see No. 59), Nobile decided after his return to Italy to repeat the expedition which, this time, was to be an entirely Italian venture, with regard to planning, equipment and manning. Nobile meanwhile had been promoted to General, and Mussolini hesitatingly endorsed the Arctic project when the Royal Geographical Society of Italy vouched for the scheme. The financial end was handled by the city of Milan, which became sponsor to the amount of 3½ million lire, while the airship was the contribution of the Italian Air Ministry. The scientific aims of the expedition were: to explore the coast of Siberia, and in particular Tsar Nicholas II Land; to penetrate to the North Pole and to land there; and to explore and map the coasts of Greenland and Canada.

Nobile now proceeded to adapt his newest airship to, and to fit it for, this challenging expedition. The design and performance of this airship, N 4 *Italia*, were comparable to those of the N 1 *Norge*, except that the overall length was slightly reduced to 341·2 ft (104 m), and the useful load was increased by about 2,865 lb (1,300 kg). Maximum speed was about 62 m.p.h. (100 km/hr).

After the completion of the extensive preparations for this expedition, *Italia* flew from Rome to Milan on 19 March 1928 and at the same time the two auxiliary vessels *Citta di Milano* and *Hobby* left La Spezia to proceed to King's Bay on Spitsbergen. On the night of 14–15 April, *Italia* left for the same destination and arrived there on 6 May. Intermediate landings had been made at Stolp in Germany, and at Vadsö in the north of Norway, on this first stage of the expedition. Upon its arrival in King's Bay the airship was housed in the shed there which meanwhile had been repaired.

The planned flights to Franz Josef's Land, Tsar Nicholas II Land and to Novaya Zemlya were made on 11, 14 and 15 May respectively. Particularly, the second air voyage was successful and profitable with respect to scientific results.

At 4 a.m. on 4 May, the airship began its journey to the North Pole and carried a crew of 16 men, plus Nobile's fox terrier Titina. All of the former crew of *Norge* were included in the present crew, and in addition Nobile had invited three scientists to participate in the expedition. They were two physicists, Dr Aldo Pontremoli from Italy and Dr Frantisek Behounek from Czechoslovakia, and the Swedish meteorologist Dr Finn Malmgren. The last-named had also been a member of the *Norge* expedition. On board also was an Italian reporter, Ugo Lago, representing the press. Aided by a strong following wind the *Italia* airship arrived at the North Pole at 20 minutes past midnight on 24 May, having covered the 885 miles (1,425 km) from the base at King's Bay in 18 hours 19 minutes. The planned landing 'on top of the world' had to be abandoned, but the successful completion of the first stage of this trip was marked by the dropping of the following objects: a large cross donated by Pope Pius XI, the Italian tricolour, the city arms of Milan, and a small locket with a portrait representing the 'Madonna of the Fire'. This was to be the end of the flights of *Italia* and its crew who up till then had seemed under a lucky star; from then on everything went wrong. Dr Malmgren, who also acted as the navigator, had Nobile head the airship straight back for King's Bay where more scientific work awaited the aircraft. This was a decision which the commander of the airship was to live to regret bitterly for, after despatching a radio report to *Citta di Milano*, *Italia* began to battle against a storm which increased in force, its headwinds retarding the airship's speed where previously it had acted as a tailwind to accelerate the vessel. The airship also begun to accumulate an ever-thickening coat of snow and ice. At one time the elevator was broken and only makeshift repairs to it could be effected. At 10.30 a.m. on 25 May Nobile received the report: 'the airship is heavy'. This resulted from the sudden loss of an amount of gas from some unestablished cause, and a moment later *Italia* hit the ice with great force. The control gondola was torn off and partly smashed. The envelope with the engine gondolas and the four crew members in them, and Dr Pontremoli and Ugo Lago as well, ascended again and their fates remain unknown to this

day. In the wreck of the control gondola were ten people, all of whom were injured more or less severely. Nobile had broken his right arm and leg. They were in desperate straits, even though it turned out later that this hard-hit little crowd were only about 218 miles (350 km) away from the base at King's Bay. They had managed to salvage some of their equipment, however, including a tent and, most important, an emergency radio transmitter. The escaping airship had also scattered some small tanks containing red aniline dye. They used this to paint the tent and make it conspicuous from the air, when aircraft could be expected to search for them. 'The Red Tent' was indeed to become the focal point in some of the most extensive air rescue activities ever undertaken on an international scale, and followed with intense world-wide anxiety, day by day. However, it was only on 3 June that the outside world received intelligence that there were survivors from the *Italia*, for on board the *Citta di Milano* mother-vessel itself they were not concerned with listening for the S-O-S signals regularly transmitted through the operator from 'The Red Tent'. Rather unwisely, the radio station on the Italian ship did not listen for these vital signs of life from the *Italia* crew, being already overloaded by the despatch of a never-ending flow of reports to Rome. An alert Russian amateur radio fan in Archangelsk, Nikola Schmidt, first picked up the distress call from the men on the floating pack-ice, their number meanwhile having been reduced from ten to six. The mechanic Vincenzo Pomella had been killed by the impact of the engine gondola on the ice. Two of the navigators, Adalberto Mariano (who had been second-in-command of the *Italia*) and Felippo Zappi, had, against the protests of Nobile, left the tent camp on 30 May, in their endeavour to reach the mainland at the North Cape. They were accompanied by Dr Malmgren who was injured and sick.

The relief now being organised comprised four Norwegian aircraft, one of which was piloted by Lt Riiser-Larsen, seven from Sweden, one each from Finland and France, eight from Italy and two from the Soviet Union, which also had the icebreakers *Krassin* and *Malygin* in action. There was poor co-ordination, or none, among the various expeditions of these countries; for it had more the appearance of keen rivalry between them. Thus 'The Red Tent' was not located until 17 June, by one of the Italian flying-boats. On 23 June the Swedish pilot Lt Einar Lundborg, with Lt Birger Schyberg as his observer, landed their Fokker C.V biplane, its undercarriage fitted with skis, on the ice floe close by the tent. Lundborg advised that he could carry only one additional passenger, and had orders to return with Nobile to the Swedish base, where they felt that the latter was indispensable for the guidance of further rescue work. Nobile protested that as the leader of the Italian expedition he should be the last man to leave the camp on the floe, but finally complied with Lundborg's demand. When Lundborg returned and attempted his second landing there, his aircraft overturned and his ski landing gear was damaged. Now Lundborg himself was detained at 'The Red Tent' for the time being, although he was eventually picked up by Schyberg on 6 July.

Unfavourable weather conditions then prevented further flying and finally it was the *Krassin* that cut through the heavy ice and reached the Red Tent camp, to liberate the five men remaining there. They had borne up patiently under miserable conditions and at long last were relieved. To top the rescue by ship of the victims of the airship disaster

the icebreaker had, on 12 July, by strange good luck managed to snatch Mariano and Zappi from otherwise certain death, when the aeroplane carried on board was launched to scout for them and observed the two wandering on the ice. They had, unfortunately, had to leave the dying Dr Malmgren behind them, and his body was never found.

The ill-fated *Italia* Arctic airship expedition was yet to cost additional lives. A French Latécoère flying-boat had flown to Norway to join the search for its members. When it left from there, northward bound on its grim task, there were also on board, besides its crew of three, Roald Amundsen and the Norwegian Flt Lt Leif Dietrichsen. When Amundsen learned that 'brothers-in-arms' needed help in the Arctic, his past quarrels were immediately forgotten, and he was determined to come to the succour of Nobile and his men. But nothing was ever heard again from 02 No. 47 *Latham* after this flying-boat took off on its mission of mercy. The Russian pilot Babushkin and his Junkers J 13 aircraft, from the icebreaker *Malygin*, were forced down and spent several days on the ice during their search for the *Italia* party.

There remains only to report that, after being rescued, Nobile was discredited and accused of shirking his duty and failing his men. Upon his return to Rome, Nobile was court-martialled and convicted of dishonouring his country. Embittered and broken in spirit, Nobile went abroad and worked first in the Soviet Union and then in the United States as a consultant on, and designer of, airships. In 1943 Nobile returned to Italy where he now lives in seclusion. The former unjustifiable accusations have been redressed and he has been granted full satisfaction.

61 Zeppelin LZ 127 'Graf Zeppelin'

After the transfer of the LZ 126, and also of the patent rights, from the Luftschiffbau Zeppelin to America (see No. 58), the future prospects of building additional airships in Germany looked anything but bright. To be sure, the Zeppelin works still existed, but Dr Eckener had only the barest number of staff members left upon his return from the United States. However, when the Locarno treaty was concluded between Belgium, France and Germany in 1921 these countries mutually agreed to honour their several frontiers, and, what is more, the restrictions on airship building activities in Germany were also repealed. As head of the Zeppelin works Dr Eckener lost no time in inaugurating a new airship to prove to the world at large the feasibility of this form of passenger service. The first problem confronting him was of an economic nature. The government could not guarantee any financial support as the Weimar Republic faced difficulties of its own. So Dr Eckener and his associates launched upon an extensive circuit of lectures and once more managed to solicit contributions from the rank and file of Germany during 1925 and 1926. Even the smallest amount was welcomed—often the contributions dropped in the collection boxes were literally in pennies – yet at the final count the starting capital amounted to 2½ million marks. When the government finally contributed another 1½ million marks, the building of the new airship was guaranteed.

The hull of the LZ 127 had slender curves, but its outlines were not the optimum efficiency attainable, as they had been dictated by and restricted to the size of the shed available for the construction of the airship at Friedrichshafen. Yet it did not fare too badly by comparison with the most advanced, present-day streamlined designs. Be-

cause the framework was built of duralumin the bare weight of the hull was only 127,868 lb (58,000 kg), and the airship was capable of flying 6,214 miles (10,000 km) with a payload of 33,069 lb (15,000 kg) at a speed of 68 m.p.h. (110 km/hr). The control gondola and the passenger section were joined and streamlined. The bridge was divided into a pilot house, a navigation room and a radio compartment. Next followed an electric galley from which one entered a spacious drawing-room having four large windows and equipped with comfortable furniture, with red curtains and carpets. The passenger accommodation was aft of this, in the form of two rows of five adjoining cabins with twin berths, divided by a corridor. Toilet and washroom facilities were also provided. There was a crew of forty men to handle the airship and in attendance on the normal number of twenty passengers. The crew kept watches in three shifts.

The sizeable quantity of hydrogen in the LZ 127 was divided off into seventeen separate gas containers. Inside the fabric covering seventeen fuel tanks were mounted at the bottom of the framework and, contrary to usual practice, did not contain petrol, but were filled with a new fuel, the so-called 'blue gas'. The five engine gondolas were mounted in such fashion that the traction on the hull was evenly distributed and also kept the rear propellers out of line of the slipstream from the forward ones.

The 8th of July 1928 was the 90th anniversary of the birth of Count Zeppelin, and on this date the silvery giant was named 'Graf Zeppelin' after him. The christening ceremony was performed by the daughter of the old airship pioneer, Countess von Brandenstein-Zeppelin. The airship made its maiden voyage on 18 September, and three more short flights later that same month. Then, on 2 October, *Graf Zeppelin* left on a circuit of Germany of 35 hours' duration, to afford as many of the contributors as possible a glimpse in the air of the outcome of their self-sacrifice. For nine long years this airship was to rule its element as a true 'queen of the skies' and a report of all the flights of the *Graf Zeppelin* would alone fill a whole book. In 1928 and 1929 alone, a total of fifty long-distance flights was accomplished by this airship. However, the highlights in the outstanding career of the *Graf Zeppelin* merit a recording here.

The crossing of the Atlantic, to the Lakehurst air base outside New York, was the first long air voyage of *Graf Zeppelin* in 1929. It lasted from 12 to 16 October and a distance of 6,167 miles (9,926 km) was covered in 111 hours 44 minutes. Out at sea the airship ran into a violent storm, and most of the covering on the port side of the fixed tail surface was torn to pieces. Skilled members of the crew, one of them being Knut Eckener, son of Dr Eckener, made makeshift repairs in the air from their precarious holding positions out in the open. The airship carried twenty passengers and a load of 62,000 letters on this occasion, and with its crew was received and feted in grand style in New York during its stay there, which lasted until 29 October. On the return air voyage to Friedrichshafen another storm was encountered, which *Graf Zeppelin* once more weathered well, and the airship landed safely at its home base after spending 71 hours 51 minutes in the air on this occasion.

During the following months *Graf Zeppelin* made nine flights over home territory. Then on 21 March 1929 it set out on its first Mediterranean cruise, with twenty-nine passengers, among them the German Minister of Traffic, the president of the German parliament and the president of Württemberg. A distance of 4,971 miles (8,000 km) was covered in 81 hours 25 minutes, without any intermediate landings, and the flight extented via Italy to Palestine and back. Next followed a similar flight to Spain. Then, on 16 May, the airship headed for South America, but had to cut the trip short due to the failure of four of its five engine units. The cause was traced to some newly-installed clutches, which caused severe vibrations with ensuing fatigue of the steel which resulted in shaft breakages. To play safe, the airship was landed at the French airship base of Cuers-Pierrefeu at Toulon, and after repairs there *Graf Zeppelin* returned to Friedrichshafen.

Thereafter the airship celebrated triumphs galore. In 1 August 1929 *Graf Zeppelin* commenced its renowned circumnavigational air trip. On the first stage the airship headed for Lakehurst to pick up the passengers of the American newspaper magnate William Randolph Hearst who, jointly with some German newspapers, defrayed half the costs of this global air venture, in return for the exclusive rights on board to report its progress. The remaining amount derived from the sale of passenger tickets and from payments from stamp collectors in many countries for the privilege of having their covers (postcards and envelopes franked with commemorative stamps and/or struck with special cachets) carried by *Graf Zeppelin* on the various stages of this flight. The airship carried sixty-three passengers on this occasion and those joining at Lakehurst included Lady Drummond-Hay, as the representative of the Hearst press, the famous polar explorer Sir Hubert Wilkins, the American airship pilot Captain Charles E. Rosendahl, and the millionaire Leeds, husband of the Grand Duchess Xenia of Russia. Friedrichshafen was considered the true starting point of this 21,250-mile (34,200 km) flight, as the airship had returned there from the United States, and on 15 August *Graf Zeppelin* set out on its world-wide adventure. The first stop was made at Tokyo, to which Dr Eckener plotted a course across Berlin, East Prussia, the Baltic States and Tobolsk and Yakutsk in Siberia. The airship landed in Tokyo on 19 August, and the next stage, to Los Angeles, was covered between 23 and 26 August. A few days later *Graf Zeppelin* continued to Lakehurst, and thus circled the northern hemisphere in 21 days 5 hours 31 minutes. Both in Los Angeles and New York the airship, as well as its crew, were showered with demonstrations of honour, while the crew were feted at a never-ending array of celebration luncheons. On 4 September the *Graf Zeppelin* once more landed safely in Friedrichshafen, but without Dr Eckener, who stayed behind in the United States to negotiate a joint German–American airship navigation concern which later led to the formation of the American Zeppelin Transport Corporation. On the last stage of the global trip the master of *Graf Zeppelin* was Captain Ernst A. Lehmann, who was second in command of the airship, and this leg of the journey was completed in 67 hours 20 minutes.

More successful flights followed. From 18 May to 6 June 1930, the airship made a trial run from Seville in Spain to Rio de Janeiro in Brazil, as forerunner of a regular airline service across the South Atlantic. In July of the same year followed a seasonal cruise with tourists to Spitsbergen, and in April 1931 another Mediterranean trip.

There had been no plans for exploring the Arctic regions with the *Graf Zeppelin* while this airship was being built. Dr Eckener had certain reservations about the use of airships in the

polar field – no doubt *Italia* was on his mind – yet on 24 July, in Friedrichshafen, he ordered 'Let go of the holding lines of *Graf Zeppelin*' and headed the airship for Franz Josef's Land to rendezvous with the Soviet icebreaker *Malygin*. This time there were forty-six people on board the airship, including a party of German and Russian scientists. The icebreaker was met on 27 July, and among those present on the Soviet vessel were the American polar explorer Lincoln Ellsworth and the Italian airship designer Umberto Nobile. *Graf Zeppelin* rested on the water for an hour while greetings and mail were exchanged, then the airship ascended again, and via Tsar Nicholas II Land, the Taimir peninsula and Leningrad, returned to Berlin.

This airship accomplished many more air voyages in the succeeding years. There were flights to Great Britain and the Soviet Union, and many short tourist excursions. They all contributed to a rising 'Zeppelin fever'. 'The Graf' was an impressive sight as the airship soared majestically along, borne on the waves of the air ocean and looking for all the world like a huge silver fish. The onlookers stood spellbound on terra firma and envied the few lucky selected individuals roaming the skies aloft.

In September 1933 *Graf Zeppelin* began to operate a more or less regular mail and passenger service between Rio de Janeiro and either Friedrichshafen or Frankfurt-on-Main. In 1933, eighteen such round trips were completed; in 1935, sixteen; and in 1936, twelve. One of the two captains, Ernst Lehmann or Max Pruss, commanded the airship on most of these trips. Success followed success.

But on 6 May 1937, the successor airship to *Graf Zeppelin*, the LZ 129 *Hindenburg*, exploded at Lakehurst (see No. 71), which curtailed the activities of the veteran airship. The *Graf Zeppelin* landed at Friedrichshafen for the last time on 8 May. Airships inflated with hydrogen were now considered 'dangerous' and the United States had a monopoly on the safe (and strategically important) helium. For some years *Graf Zeppelin* was laid up in its shed at the Rhein–Main air base outside Frankfurt-on-Main, its gas cells deflated, and served as a museum piece which was viewed by many visitors. The veteran airship could look back on a long career spanning five hundred and ninety flights. It had spent a total of 17,178 hours in the air and covered a distance of 1,053,389 miles (1,695,272 km) while carrying about 16,000 paying and satisfied passengers in all. The *Graf Zeppelin* was finally broken up in May 1940, when the same fate also befell the brand new LZ 130 *Graf Zeppelin II*, even though the latter had only flown on very few occasions.

Specification of LZ 127 'Graf Zeppelin'

Volume: 3,708,040 cu.ft (105,000 cu.m)
Length: 776·25 ft (236·6 m)
Diameter: 100·1 ft (30·5 m)
Engines: Five 580 h.p. Maybach VL 2 twelve-cylinder
Useful load: 160,937 lb (73,000 kg) including a payload of 33,069 lb (15,000 kg)
Maximum speed: 79·5 m.p.h. (128 km/hr)
Cruising speed: 68 m.p.h. (110 km/hr)
Maximum range (with only four engines running all the time): 7,456 miles (12,000 km)

62–63 **The British passenger airships R 100 and R 101**

After the R 38 disaster in August 1921 (see No. 52), it was decided to disband the British military airship section of the Royal Air Force, and to suspend all further airship development work. The British government, however, did not wish to see all airship activities left to other nations, and was therefore open to entertain propositions for commercial exploitation of this type of aircraft. In 1922 Commander Dennis Burney, later Sir Dennistoun Burney, advanced a promising scheme of airship services linking the various parts of the British empire. The plans called for substantial subsidies and were criticised severely by the Labour government. After an extensive political tug-of-war and based upon a wide-ranging experimental programme with tests conducted by the Air Ministry on R 33, among other aircraft (see No. 51), the decision was made to build two large airships. One of them, the R 100, was to be built as a private enterprise by Sir Dennistoun Burney's own concern, the Airship Guarantee Co. at Howden (in which firm Vickers held a financial interest); the other airship, R 101, was to be built at the government airship works at Cardington. This explains why they were promptly nicknamed respectively the 'Capitalist Airship' and the 'The Socialist Airship'.

While these airships were in the planning stage the Air Ministry was charged with the organisation of an airship route from London to India with all necessary sheds, mooring masts, weather stations and so on.

It was estimated that the two airships would be completed in five years, but the designers of R 101 soon ran into endless snags from bureaucratic officialdom and uncalled-for interference from officials at all levels. At the same time the engineers at Cardington were on their guard against the profusion of instructions to incorporate all kinds of new (and in most cases superfluous) gadgets. The specifications for R 100 and R 101 were identical, yet the outcome was bound to differ as their two designers, B. N. Wallis and Lt Col V. C. Richmond respectively, worked with varying organisations. The R 100 had the best air performance and was of simplified construction, its design being conventional; the R 101, on the other hand, was the more interesting in its layout, and was of superior workmanship. A common feature of both airships was their simplified and stronger framework by comparison with the German Zeppelins; also, their passenger sections were incorporated inside their hulls. But any similarity between them also ended there, for right from the start the R 101 turned out to be a complete failure. Its maiden voyage on 14 October 1929 clearly revealed that the airship was dangerously overweight and underpowered. After the airship had made ten flights it was decided to lengthen it by 46 ft (14·02 m) and to rebuild (though not to lighten) the engines. The rebuilding was completed by 25 September, by which time the R 101 had cost the British taxpayer more than £1,000,000, and still the end was not in sight.

The alterations were a qualified success, but soon new problems emerged. The covering had a tendency to tear – the same thing was to happen later with the R 100 – and the elevators occasionally caused some unexplained and dangerous control complications.

Meanwhile the privately-built R 100 had demonstrated its good airship qualities. On 16 December 1929 it was cautiously taken outside its shed by four hundred soldiers, and made its maiden voyage for which it had already been trimmed beforehand. It proved very light and everything went well. The airship completed its trial runs and there was little that needed to be changed. Then, on 29 July 1930, the

R 100 left its mooring mast at Cardington and, with a crew of 42 men and with 13 passengers on board, set course for Montreal under the command of Sqn Ldr R. S. Booth. The airship reached Montreal on 1 August and the only moment of peril occurred while the R 100 was passing along the St Lawrence river and ran into a violent local thunderstorm. The airship pitched and rolled a great deal. Some holes were torn in the covering astern, otherwise the airship sustained no real damage, thanks to its strong construction. During its stay in Canada the R 100 flew to Ottawa and Toronto; it then crossed the Niagara Falls and flew over the state of New York. The airship was back in England on 16 August after a very successful trip. While the westbound trip had lasted 78 hours 51 minutes, the return trip was accomplished in 56 hours 30 minutes, with the assistance of a tail-wind. After these two crossings of the Atlantic the airship had a well-deserved rest in its shed at Cardington and then was thoroughly overhauled in preparation for other forthcoming long-distance flights.

Meanwhile the personnel at the Air Ministry prodded the engineering staff of the R 101 and urged them on. The British government was anxious to have this airship inaugurate the planned route to India in October 1931. Against the better judgment of the people at the yard they reluctantly reported the airship ready. Some of the engineers had their grave doubts in this respect, but kept silent about it. The R 101 had never yet been tested at full speed, nor under unfavourable weather conditions. The airship was due to depart for Ismailia and Karachi on Saturday, 4 October 1931, but first a trial run was squeezed in before that date. This ought to have been of at least 24 hours' duration but, everybody being pressed for time, it was cut down to 17 hours. Then, when the R 101 eventually left its mooring mast at Cardington on what was to be its first and last commissioned flight, one of the saddest chapters in the history of airship development was written. An over-tired crew, in an unfinished airship, launched into an altogether poorly planned flight of an enormous length. It just had to spell disaster, and the final catastrophe came terrifyingly fast.

The air passage over southern England was slow and difficult. One of the engines soon had to be stopped for repairs. The R 101 was leaking and already so heavy when reaching the French coast that its chances even of returning safely to Cardington under the increasingly impossible weather conditions must have been nil. The commander of the R 101, Flt Lt H. C. Irwin, and his crew of forty-one men must then already have had their grave doubts about the behaviour of the airship. There were some prominent passengers on board including the British Air Minister, Lord Thomson; the Director of Civil Aviation, Sir W. Sefton Brancker; the Director of Airship Development, Wg Cdr R. B. B. Colmore; and the former commander of the R 34, Major G. H. Scott, who was in charge of this air expedition. Whatever their innermost thoughts, the entire complement kept their feelings to themselves and displayed no outward signs of being downhearted. After enjoying an excellent dinner in the elaborate dining hall they gathered in the smoke room and lit their cigars, not many feet away from gas cells filled with hydrogen. Then at midnight they retired to their comfortable sleeping cabins, relieved to have left the English Channel behind them. On the bridge, on the other hand, the officers were worried, for the stronger the gale grew,

the more uncontrollable the R 101 became.

At 1.30 a.m. the airship passed Saint-Valery-sur-Somme in France at such a low altitude that the roar from its straining engines frightened villagers out of their beds, to tumble or dash to the windows for a skyward glance. Six miles (10 km) further on the R 101 crossed Quesnoy, where the inhabitants were convinced that the house roofs were going to be torn off as the giant vessel passed low overhead in the pitch-dark night. It was now Sunday, 5 October, and on board the airship the watch was changed for the last time at 2 a.m. Nine minutes later the airship hit the ground at a very shallow angle at Allonne, near Beauvais. After a slight skip the R 101 crashed again and broke asunder. For one second everything was quiet, then a huge flame shot against the rain clouds and a hollow boom sounded through the valley. The R 101 had perished. So had those who designed it, and the officers who had gambled on guiding the airship to its destination. Only eight members of the crew (two of whom died of their injuries shortly afterwards) survived the immediate disaster, which cost the lives of forty-eight men in all. The survivors had been stationed in the rear engine gondola and the miracle that kept them alive in the inferno of the fiercely-burning wreckage was the emergency water ballast tank which Flt Lt Irwin had emptied in a last desperate attempt to save his doomed airship.

This disaster was a severe blow to the British nation and the public later derived little satisfaction from the investigations to establish the cause of the calamity. The actual faults were never pinpointed but all concerned were in agreement that both human and technical errors had been contributing factors. The last flicker of any British interest left in the building of large airships had been extinguished for good. Steps were even taken to eradicate completely all traces of past work in this field, for the R 100, the old and deserving sister airship of R 101, was dismantled into small components and these remains were flattened with a steamroller and sold as scrap.

Specification of R 100

Volume: 5,200,000 cu.ft (147,248 cu.m)
Length: 709 ft (216·1 m)
Diameter: 133 ft (40·54 m)
Engines: Six 670 h.p. Rolls-Royce Condor IIIB twelve-cylinder
Useful load: 160,000 lb (72,570 kg) including payload of 55,000 lb (24,948 kg)
Maximum speed: 81 m.p.h. (130 km/hr)
Range: 3,600–5,000 miles (5,795–8,050 km)
Passengers: 100

Specification of R 101*

Volume: 5,500,000 cu.ft (155,743 cu.m)
Length: 777 ft (236·8 m)
Diameter: 133 ft (40·54 m)
Engines: Five 585 h.p. Beardmore Tornado Diesel eight-cylinder
Useful load: 160,000 lb (72,570 kg) including payload of 55,000 lb (24,948 kg)
Maximum speed: 74·5 m.p.h. (120 km/hr)
Range: 3,600–5,000 miles (5,795–8,050 km)
Passengers: 100

* After the rebuilding in 1930.

64 **Metalclad ZMC-2**

The ZMC-2 (serial number A8282) was built by the Metalclad Airship

Corporation (formerly the Aircraft Development Corporation) in Detroit, Michigan. It was a noteworthy innovation in airship building and, although it was destined for the U.S. Navy, its designation was at variance with the usual nomenclature practice. 'MC' stood for 'Metal Clad' and the figure '2' indicated the gas content, which was 200,000 cu.ft (5,663·4 cu.m).

The balloon envelope was reinforced with ribs on the inside and conveyed the impression that with this structure the airship belonged to the rigid type, as the envelope was made of many small 'Alclad' duralumin sheets of 0·08 in (2 mm) thickness, joined together. Yet, like the 'Blimps', ZMC-2 was a non-rigid airship in which the pressure to maintain the shape of the envelope was accomplished by inflation of two ballonets inside the envelope. The airship was filled with helium and the gas was in direct contact with the envelope, and not contained in special cells. The metal envelope was made gas-tight through a special manufacturing process whereby a machine developed for the purpose automatically sealed the thin aluminium alloy plates with three million rivets. Perhaps its operation can best be described as a kind of stitch sewing with a metal thread being cut continuously.

The Aircraft Development Corporation was formed for the express purpose of producing an airship with this novel feature, and the design and development of ZMC-2 began in 1922. By 1926 the Navy was satisfied that an airship of this nature was feasible, and ordered one example. ZMC-2 made its maiden voyage on 19 August 1929, and was accepted by the U.S. Navy one month later.

In the air, the unusual ratio of diameter to length of this airship was conspicuous. Its aspect was that of a plump sausage, and many people were of the opinion that ZMC-2 would not prove dirigible at all, yet the designers had this problem well under control by means of eight fixed fins, mounted some way forward on the stern part of the metal envelope. Rudders were attached to four of them and elevators to the others, all eight movable surfaces being of the balanced type.

The ZMC-2's performance was excellent throughout its span of ten years of operation, and it wore out its original engines, which were replaced by new ones. The airship was in the air for the last time on 19 August 1939, the tenth anniversary of its first trial flight. Afterwards various tests were conducted with it on the ground and it was finally broken up in 1941.

Specification of ZMC-2

Volume: 200,000 cu.ft (5,663·4 cu.m)
Length: 149 ft 5 in (45·54 m)
Diameter: 52 ft 8 in (16·05 m)
Maximum lifting capacity: 12,250 lb (5,454 kg)
Useful load: 750 lb (340 kg)
Engines: Two 220 h.p. Wright J–5 Whirlwind seven-cylinder radial
Maximum speed: 62 m.p.h. (100 km/hr)
Range: 675 miles (1,086 km)
Crew: 2 men

65 **The B class airships of the U.S. Navy**

The U.S. Navy acquired its first 'Blimp' in 1915. This small non-rigid airship bore the original designation DN-1, and was later called the A-class. It was built by the Connecticut Aircraft Company based upon German and Austrian intelligence and proved a failure, chiefly because it was too heavy.

The B class airships of the U.S. Navy had a better performance. Their design was based upon the British types that had successfully served as air scouts at sea, and in shadowing the German submarines during the war. This induced the U.S. Navy in 1917 and 1918 to order sixteen airships of the B class of which Goodyear was to build B-1 to B-9, Goodrich B-10 to B-14, and Connecticut Aircraft B-15 and B-16. They were delivered between June 1917 and July 1918. Goodyear later rebuilt three of these airships, which were then redesignated B-17 to B-19, and also built a newer and larger design, the B-20. The first of the series of B-class airships, the B-1, made its maiden voyage on 30 May 1917, two weeks after the United States declared war on Germany.

The Buffalo and Hammondsport (New York) plants of the Curtiss Aeroplane and Motor Co. built most of the gondolas and engines for the B-class airships. They were just slightly modified aeroplane fuselages with two separate cockpits. Before long their wheeled undercarriages were replaced by air-filled flotation bags. The Goodyear concern also provided the training facilities and had charge of the production of hydrogen for filling these airships.

The B class were found to be reliable, and well suited to their tasks. On at least two occasions, airships of the B class detected and bombed German submarines which had been despatched to mine the various shipping routes from the port of New York.

These good results encouraged the U.S. Navy to order ten airships of the improved C class in September 1918. They were to engage the German submarines in European waters, but the war ended before any of them were completed. In May 1919 one of these small airships, the C–5, made a gallant attempt to become the first airship to cross the Atlantic. After having stayed in the air for 25 hours the C–5 had to give up and landed in Newfoundland where it tore from its moorings when a storm arose, and disappeared out to sea. On 1 December 1921, C-7 was the first airship in the world to be flown filled with helium. Henceforth this type of gas became the standard and was used exclusively in all American military airships.

Specifications of the B class (Goodyear)

Volume: 77,000 cu.ft (2,180·4 cu.m)
Length: 160 ft (48·77 m)
Diameter: 31·5 ft (9·60 m)
Engine One 100 h.p. Curtiss OXX-2 eight-cylinder water-cooled
Maximum speed: 45 m.p.h. (72 km/hr)
Operational ceiling: 7,000 ft (2,135 m)
Endurance: approx. 16 hours

66 **The Goodyear fleet of advertising airships**

In 1925 the Goodyear company decided to start the building of a fleet of small non-rigid airships for the training of crews and for experimental purposes, including passenger and advertising flights.

This decision was based on the sound reasoning that the Goodyear company stood a good chance of also leading the way when large rigid airships were to be developed in the future, as its experience gained from building more than one hundred non-rigid and semi-rigid airships would be of some consequence. The air-minded top management took into consideration that after the delivery of *Los Angeles* to the U.S.A. (see No. 58) Germany was ordered to disband the Zeppelin airship works in compliance with the terms of the Armistice. The upshot would be that their staff of engineers and technicians

would be scattered, and if Goodyear were to acquire their unique experience and skill this concern could dominate the airship field. The negotiations to this end succeeded, and in an agreement signed by the American government with the Zeppelin Luftschiffbau in Friedrichshafen in 1924, Goodyear acquired the Zeppelin patents, together with the special equipment of the works there, and engaged a nucleus of the staff headed by the chief engineer, Dr Karl Arnstein, for its newly-formed subsidiary Goodyear-Zeppelin Corp., later renamed Goodyear Aircraft Co. The U.S. Navy followed these developments with interest, and when the new airship concern was formed they made advances and began to work hand in hand with it.

As already mentioned, Goodyear wanted first to gain more experience from the operation of small airships before tackling larger sizes. Its first company-owned airship, the 35,000 cu.ft (991·1 cu.m) *Pony Blimp*, dated back to 1919. Now, in July 1925, *Pilgrim* became the first unit in the fleet of Goodyear airships. It was filled with helium, as all later ones have been. *Pilgrim* was also the first non-rigid airship with an enclosed gondola attached directly to the envelope. This small airship became known as America's first 'air yacht' and hopes ran high that wealthy sportsmen might come forward as prospective buyers of more of them for their personal use. *Pilgrim* made a total of 465 flights before being donated to the National Air Museum of the Smithsonian Institution in Washington, D.C.

Puritan came next, in August 1928, followed in 1929 to 1932 by *Mayflower*, *Vigilant*, *Volunteer*, *Defender*, *Reliance* and *Resolute*, the two last as replacements for *Mayflower* and *Vigilant* when they became obsolete. *Columbia*, *Enterprise* and *Ranger* were the last three airships of this series. *Defender* was the flagship of this fleet of airships. Its envelope held 178,000 cu.ft (5,040·4 cu.m) of helium and it could carry 10 passengers while the other airships had seating capacity for six. *Defender* was later acquired by the U.S. Navy (and designated G-1); so were, in February 1942, *Reliance*, *Resolute*, *Enterprise*, *Ranger* and one more 'Blimp', *Rainbow*, all of them being used to train naval airship crews with 'L' as the letter designation of their class (see No. 72).

Special motor vehicles were used for mooring these airships and to move them about on the ground. After the airship had been moored the vehicles had provision for a 360° rotation, thus enabling them to follow the movements of the airship.

Different manufacturing procedures were adopted for these airships, and both the materials and engines used could also vary from one to the other. A number of envelopes of different sizes might also be experimented with for an airship during its lifetime.

Prior to World War 2, Goodyear's fleet of advertising airships had carried a total of about 400,000 passengers without any mishaps, which speaks volumes for the soundness of their design.

Specification of the Goodyear airship 'Pilgrim'

Volume: 57,000 cu.ft (1,614·1 cu.m)
Length: 110 ft (33·53 m)
Diameter: 32 ft (9·75 m)
Engine: One 60 h.p. Lawrence radial
Cruising speed: 37 m.p.h. (60 km/hr)
Range: 400 miles (644 km)

67 **Auguste Piccard – the conqueror of the stratosphere**

Around 1930 the free balloon, the veteran among the various types of aircraft, enjoyed a renaissance in regard to ascents to hitherto unchallenged altitudes. This became feasible as the result of a number of improvements, especially to what literally had been the 'basket'. This meant that a free balloon now could climb some 16,400 ft (5,000 m) above the ceilings of the aeroplanes of that period.

One of the first to avail himself of this new type of balloon was Auguste Piccard, a native of Switzerland, who in 1922 had become professor of physics at the technical college in Brussels. Piccard specialised in the study of cosmic rays, and in this field was joined by his twin brother, Jean Piccard, also a physicist. As far back as 1913 the two brothers had made a balloon ascent to an altitude of about 10,000 ft (3,000 m) to measure atmospheric pressures. With financial support from a Belgian foundation for the promotion of scientific research, Auguste Piccard in later years made a number of balloon ascents, though none of them was of any particular aviation significance.

With the persistence characteristic of this distinctive scientist, however, Piccard by 1930 commanded sufficient money to order a special balloon from the Riedinger company in Augsburg. In recognition of the support from the Fond Nationale de la Recherche Scientifique, he named this balloon *F.N.R.S.* Its gondola was made of aluminium, in the shape of a ball, and immediately attracted world-wide attention. However, an ascent on 14 September 1930 to an altitude of 52,500 ft (16,000 m), planned by Piccard and his assistant, Dr Paul Kipfer, was a complete failure, as the balloon simply refused to leave the ground, and he became a laughing-stock. His appearance was against him and it did not help matters either that on this occasion he and his companion had turned up wearing basket-like helmets with wicker-mats and padded with pillows. By general concensus they were now merely considered eccentrics.

On 27 May 1931, however, the ridicule ceased. A new balloon envelope of 498,991 cu.ft (14,130 cu.m) capacity easily and impressively lifted the hermetically-sealed spherical gondola with its automatic oxygen supply from the starting ground at Augsburg in Bavaria. In 30 minutes the two scientists had risen to 51,775 ft (15,781 m). During the descent the balloon drifted slowly southward and the two men discovered that their car had developed a slight leak through which air escaped slowly, but this caused no serious trouble. But their landing at night in the snow-covered wastes of the Obergurgl section of the Tyrolean Alps was quite dramatic. Piccard and Kipfer managed to reach an inhabited area, but they had to leave the balloon envelope and gondola behind and were not able to recover them until the following year. By good fortune all the instruments, including the ionisation equipment for measuring cosmic rays, were intact. Needless to say, after his success Auguste Piccard was acclaimed as the conqueror of the stratosphere.

Yet the established altitude record fell short of his aim of 52,500 ft (16,000 m), so Piccard at once planned another ascent. A new and improved gondola was built, which unfortunately was to cost the lives of two of his assistants when a test model exploded in the workshop while an experiment was being conducted.

On 18 August 1932 Piccard was ready to ascend again, this time from Dübendorf airport at Zürich where 30,000 spectators were in attendance. Piccard took off early in the morning and this time was accompanied by Dr Max Cosyns from Brussels, oxygen to last the two men for 32 hours, provi-

ment, together with Alpine outfits for the two men. As the balloon ascended, a Swiss aeroplane escorted it to an altitude of 9,850 ft (3,000 m). Thereafter the two men were left to their own resources. They radioed that all was well, in spite of the penetrating cold, when they had ascended to an altitude of 52,500 ft (16,000 m). At 5 p.m. the next day the inhabitants of Peschiera on the southern shore of Lake Garda in Italy glimpsed the balloon, and soon it prepared to land. The altimeter registered proof of the establishment of the new altitude record of 54,789 ft (16,700 m).

As befitted a celebrity of his rank, Professor Piccard now lectured, but he never re-entered the stratosphere. When further balloon experiments disappointed him his interest was directed in the opposite direction and he took to deep-sea diving and underwater research. His twin brother Jean carried on with balloon ascents to high altitudes after emigrating to the United States, and on one of these trips, from Detroit, he succeeded on 3 October 1934 in beating the record of his brother Auguste by nearly 2,250 ft (685 m) as he reached an altitude of 57,037 ft (17,385 m). He was on this occasion accompanied and assisted by his wife, Jeanette, who thus became the first woman to penetrate the stratosphere. Only the Russian woman astronaut Valentina Tereshkova has stayed longer, and further out, in space. This occurred with the Vostok 6 spacecraft in 1963.

68 **The stratosphere balloon 'Explorer II'**

The first American attempt to ascend into the stratosphere with a free balloon was made on 20–21 November 1933. The balloon, of Goodyear make, was manned by Major C. L. Fordney and Lt Cdr T. G. W. Settle who set an American altitude record of 54,675 ft (16,665 m).

A new world's altitude record was established in the Soviet Union in January 1934 when the balloon *Ossoaviakhim* ascended to 72,178 ft (22,000 m) but during the descent the car tore loose and crashed. The three occupants were killed.

On 28 June 1934 the Americans again attempted to improve upon the world's altitude record in a joint venture of the U.S. Army Air Corps and the National Geographical Society in Washington, D.C., which paid for the *Explorer I* stratosphere balloon of 3,000,000 cu.ft (84,951 cu.m). Manned by Major W. E. Kepner and Captains A. W. Stevens and O. A. Anderson, it had reached an altitude of 60,000 ft (18,288 m) — a new American record – when from down inside their ball-shaped metal gondola the crew noticed an ever-widening tear in the balloon envelope. All over the United States an anxious public listened to the running commentaries of the three aeronauts transmitted directly by radio from the gondola as they began their perilous descent. At an altitude of some 6,500 ft (2,000 m) the envelope tore apart completely and the gondola commenced to plummet to the ground like a stone. It looked like a repetition of the similar Russian disaster, but at that very instant the three men coolly took to their parachutes and managed to land safely.

The following year Stevens and Anderson repeated their attempt to climb higher than anybody else had managed to before. In the summer of 1935 a new giant balloon, the *Explorer II*, was readied at a special camp, the 'Strato Bowl' near Rapid City in South Dakota. Its cubic capacity amounted to 3,700,000 cu.ft (104,772 cu.m) and it had a diameter of 192 ft (58·52 m). The envelope was made of 115,927 sq.ft (10,770 sq.m) of rubberised fabric. The gondola equipment was the most complete yet, comprising hundreds of instruments and pieces of apparatus for scientific purposes. Among the matters to be investigated were five different forms of bacteria and diseases of plants. When examined later in laboratories these cultures were found to be viable at high altitudes. It scarcely needs to be added that on board the gondola an air-conditioning unit and the newest style of oxygen inhalers were installed. There was also a darkroom, a short-wave radio transmitter and an ingenious machine that automatically recorded the readings of 19 different instruments.

Most of the summer and autumn was spent in testing the numerous pieces of equipment and having them installed and adjusted. The date of 11 November was fixed for the ascent. Prior to that date 40 large lorries had to deliver the 1,475 bottles of compressed helium required to feed 225,000 cu.ft (6,371 cu.m) of the gas into the envelope, which corresponded to filling it to about one-fourteenth of its capacity. It provided sufficient lift at the start and the envelope would become fully inflated before the balloon reached its ceiling. During the night of 10–11 November the balloon gradually assumed its shape with the appearance of a huge monster. From top to bottom it measured 315 ft (96 m), the height of a small skyscraper. At dawn Stevens and Anderson, wearing parachutes and woolly pointed caps, entered the gondola through a small opening. Then the weighing-off began. The 40 bags of ballast were filled with lead shavings of a total weight of 8,000 lb (3,630 kg) and amounted to 40 per cent of the lifting capacity of 20,175 lb (9,152 kg). A parachute with a diameter of 82 ft (25 m) was mounted on top of the gondola as an added safety precaution.

The balloon climbed steadily, and without any hitches, from the start at 4 a.m. until 19 minutes past noon, when it had reached its ceiling and the altimeter reading indicated 74,185 ft (22,612 m). During the ascent the two aeronauts had crossed the invisible borderline between the troposphere and the stratosphere at an altitude of 36,000 ft (11,000 m). Although both Stevens and Anderson were kept fully occupied performing their many duties – one of their tasks being to take infra-red photographs of all of the state of South Dakota extending below them – it did not escape their attention that their pressure-proof compartment had sprung a small leak, through which their precious supply of oxygen was escaping. After makeshift repairs they decided to curtail their stay in the stratosphere. When the car again touched terra firma at White Lake, about 125 miles (200 km) from their starting point, the two aeronauts had been aloft for 8 hours 13 minutes.

The altitude record for free balloons now stood to the credit of the United States and was not to be beaten until November 1956. Then it once more went to two Americans, Captains Lewis and Ross, who established the new world's record when their balloon climbed to an altitude of 75,787 ft (23,100 m). Valuable scientific results had been obtained on both of these occasions and they were to form the foundation on which the exploration of outer space was to be based in the years to follow.

69–70 **The ZRS-4 'Akron' and ZRS-5 'Macon' of the U.S. Navy**

In 1926 the American Congress granted the U.S. Navy permission to build two large, rigid airships for reconnaissance. While the U.S. Navy had previously had them built at Navy yards (see ZR-1 *Shenandoah*, No. 57) it was this

time decided to have them built by private enterprise. Specifications were drawn up with respect to performance, strength, safety factors and so on, and tenders were invited. Thirty-seven different bids were received, three of them from Goodyear–Zeppelin in Akron, Ohio, and with Goodyear's extensive experience in the building of airships this concern was the successful bidder and was awarded the contract for the building of the ZRS-4 and ZRS-5.

In Akron the work was first concentrated on the design and construction of a huge dock or shed in which to build these airships. On 7 November 1929 the erection of the framework of the ZRS-4 was inaugurated. The chief of the naval airship division, Admiral W. E. Moffett, drove a gold rivet into the main bulkhead of the airship. The chief designer, the former Zeppelin expert Dr Karl Arnstein, and his staff were now faced with some difficult years. Right from the early building stages this airship was in the public limelight. Rumours circulated about sabotage to vital components of the framework, about materials of inferior quality going into the airship, and to the effect that the airship would be found too heavy. All of them were refuted emphatically by the experts of both the U.S. Navy and of the yard. The ZRS-4 was an excellent airship indeed, and in every respect superior to ZR-3 *Los Angeles*, for instance (see No. 58). Thus its eight engines were incorporated inside the huge hull, with only the propellers projecting. Not only were the propellers reversible (to provide braking effect during landing, if required), but they could also be swivelled and placed in a horizontal position, pointing either upward or downward to provide an upward or downward push which was of immense value during the starting and landing manœuvres. While there had only been one passageway in previous Zeppelin airships, no fewer than three were provided in the hull of ZRS-4. Two were placed in the bottom of the hull, interconnected by means of cross-tunnels. The third passageway extended along the top part of the hull. Last, but not least, ZRS-4 was a real aircraft carrier. It had been found feasible to attach an aeroplane to *Los Angeles* in flight and later release it again, but ZRS-4 could, while in flight, actually receive in flight five scout or reconnaissance aeroplanes and store them in a special hangar inside its huge belly. For ZRS-4 and its completely identical sister airship ZRS-5 were to act as the eyes and ears of the Navy, the organs today represented by radar.

The ZRS-4 was finally christened on 8 August 1931, with many festivities that assumed an air of carnival entertainment. America's first lady, Mrs Herbert Hoover, the wife of the President of the United States, performed the honours and gave the airship the name *Akron*. It had to undergo numerous tests prior to the maiden voyage and thus it was only on 23 September that *Akron's* first master, Captain Charles E. Rosendahl, could give the order 'Ship up' for the first time. Additional trial trips followed, and on 27 October the airship was officially accepted by the U.S. Navy. In spite of minor mishaps sustained by the airship, the Navy held it to be a valuable adjunct to the fleet of surface vessels, but *Akron* never enjoyed a charmed career. One incident (for which the airship could only be blamed indirectly) happened when a landing was not completed, and though the ground crew were ordered to let go of the holding ropes three sailors held on to them and were carried aloft by the airship. Two of them released their holds and plunged to their deaths.

The third clung to his rope and an hour later was hauled on board the airship. He was in a state of shock, but otherwise unharmed.

After *Akron* had settled down in service the so-called 'trapeze artists', the pilots of the small Curtiss F9C Sparrowhawks, began to practise hook-ons and releases of their aeroplanes to and from the airship, by which time *Akron* had joined the Atlantic Fleet division. It was now commanded by Captain Frank McCord, a capable naval officer but as yet fairly inexperienced in the handling of airships. On 3 April 1933 *Akron* was readied for a flight in which the airship was to take bearings on, and check, a number of northern stations on the American continent along the Atlantic coast. On this occasion its complement of aeroplanes was left behind, but it carried a very important passenger, Admiral Moffett. *Akron* took off from Lakehurst, outside New York, in the evening in rather bad weather as it was foggy and thunderstorms were advancing. At midnight the airship was far out to sea over the turbulent Atlantic Ocean in a vain attempt to evade the violent storm. Finally McCord decided to make for the coast again. Shortly afterwards *Akron* was seized by a strong downdraught and hit the water with great force. All lights went out and the members of the crew who were caught inside the hull broke out through the canvas cover only to end in the ice-cold water. By chance a German tanker, *Phoebus*, was close by and had seen the airship plunge into the sea. Thus help was quickly at hand, yet only one officer, Commander Herbert V. Wiley, and two of the 76-man crew were rescued, for the *Akron* had not carried any life-belts.

Less than a month before this disaster ZRS-5 had been completed, taken from its shed, and named *Macon* by the wife of Admiral Moffett, who was so shortly to become a widow. In October 1933 *Macon* was stationed at the newly-established Pacific coast Moffett Field naval airship station at Sunnyvale, California. From here the airship and its aeroplanes took part in several successful manœuvres of the Pacific Fleet. On these occasions *Macon* was repeatedly subjected to severe strain when making abrupt turns in evasive actions. On 21 April 1934, once more bound for a rendezvous with a naval force in the Caribbean Sea, *Macon* was crossing the south-western corner of Texas and passing through some foul weather when one of the senior engineers on board observed an incipient rupture in one of the large circular inside frames in the stern section. It was the one supporting the four fixed tail surfaces, and the damage might have been the result of overload conditions. Only temporary repairs by means of wooden planks could immediately be performed, but the airship returned safely to its temporary base, Opalocker, in Florida. Thorough repairs had, however, to be deferred to a later date, and actually were never made, as *Macon* could ill be spared from the continued fleet manœuvres. Here the airship played such a successful part that even its antagonists had to admit that aircraft of this type were important military weapons.

When *Macon* returned to California its commander up to this time, Captain Alger H. Dresel, was succeeded by Herbert V. Wiley. This naval officer had already had a long career with airships, as he had previously served in both *Shenandoah* and *Los Angeles* and, as already recorded, was one of the very few survivors from the more recent *Akron* disaster. The U.S. Navy looked to him to exploit fully those qualities that *Macon* had already demonstrated. Wiley was a strong advocate of the

airship/aeroplane combination. He also reintroduced the twenty-year-old German practice of lowering an observer in a small car through the cover of clouds below the airship. In November 1934 *Macon* participated in additional naval exercises in the Pacific Ocean with outstanding success. Both the U.S. Navy Bureau, government circles and the public seemed about ready to forget the airship disasters of former years.

On 11 February 1935, *Macon* was once more out on routine practice flights off the south coast of California. The weather was not very promising, but no one was worried, for this airship had long ago demonstrated its unsurpassed reliability. Both that day and the next its small F9C aeroplanes were very active in their endeavours to locate the 'enemy' fleet units. By 10 a.m. on 12 February, *Macon* had fulfilled its assignment and set out on its return trip to Sunnyvale. Off Cape San Martin the fog grew denser and when at 5 p.m. the airship was off the Point Star lighthouse Wiley decided to head away from the coast and for the time being stayed out over the sea. Shortly afterwards the airship passed through a storm of rain. A crash was heard and the airship began to vibrate. The helmsman reported that the big wheel felt quite slack between his hands. Nobody knew yet that the top fixed tail surface, and the rudder mounted to it, had disappeared completely. But soon everybody on board was aware of the seriousness of the situation as the whole tail section began to break off. The countermeasures taken could not save *Macon* from sharing the fate of her sister airship. It soon rested in the sea, helpless. The old and long-neglected damage had at last got the better of the airship. Except for two who drowned, all hands on board managed to climb on to the nose part of the airship, which kept floating. Vessels soon came to the rescue and the men on board gazed at an odd spectacle. The survivors on the wrecked section of the airship – there were eighty-one of them – behaved like frolicsome schoolboys because they were under the influence of the helium escaping from the burst gas cells. During their brief intoxication all of the crew of the *Macon* even spoke with canto voices!

The aftermath reaction was crushing. That this cruel fate should befall even the *Macon* airship was more than the American public could stand. The outcome was that the word 'airship' was banished from American newspapers and the U.S. Navy abandoned all thoughts of having more rigid airships built. Even the old and worthy *Los Angeles* was sacrified. It was broken up in its shed at Lakehurst simply because of fear of what might still be in store for this seemingly indestructible airship.

Specification of ZRS-5 'Macon'
Volume: 6,500,000 cu.ft (184,060 cu.m)
Length: 785 ft (239·3 m)
Diameter: 132·9 ft (40·5 m)
Engines: Eight 560 h.p. Maybach VL II twelve-cylinder
Lifting capacity: 403,000 lb (182,800 kg)
Payload: 160,644 lb (72,867 kg)
Maximum speed: 87 m.p.h. (140 km/hr)
Cruising speed: 63 m.p.h. (102 km/hr)
Maximum range: 7,525 miles (12,110 km)
Normal range: 5,480 miles (8,820 km)
Crew: 60–75 men

When *Akron* and *Macon* crashed they had made 73 and 54 flights respectively with total flying times of 1,695 and 1,798 hours.

71 **Zeppelin LZ 129 'Hindenburg'**
Encouraged by the attainments of *Graf Zeppelin* (see No. 61), Dr Hugo Eckener and his engineers in Friedrichshafen in 1929 decided to tackle next the ideal airship for trans-Atlantic crossings. The first design bore the factory number LZ 128 and according to the estimates ought to have been able to carry from 30 to 34 passengers. The gas cells were to be inflated with hydrogen, as in all previous Zeppelins. Yet, when the R 101 in 1930 ended as a blazing inferno in France (see No. 63) the Zeppelin company realised that efficiency must yield to safety in future airship operations, so LZ 128 was dropped in favour of a new layout, LZ 129. This airship was to have about the same carrying capacity and performance as the former; the main difference being that the safe but extremely costly helium was to replace the cheap but inflammable hydrogen in the filling of the airship. In Friedrichshafen they took it for granted that the United States, which was the only country where helium was produced, would co-operate by supplying the required quantity of this gas.

In cubic capacity, LZ 129 was to be almost double the size of *Graf Zeppelin*, yet only slightly more than 29½ ft (9 m) longer.

Work on this, the largest airship yet to be conceived, began in the autumn of 1931. Dr Ludwig Dürr took charge of the design. His extended experience in the building of airships was unrivalled, as his association with Count Zeppelin dated back to 1899. Dr. Arthur Foerster was responsible for the important stress analysis and calculations, and the son of Dr Eckener, Knut Eckener, was works manager. Aiming at improved stability, the whole passenger section was enclosed inside the hull which was a departure from the design of *Graf Zeppelin*. There were two passenger decks, an upper 'A' and a lower 'B'. The A deck contained a dining room 32·8 ft (10 m) long, 16·4 ft (5 m) wide which seated 34 people. Beyond this were a reading and writing room and a spacious lounge, the pièce de résistance of which was a small, dainty Blüthner lightweight piano. Here were also to be found two 49 ft (15 m) long promenade decks, one each on the port and starboard side. The decks were provided with large picture windows affording unsurpassed views. All the passenger accommodations were painted in harmonising colours and elegantly decorated. On the walls hung original paintings depicting the milestone events in the development of aeronautics. Finally, the centre section of A deck was divided into twenty-five single- and twin-berth cabins. Since trans-Atlantic airship passage, both in the northern and southern hemispheres, was much in demand, this airship later had nine more cabins added on B deck where a small smoking room was also provided. For reasons which will become evident later the smoking room was kept strictly isolated, and only one single, special lighter was used there. Also installed on B deck were the toilet, washrooms and pantry. The quarters of the 55-man crew (who worked in watches), and eight holds each of 1,102 lb (500 kg) capacity, were provided in the large triangular lattice keel running the full length of the airship. Bulky freight was handled and stored in two additional holds of 5,512 lb and 1,323 lb capacity (2,500 kg and 600 kg) respectively.

With a take-off weight of 533,518 lb (242,000 kg), LZ 129 was extremely difficult to handle on the ground, so it was well that even then it could move both forward and backward under its own power as the airship was equipped with shock-absorbing and retractable

wheels, under the control gondola and under the bottom tail fin.

The plans for LZ 129 went awry in one respect: the sixteen large gas cells of the airship never became inflated with helium. Contrary to all expectations the United States government refused to grant an export permit for this strategically important gas. The main reason why helium was not released to Germany was that the Nazis had come to power there by the middle of the nineteen-thirties. Even to have the LZ 129 completed, the reluctant Dr Eckener had to pay his tribute to the ruling party in Germany. The head of the German Air Ministry, and later for some brief years second in command of Germany, Hermann Goering, contributed 5 million marks of official money whereby the Deutsche Zeppelin Reederei, the German navigation company operating the Zeppelin airships, came under government control.

The gas cells were altered in some respects and the airship was safeguarded as much as possible against the formation of static electricity. On 4 March 1936, LZ 129 made its maiden voyage, strangely enough without having been christened, as the decision had been made long ago to name it after the 'grand old man' of the Weimar republic, Field Marshal Paul von Hindenburg. Some said that the christening had been postponed because other circles had proposed that the airship be named 'Adolf Hitler'. It is certain, though, that on the *Hindenburg*'s seventh flight, on 26 March, it was obliged to join *Graf Zeppelin* in a circuit of Germany of three days' duration, as part of the propaganda on behalf of the coming leader of Germany.

Meanwhile Dr Eckener had arranged with the American naval authorities that *Hindenburg* would make ten Atlantic crossings in each direction during 1936. On 6 May, the airship started for the first time from Friedrichshafen and completed the crossing to America in the record time of 64 hours 53 minutes. Captain Ernst A. Lehmann was the master of *Hindenburg* on this trip and on several of the following ones. That same year the airship also completed seven round trips to Rio de Janeiro and on fifty-six long and short trips carried a total of 2,656 passengers, all of whom praised the extremely stable *Hindenburg* and commented favourably on how quiet it was to travel inside the airship hull. In 1937, *Hindenburg* resumed its South Atlantic crossings, leaving Europe on 16 March and arriving back again from the Brazilian capital on 27 March, as usual fully booked both ways. The engines were then overhauled and extra cabins installed on B deck to provide additional sleeping accommodation. *Hindenburg* was then ready to resume the North Atlantic crossings scheduled for the coming season on that much-travelled route.

Displaying much diplomatic skill, Dr Eckener had meanwhile managed to arrange the formation of the American Zeppelin Transport Corporation, in which Germany's contribution was to be the *Hindenburg* and one more airship, the LZ 130, then being built at Friedrichshafen, while the two American airships to follow suit were still only in the planning stage.

On 4 May, *Hindenburg* left Europe from the new Rhein–Main base outside Frankfurt, on the first of the eighteen flights to North America planned for that year. It was under the command of Captain Max Pruss, accompanied by Ernst Lehmann as an observer. The airship carried 36 passengers and a crew of 61. At 3.30 p.m. on 6 May the airship passed over the Empire State Building in New York City on its way to Lakehurst, where the commanding officer of this air base, Captain Charles

E. Rosendahl, was ready to receive the airship, heading the 110 sailors and 118 civilians composing the landing crew. Also present was the ubiquitous crowd of newspaper reporters and photographers who impatiently awaited the arrival of the airship, several hours overdue as a result of local thunder showers. The cautious Max Pruss kept cruising around waiting for the weather to clear. When at 7 p.m. only light clouds covered the sky on that spring evening, the pride of Germany soared over the field with searchlights playing on the ground from an altitude of only 500 ft (150 m) and turned towards the mooring masts. Standing at the windows of the promenade deck the passengers watched keenly as the two 395 ft long (120 m) landing ropes were caught on the ground and moored to two small railroad cars running on circular tracks around the mast. The deep hum of the engines crescendoed to a roar since the propellers had been reversed for braking effect. In the radio cabin of *Hindenburg* the operator was just then in communication with *Graf Zeppelin*, which was crossing the South Atlantic ocean. The time now was 9.25 p.m.

Suddenly a flame shot up from the top side of *Hindenburg* just ahead of the top vertical fin. In the control car Max Pruss felt a jerk in the airship, and glancing downwards discovered that the sanded soil of Lakehurst was lit by a reddish tinge. Instantly he realised what had happened and coolly refrained from emptying the ballast tanks. Now it was imperative to have the airship settle on the ground as fast as possible. The burning hull sank the last few feet beneath an enormous mushroom of fire and smoke while the landing crew and nearby onlookers alike ran away in a shower of flame and sparks as far as their legs would carry them. Human forms tumbled out of the doors, hatchways and windows of the dying airship.

The horrifying spectacle was over in forty brief seconds. Most of the victims of the disaster lay buried below the glowing hot metal frame. Others, Ernst Lehmann among them, died later at the hospital where they were brought. A total of 13 passengers and 22 crew members, including one of the ground crew, perished in this disaster; miraculously, 23 passengers and 39 crew members survived; Max Pruss was one of them. Several theories were advanced as to what caused this calamity. Dr Eckener was of the opinion that an interior staywire had broken while the apparently tail-heavy airship was being manœuvred, and pierced one of the gas cells while simultaneously creating static electricity and igniting the escaping hydrogen. Others attributed it to 'St Elmo's fire', or said that the airship had been hit by lightning. There were even rumours of sabotage, when a Luger pistol from which one shot had been fired was found in the

Specification of the LZ 129 'Hindenburg'

Maximum volume: 7,062,940 cu.ft (200,000 cu.m)
Length: 803·8 ft (245 m)
Diameter: 153·5 ft (46·8 m)
Lifting capacity: 471,790 lb (214,000 kg)
Engines: Four 1,320 h.p. Daimler-Benz DB 602 Diesel sixteen-cylinder
Payload: 15,432 lb (7,000 kg) of passengers and 26,455 lb (12,000 kg) of freight and mail
Maximum speed: 84 m.p.h. (135 km/hr)
Cruising speed: 78 m.p.h. (125 km/hr)
Range: 8,700 miles (14,000 km)

burned-out wreckage. In the end, however, all agreed that the direct cause was the disastrous hydrogen.

The *Hindenburg* also spelled finis for the *Graf Zeppelin* and the just-completed LZ 130 *Graf Zeppelin II*. No more passengers were carried in these mastodons of the air, in spite of several attempts to operate them again.

72 The K class of the U.S. Navy

In 1942 and 1943 the U.S. Navy established twelve airship squadrons and fifteen special bases for them. The original plans called for the procurement of forty-eight small non-rigid airships, but after the Japanese attack on Pearl Harbor in December 1941, this quantity was augmented considerably. Thus by June 1942, a total of two hundred airships of the G, K and M classes was on order.

The U.S. Navy used small airships extensively in World War 2 primarily for their ability to stay in the air for many hours on end, and also for their suitability as escorts for slow-moving convoys of freighters, and in shadowing enemy submarines. The vulnerability of the airships was of less consequence, since they were mainly intended to operate along the wide coasts of the United States where no enemy submarines were ever in action. And, indeed, throughout all the war years, only one 'Blimp' was lost while engaging an enemy vessel. This was K-74 of the extensively used K class, which on 18 July 1943 fought it out with the German submarine U-134 which it took by surprise while the latter craft was surfaced. The superior firepower of the submarine soon had the envelope of the small airship perforated in numerous places, and the loss of gas through the many holes slowly forced the airship down in the water. All of the crew except one man were rescued.

A total of 135 airships of the K class were built, but it is difficult to deal with them in chronological order, partly because they were acquired over a long span of time and partly because each series presents a number of design variations.

K-1 (serial number 9992), of 319,900 cu.ft (9,059·6 cu.m) capacity, was planned by the U.S. Navy in 1931 and constituted a completely new type of non-rigid airship. The envelope was ordered from Goodyear while the gondola, to be attached directly to the envelope, was built at the Naval Aircraft Factory at the Navy Yard in Philadelphia. The power plant comprised two 330 h.p. Wright J-6-9 radial engines. In K-1 the U.S. Navy acquired an outstanding patrol airship that was a big improvement on the two types borrowed from the U.S. Army in 1937 (the TC-13 and TC-14). However neither of these, nor the K-1, could be placed in actual service as the guarding of the coasts of the United States was the exclusive domain of the U.S. Army, so that K-1 was used for experimental purposes and as a training airship.

The development of 'Blimps' began to make real headway when all patrol duties in 1927 became the responsibility of the U.S. Navy, which lost no time in readying the 404,000 cu.ft (11,440 cu.m) size K-2 powered by two 550 h.p. Pratt & Whitney R-1340-AN-2 Wasp radial engines. The later production of K-class airships appears somewhat haphazard in respect to the sequence of designation numbers. For instance, K-5 up to and including K-8 belonged to the second series, while K-3 and K-4 were of the third series. K-3, K-4, K-7 and K-8 served as training airships; all other K-class airships up to and including K-135 performed patrol duties; and from K-14 on, they had envelopes of a capacity of 425,000 cu.ft (12,034·7 cu.m). Several of the K-class airships were not allotted any serial numbers.

It is noteworthy and proper to record here that the first non-rigid airships to cross the Atlantic were of the K class. This occurred in 1944, when the U.S. Navy ordered six K-class airships to Port Lyautey in French Morocco, where they were to operate as the 14th Squadron. K-101, K-112, K-123 and K-130 were four of them, and they flew from South Weymouth, Massachusetts, to Morocco via Newfoundland and the Azores in 58 hours.

After the war some of the K-class airships were modified and rebuilt extensively. With a new gas capacity of 527,000 cu.ft (14,923 cu.m) two of them received the designations ZP2K and ZP3K (later ZSG-2 and ZSG-3) while the unmodified K airships became the ZPK class. Still newer models were developed after the war from the K class, but they no longer had much in common with their predecessors. These airships bore the designations ZP4K and ZP5K, later ZSG-4 and ZS2G-1.

Specification of K-14 to K-135
Volume: 425,000 cu.ft (12,034·75 cu.m)
Length: 251·7 ft (76·72 m)
Diameter: 62·5 ft (19·05 m)
Engines: Two 550 h.p. Pratt & Whitney R-1340-AN-2 Wasp radial
Maximum speed: 75 m.p.h (121 km/hr)
Cruising Speed: 47 m.p.h. (75 km/hr)
Range: 2,000 miles (3,220 km)
Crew: 12 men

Specification of the L class
Volume: 123,000 cu.ft (3,483 cu.m)
Length: 149 ft (45·42 m)
Diameter: 39 ft (11·89 m)
Engines: Two 145 h.p. Warner R-500-2/6 radial
Maximum speed: 60 m.p.h. (96 km/hr)
Range: 500 miles (805 km)
Crew: 4 men

Besides the classes already mentioned the U.S. Navy during World War 2 also had airships of the L class, but they were only used for the training of crews.

The U.S. Navy ordered the first airship of this class, L-1 (serial number 1210) in 1937. L-2 and L-3 were ordered in 1940. L-4 to L-8 were former Goodyear advertising airships (see No. 66). Thus L-4 (serial number 09801) was the former *Volunteer* which along with *Mayflower* and *Vigilant* dated all the way back to 1929. L-5 (serial number 09802) was ex-*Enterprise*, L-6 to L-8, the former *Reliance*, *Rainbow* and *Ranger*. No serial numbers were allotted either to these last three of the former advertising airships or to the L-9 to L-22 production airships of the same model.

73 The N class of the U.S. Navy

Only one airship of the ZPN-1 type was built. In 1954 it was redesignated ZPG-1 and was the prototype of a planned series with extra long range. The gondola was provided with an upper and a lower deck. The two pusher propellers were interconnected so that one engine could drive both of them when the airship cruised at a low speed. The four inclined tail fins of the N airships were a distinctive feature of this class and broke with the previous tradition of having the fins mounted vertically and horizontally.

The next series of 'Blimps' of the N class incorporated so many changes that they were given the new type designation ZP2N. This became ZPG-2 when the new U.S.N. designation system for airships was introduced in

1954. A total of twelve airships of the ZP2N-1 class was ordered and the first of them made its maiden voyage in March 1953. The extraordinary range and endurance were soon demonstrated in a convincing way. Commanded by Commander M. H. Eppes, one of these airships established the record, unchallenged in 1954, of staying in the air for 200 hours 6 minutes without refuelling. Three years later another airship of this class, named *Snowbird*, under the command of Commander J. R. Hunt, bettered this record by 64 hours, its voyage lasting for 11 days and nights and 14 minutes. The course followed was from South Weymouth in Massachusetts, across the North Atlantic, south around the Canary Islands and the Cape Verde Islands, then via the Virgin Islands on to Key West Florida, where the crew of 14 men again set foot on solid ground on 15 March 1957.

Five more ZP2N airships were ordered later. They were first designated as ZP2N-1W and later as ZPG-2W. They were fitted with special equipment and could undertake both control and airborne early warning tasks. These airships were easy to distinguish from the ZP2N–1 class because they carried an outside radome on top of the envelope; there was an additional radome inside the envelope. The crew numbered 21 men.

The last units of the N class were four ZPG-3W airships, the largest ever build of the non-rigid type, but also the last of this type to be supplied to the U.S. Navy. Their envelopes had a capacity of 1,516,000 cu.ft (42,928·4 cu.m) and their length was 403 ft (122·8 m). The gondola, the radar equipment and the crew accommodation were the same as in the ZP2N-1W/ZPG-2W airships, but the engines installed in them were the more powerful 1,525 h.p. Wright R-1820-88 Cyclones. The first ZPG-3W airship flew in July 1958.

In June 1960 one of the ZPG-3W airships collapsed in the air out over the Atlantic with the loss of almost all on board. This was a contributing factor in ending the building of airships for the U.S. Navy, although by then the latter had already resolved to discontinue the operation of lighter-than-air craft. The final decision to do so was announced on 28 June 1961.

Specification of the ZPG-2 type
Volume: 1,011,000 cu.ft (28,628·4 cu.m)
Length: 343 ft (104·55 m)
Diameter: 75·5 ft (23 m)
Engines: Two 800 h.p. Wright R-1300-2A Cyclone radial
Maximum speed: 87 m.p.h. (140 km/hr)

74 Barrage balloons in World War 2

In the early nineteen-thirties captive and barrage balloons were completely eliminated as military equipment in favour of observation aircraft with their greater mobility and reduced vulnerability. However, when World War 2 broke out the balloon once more regained its importance, though only in the part of barrage balloon. The object of such barrages is to protect particularly vulnerable targets against attacks by dive-bombers and low-flying aircraft. Two forms of such barrages were prepared: stationary and mobile ones. The first style was planned for use at altitudes of up to 10,000 ft (3,000 m) and here relatively large, well-anchored balloons were used. The mobile balloons were moored to motor vehicles, ships or lighters and were seldom raised to altitudes of more than 1,970 ft (600 m). There was no denying that the balloons were vulnerable, but gathered

in groups for barrage tasks they were still of considerable value as they demoralised the crews of attacking aircraft, especially if they flew in darkness. Thus the British Balloon Command scored its first 'victory' before the fighting in France was over. One day a British balloon unit in Le Havre was able to report that a German aeroplane had met its end between the steel cables. Enemy countermeasures, such as the Germans' attempt to outfit some of their aircraft as 'cable cutters' by reinforcing their wing leading edges, were unsuccessful. Finally, the balloon barrages were supplemented by other forms of anti-aircraft defence. The balloon barrage arrangements varied according to whether extended areas or pinpointed targets like factories and harbours were to be protected. They could then aptly be described as 'circular', 'chessboard' and 'pin-point' barrages respectively.

Almost all the warring nations employed balloon barrages, but nowhere else was this form of silent and inactive defence of more importance than in Great Britain. Already, on 17 March 1937, a special balloon unit, No. 30, was formed as part of Fighter Command. For operational reasons this unit was on 1 November 1938 incorporated in the newly-formed, independent Balloon Command, the chief of which was Air Vice-Marshal O. T. Boyd. When the war broke out on 3 September 1939 there was already a barrage around London comprising 444 balloons while an additional 180 balloons were distributed among the provincial cities. The demand for balloon barrages grew steadily and the existing 18 balloon centres with their 47 balloon squadrons were kept more than busy. In the early stages of the war the protection of large industrial establishments and ports was considered of the first importance. Further, the Thames estuary and other waterways of similar importance had to be denied to enemy minelayers as much as possible. During the German attacks on the southernmost flying fields in England and on the Allied convoys, Balloon Command played an important part. During the 'Battle of Britain' about 2,400 balloons were in the air. The personnel handling them often worked under difficult conditions as many of the small stations were located in secluded spots which hampered the flow of stores and other supplies and made the service life very monotonous.

In 1942 many of the male personnel of Balloon Command were replaced by women of the W.A.A.F. (Women's Auxiliary Air Force). When the German High Command at about the same time launched the 'Baedecker raids' against English historical cities these servicewomen were subjected to great strain, and volumes could be written about their sacrifices and about the courage they displayed. To mention one single incident, W.A.A.F. Corporal Lillian Ellis in May 1943 was awarded the British Empire Medal for courage displayed in remaining at her station in South Wales during an air attack, though she was wounded.

The largest balloon barrage on record comprised 1,750 units and was formed in 1943 to assist the Home Defence during the threat of the V1 flying bombs. Eight thousand of these weapons were despatched, at a daily average of 100 for 80 days. Of these 29 per cent got through to the London area. Of the remaining 71 per cent a total of 279 V1s was stopped by the balloon barrage.

Most of the Allied operations with the object of establishing bridgeheads on the coastlines occupied by the enemy were supported by units from Balloon Command. They were in action on Sicily and in Italy, landed

with the attacking troops on Corsica and at Salerno, and likewise participated in the Persian Gulf and at Suez. Balloon Command also toiled during the preparations for the invasion of northern France in 1944 and afterwards had 4,000 men engaged when these bridgeheads on the Channel Coast were established.

Balloon Command was disbanded on 5 February 1945, as by then there was no longer much likelihood of renewed air attack on England, since the German Luftwaffe had lost the initiative. Yet balloon barrages reappeared in the final stages of the war, Montgomery's forces using them in Holland, on the Rhine and elsewhere.

One of the standard British types of captive balloon, the so-called 'L.Z.' which was based on the French Caquot model from 1915 (see No. 46), was sent to the United States during the war. In that country it became the inspiration for the ZK balloon mass-produced by Goodyear. Though the United States was not threatened by direct air attack at any time during the war, six balloon squadrons were formed to protect naval bases and depots. The American balloon barrages were operated almost exclusively by the U.S. Army and U.S. Marine Corps.

75 The 'Fu-Go' balloon bomb

On 18 April 1942 Lt Col James H. Doolittle led 16 North American B-25 Mitchell bombers in a surprise raid on Tokyo. They caused little damage to the city, but the effect on morale was far-reaching, as an American attack on the Japanese capital had hitherto not been considered feasible such a short time after Pearl Harbor. This air attack even influenced Japan's strategy in the Pacific, but at the same time her military leaders fervently desired to retaliate against the American mainland. The solution plan sounded like simplicity itself. When the winds were favourable the United States was to be saturated with balloons carrying 5 or 12 kg incendiary bombs and 15 kg anti-personnel bombs to wreak havoc on American cities, forests and crops, and to kill many people.

A couple of years were spent in manufacturing the balloons with their bombs and, above all, the necessary automatic release equipment. Finally, on 3 November 1944, the first of (eventually) some 9,300 balloons of this kind were launched. Two days later (4 November, having crossed the international date line), one of these was found floating, without its load of bombs, in the Pacific Ocean near San Pedro, off the coast of California.

This Japanese concept of balloon bombs really dated from 1933, when the Japanese also tried to develop other revolutionary weapons. One of these experiments resulted in a tiny radio-controlled, unmanned armoured vehicle given the code name 'I-Go'. Another of these weapons was a rocket identified as 'Ro-Go'. This arsenal was even to include an electrical 'death-ray', but the balloon bomb 'Fu-Go' was considered the most promising. The main problem in connection with this scheme was to evolve a way of maintaining a steady altitude for the period of fifty to seventy hours required for the crossing of the Pacific, a distance of 5,965 miles (9,600 km), and a means of releasing the bomb load in the United States at the proper time. Japanese ingenuity solved both problems, at least on paper. The gas escape valve was to be combined with an automatic ballast release mechanism. This consisted of a cast-aluminium wheel, mounted horizontally, on to which were hooked 32 sandbags. The ballast bags hung in pairs, and each pair was fitted with a release fuse that could be fired by means of an aneroid connected to a small

battery. Whenever the balloon sank to a pre-set minimum altitude, either due to loss of gas or because it was cooled down, a fuse was ignited and two of the sandbags were dropped. When the load of sandbags was spent the bomb load in its turn was released and the balloon would destroy itself by means of a small explosive charge. Ahead of the balloons carrying bombs, other balloons were released which carried radio equipment to send back information about the weather and wind conditions along the route. The Japanese scientists realised that these bomb-carrying balloons must be despatched during the winter months, because the easterly winds predominate from October to March.

The envelopes of these balloons were made of three or four layers of silk tissue paper glued together. The envelopes had a diameter of 32·8 ft (10 m) and contained 19,070 cu.ft (540 cu.m) of gas. When fully inflated with hydrogen they had a lifting capacity of 992 lb (450 kg) at ground level and of about 298 lb (135 kg) at an altitude of 29,530 ft (9,000 m). The envelopes were contained in fabric 'parachutes' which covered their top half and from which the bomb load and ballast mechanism were suspended in the usual balloon style, except that the hoop or ring and car suspension of the larger balloons were replaced by two knots. While the Japanese experimented with the 'Fu-Go' weapon they also trained crews to handle these balloons and selected the bases from which to release them. Three bases were established, all located on the east coast of Honshu Island. When the preparations had been completed a mass production of the balloon envelopes was initiated at several places around Tokyo. Schoolchildren mainly were employed to glue the sheets of tissue paper together. Later the envelopes were also made of silk.

The Japanese Major General Sueyoshi Kusaba was in complete charge of the 'Fu-Go' project and personally watched the first despatches closely. He had more than 10,000 of these balloons available and a time limit of five months in which the winds would be sufficiently favourable to prove the feasibility of this scheme, so it was a race against time. The Japanese intelligence service was alerted to run down any reference to the balloons that might be printed or broadcast in the United States and reveal or hint what effect they had had there.

The 'Fu-Go' balloons did actually reach the United States and for a while puzzled everybody there. The finding of the first 'dud' has already been mentioned. On 6 December 1944, a bomb crater was discovered near Thermopolis in Wyoming. The third balloon to reach the U.S. mainland was found on 11 December in the neighbourhood of Kalispell in Montana. On 31 December a balloon and some of its equipment were found at Estacada in Oregon; and several more balloons were found early in January 1945. The experts of the defence forces soon established the origin and purpose of the balloons. Discreet investigations were conducted. It was mainly the hazard of the incendiary bombs to the dry forests that was feared, the safety of the public did not seem at stake, so the American press agreed voluntarily to abstain from any reference to the finding of these balloons. However, the discovery of the first two balloons had already been mentioned in newspapers and broadcasts, and the Japanese possessed this news.

On 5 May 1945 a woman and five children were killed in the vicinity of Lakeview in Oregon when one of the balloon bombs exploded while they were pulling it out from under some trees. It was then decided to advise the

public fully about the balloon bombs, even if this would aid the Japanese. What the Americans did not know at that time was that the Japanese had already abandoned the project, about a month before the Lakeview incident.

More than nine thousand bombs had been despatched, while another 1,000 had been defective; of the former, only 285 were accounted for, most of which were found all over the U.S.A., Canada, Alaska and Mexico. In March 1945 General Kusaba was suddenly ordered to halt his activities. The Japanese general staff now considered this scheme stupid and pointless, since they had had no evidence of its effects.

This does not end the story of the 'Fu-Go' weapon, which in a way can justly be termed the first intercontinental missile on record. On 1 January 1955 the American Defence Department circulated a bulletin about the recent find of a fully-live balloon bomb in Alaska, and at the same time issued the warning that several hundred more of these dangerous weapons might still turn up in different states. It would be a tragedy if American lives were still to be lost from weapons used in a war which ended more than a quarter of a century ago.

76 The ZSG-4 airship of the U.S. Navy

The well-known K class (see No. 72) from World War 2 was developed further in various ways after the war. This resulted, for instance, in a series of fifteen ZP4K airships intended for anti-submarine tasks. The prototype of this series was in the air for the first time in December of 1953. One of these airships, No. 133639, was removed from the series to be developed further and on 29 November 1956 was given the designation XZSG-4.

The U.S. Navy had long wished to have the procedure in operating the small patrol airship simplified as much as possible. Formerly it had been the practice that the first pilot handled the elevator and the second pilot operated the rudder. In this experimental airship it was arranged that one crewman could handle both controls. It was also the first airship to have an envelope made of Dacron. This synthetic material had proved both lighter and stronger than the grades of fabric used previously. Dacron is one of Goodyear's innovations in airship construction and also has the advantage of holding the loss of gas to a minimum. It is obvious that this is important in view of the high cost of helium.

In its final form, ZSG-4 was fitted with the very latest electronic equipment then available for the detection and destruction of submarines. The airship was also fitted with facilities for refuelling in the air, hence its flight duration was almost infinite, for by means of electrically-driven winches stores, fresh water supplies and relief crews could also be taken on board anywhere and at any time.

Specification of the ZSG-4
Volume: 527,000 cu.ft (14,923 cu.m)
Length: 266 ft (81·1 m)
Diameter: 70 ft (21·34 m)
Engines: Two 550 h.p. Pratt & Whitney R-1340-46 Wasp radial
Maximum speed: approx. 81 m.p.h. (130 km/hr)
Crew: 8 men

77 Goodyear's 'Super Skytacular' advertising airships

Since World War 2 ended, non-rigid airships exclusively have been in service in France, Japan, the Soviet Union, Great Britain and the United States.

Most of them have been of Goodyear make, for this concern still dominates the airship field even though small airships are no longer used for military purposes. Goodyear has since 1917 built somewhere in the region of three hundred airships.

At the beginning of 1968 Goodyear Tire & Rubber Co. operated two of its own airships for advertising purposes. They were the *Mayflower III* and *Columbia II*, and their design was based upon the much older L class (see No. 72). The company then wished to expand and intensify this form of aerial advertising, so the airships were modernised by its subsidiary, Goodyear Aerospace Corporation, which handles all guided missiles and space activities of the parent concern, and it also was given the assignment of building a new and improved airship. It was named *America* and made its maiden voyage on 25 April 1969. It was stationed in Houston, Texas, while *Mayflower* was based in Los Angeles, and *Columbia* in Miami.

All three airships have envelopes made of the synthetic material Dacron and are filled with helium. The control gondola seats one pilot and six passengers. The advertising messages are displayed on both sides of the envelope and in the daytime can be read distinctly from an altitude of 1,000 ft (300 m). The 'Super Skytacular' signs also carried are a spectacular system of displays with a 'moving picture' effect at night achieved by numerous coloured electric light bulbs. The messages conveyed often solicit contributions to various charity drives or are in some way public-spirited, for these Goodyear advertising airships are not operated particularly as a money-making device. The Goodyear 'winged foot' trade-mark has become associated with airships in the public mind, so to 'keep them flying' is not only valuable publicity but concurrently produces a priceless combination of image and goodwill.

The 'Skytacular' airship billboards measure 105 ft by 26 ft (32 × 7·9 m) and are composed of 3,780 blue, green, red and yellow light bulbs that are interconnected with 423,228 ft (129,000 m) of wiring. The messages are animated in the style of newspaper or film cartoons. The desired messages are produced in an electronic laboratory on the ground, the 'movie sequences' are 'drawn' with a light pistol one by one on a type of TV screen, composed to correspond to the pattern of bulbs on the two sides of the airship envelope. It is all tape-recorded simultaneously with the text which is recorded by a form of teletype printer. In the airship the contents of the tapes enter four units, each of which activates all the bulbs of one colour. The end result is a co-ordinated 'Super Skytacular' animated film or electric message in four colours.

America may today be the best place to enjoy the sight of an airship in flight, for there you stand a good chance of seeing either the *Mayflower*, *Columbia* or *America* in action. During the six summer months these small, busy airships jointly travel 185,000 miles (300,000 km) or more on visits to the

Specification of N10A 'America'
Volume: 202,700 cu.ft (5,740 cu.m)
Length: 192 ft 1¼ in (58·55 m)
Diameter: 50 ft (15·24 m)
Engines: Two 210 h.p. Continental six-cylinder
Maximum speed: 50 m.p.h. (80 km/hr)
Cruising speed: 35 m.p.h. (56 km/hr)
Endurance: 20 hours

various states. The newest Goodyear advertising airship is in Europe, where it was completed in England and flown for the first time on 8 March 1972. This is *Europa*, which has a length of 192 ft 6 in (58·67 m) and is powered by two 210 h.p. Continental IO-360-D six-cylinder engines. This airship almost came to grief, as so many of its predecessors have done, when on 19 April 1972 it tore away from its mooring mast at Cardington, Bedfordshire, and was badly damaged when colliding with some trees near the base.

78 The 'Excelsior' project

Towards the end of the nineteen-fifties Captain Joseph W. Kittinger of the U.S. Air Force made some daring parachute jumps from previously unattempted altitudes. There was a threefold purpose in conducting these tests, which formed part of the so-called *Excelsior* programme. First, the Air Force wanted to ascertain whether the new automatic Beaupre parachute outfit was capable of steadying the free falls from altitudes higher than 100,000 ft (30,500 m) which would become normal practice in the future. It had been established in laboratory tests that a man is subjected to a destructive rotation of no fewer than 465 r.p.m. when he leaves an aircraft (or, for that matter, a space capsule) at an altitude of, say, 82,000 ft (25,000 m) and makes a free fall. This drop form is imperative because of the initial shock, his supply of oxygen and the frigid temperatures to which he is exposed. The Beaupre parachute was the first really new parachute design since 1924. It was provided with a small stabilising parachute with a diameter of 6 ft (1·8 m) – not to be confused with the ordinary small drogue parachute which unfolds the main parachute. The function of the stabilising parachute was to prevent such rotation. The second purpose of the experiments was to test the new, partly pressure-tight suit, designated MC-3, under actual conditions. Last, but not least, the opportunity would be taken to gauge a completely isolated individual's ability to perform all the demanding procedures of the rescue operation without any previous training.

Kittinger was a thoroughly trained parachute jumper and an experienced pilot. He had not only made ordinary jumps, but had also participated in the 'Man High' programme, which can be looked upon as the preliminary to *Excelsior*. Paradoxically, when these programmes were conducted no aircraft with the required ceilings were available. They had to fall back on the oldest form of aircraft: the balloon. Two firms, General Mills and Wintzen, built a pear-shaped balloon of 2,000,000 cu. ft (56,634 cu.m) capacity. Its envelope was made of polyethylene material and it was inflated with helium. This special balloon for the 'Man High' programme had ascended to an altitude of 96,127 ft (29,300 m) in 1 hour 15 minutes before this programme was wound up on 2 June 1957. Kittinger was placed in a small, closed capsule below the balloon envelope, but did not jump on this occasion. It was nevertheless a perilous ascent, as the oxygen supply equipment had been installed wrongly and pumped oxygen away from the capsule instead of supplying to it.

The *Excelsior* programme was divided into three stages, the wide Tularosa basin in New Mexico being the place of departure for all of them.

Excelsior I was launched on 16 November 1959 and was scheduled to climb to an altitude of 60,000 ft (18,300 m). During the ascent the fierce beams of the sun bothered Kittinger and interfered with his instrument readings, almost rendering them impossible. Thus he exceeded his 'ceiling' and

experienced difficulties with the helmet of his pressure suit as it lifted from his shoulders. It was not until he had reached an altitude of 76,050 ft (23,180 m) that Kittinger managed to leave the capsule to begin his long descent. After a free fall lasting only 2½ seconds instead of 16, as planned, the small auxiliary parachute was released that was to unfold the stabilising parachute. This the latter failed to accomplish, since Kittinger was still dropping at an insufficient velocity. To complicate matters even more, the lines of the stabilising parachute wrapped themselves around Kittinger's neck. After falling some 16,000 ft (5,000 m) in this manner Kittinger finally attained a falling velocity of 422 m.p.h. (680 km/hr), and now his body began to rotate at a mad rate. He was unable to stop these rotations and soon lost consciousness. At an altitude of 11,000 ft (3,350 m) the automatic emergency parachute unfolded, only in its turn to become entangled in the wild, fluttering lines of the rest of the equipment. Fortunately, the developer of the parachute, Francis Beaupre, had provided for a situation of this nature by using lines with a low yielding point to retrieve such a perilous dilemma. This yielding point had been reached and exceeded; the lines gave way, and when Kittinger recovered he was gently approaching the ground, borne by his fully-unfolded emergency parachute.

Some lessons had been learned, and experience could also be derived from a film that showed this parachute jump from start to finish. The ascent of the balloon *Excelsior II* went off without any hitch on 11 December 1959. Kittinger left the capsule at an altitude of 74,737 ft (22,780 m) and 12 minutes 32 seconds later was back again on the ground.

Excelsior III accomplished the peak achievement in this run of experiments constituting the survival programme of the U.S. Air Force. On 16 August 1960 Kittinger once more saw the desert sands fade away below him. His capsule was a completely new type, daring to a degree hitherto unheard of, as it was completely open on one side and at the top. Everybody was supremely confident that Kittinger's pressure suit and the rest of the equipment worn by him would work perfectly. In this 'battledress' Kittinger weighed almost 310 lb (140 kg) when he took off at 5 a.m. The top of his large shining balloon projected 394 ft (120 m) above his head. The Schjedahl firm had built this balloon and its envelope was made of mylar plastic material. Kittinger got badly scared when, at an altitude of 48,000 ft (14,630 m), he discovered that the right glove of his pressure suit did not function properly. On the threshold to the 100,000 ft (30,000 m) altitude his hand was numb and quite useless. Kittinger was overcome by the idea of his complete isolation, but by applying great will power managed to reason himself out of this psychological crisis. When Kittinger had reached the altitude of 102,890 ft (31,370 m) – on the threshold of space – he stepped from the edge of the capsule with these words on his lips, 'God, I resign myself into your hands'. Kittinger tape-recorded his descent and left all manipulations to his automatic equipment, which worked perfectly in spite of his subjection to a speed of 615 m.p.h. (990 km/hr) by the time he was passing the 85,000 ft (26,000 m) altitude mark. He was not rotating at all, but that speed is something which the human body has no way of grasping and Kittinger did not feel it at all. The full duration of his descent was 13 minutes 45 seconds, of which the free fall itself lasted only 4 minutes 37 seconds. However, when a human being, even for a few brief moments,

is travelling like a comet, each minute feels like eternity.

The valuable experience gained from the *Excelsior* programme was the outcome of intensive teamwork by many people over an extended period of time, but in the end the dauntless contribution of one single individual was all-decisive in carrying it to a successful conclusion. Towards the end of the 'fifties other valuable experiments with both manned and unmanned balloons were also conducted. All these studies were preliminaries to the coming explorations and travels in space.

79 **The modern hydrogen balloon** The well-established ball-shaped free balloon, inflated either with hydrogen or with coal gas, has its faithful devotees even today in spite of a degree of inherent fire hazard. Except for the years of the two world wars the interest in this field has never flagged, nor does it ever lack excitement. It is interesting, too, that the modern gas balloon is almost identical with the one that the Frenchman Charles introduced as far back as 1783 (see No. 2).

The aeronaut of today belongs to a small and exclusive circle of enthusiasts who thoroughly enjoy their leisurely aerial jaunts, leaving the selection of their destination to the caprices of the wind. In splendid isolation and salutary silence they float across the ever-changing landscape by day (or night, when an enchanting Moon may turn the ground below into a fairyland). If they want to stay up for any length of time, or hope to cover considerable distances, balloon pilots still have to avail themselves of the gas-filled type. For, even though a modern variety of the hot-air balloon has become quite popular, that style of balloon is limited to trips of a few hours' duration. The sporting element enters when balloon races are arranged. The pilots may compete to discover who can cover the greatest distance or manage to land closest to a pre-fixed goal. 'Fox hunts' are another popular form of balloon competition. One balloon will start as the 'fox' and the other participating balloons will strive to descend as close to the landing spot of the 'fox balloon' as possible. Today Holland, Switzerland and Germany are the most active ballooning countries.

Balloon races reached the peaks of their popularity in the periods from 1900 to 1914 and again between 1920 and 1939. The Gordon Bennett balloon races were the most important annual event of an international character. James Gordon Bennett was the very wealthy owner of the *New York Herald* newspaper who offered a trophy bearing his name and 12,500 francs (when money was still on the gold standard) to be competed for annually, the winner being the pilot landing his balloon farthest away from the starting point. The first Gordon Bennett balloon race was held in Paris on 30 September 1906 and was won by Lieutenant Frank P. Lahm, U.S. Army. He flew to Yorkshire, in England, a distance of 402 miles (647 km), in his balloon *United States*. The race was always held in the country of the previous year's winner, and in this manner the first series continued until 1920, interrupted only by the war years. The second series was held from 1925 to 1928, the third series in 1929 and 1930, and the fourth series from 1932 to 1938.

The Gordon Bennett balloon races were always very dramatic, but fortunately often also interspersed with comical incidents. The most hazardous course was that of the 1923 race, held in Brussels on 23 September. Five aeronauts were killed at the start and five more were injured. These fatal accidents were caused either by flashes of lightning hitting the balloons or by

their collision with high-tension wires. In 1925 the race was again held in Brussels and this time one of the participants, the pilot of the American balloon *Goodyear III*, accomplished nothing less than sailing out over the sea to land directly on the bridge of a steamer. Another American balloon entered in this event, *Elsie*, collided with a passing train when it landed at Étables in Bretagne. Each country was always limited to three entries, so formerly the races were often preceded by elimination heats as there was keen rivalry among balloon pilots for the honour to represent their national colours.

World War 2 ended the Gordon Bennett balloon races for good. Ballooning was resumed after the war and in the United States balloon ascents served as a preliminary stage in the training of new airship pilots. The balloons used for this purpose were of the so-called ZF type and three different sizes were used, of 9,000, 35,000 and 90,000 cu.ft (255, 991 and 2,548·5 cu.m) capacity respectively.

When in 1913 the German Hugo Kaulen from 13–17 December covered the distance of 1,756 miles (2,827 km) from Bitterfeld in Saxonia to the Perm district in Russia in 87 hours, in his balloon *Duisburg* of 56,500 cu.ft (1,600 cu.m) capacity, he set a duration record for balloons which stands unbeaten to this day. He then also established a world's distance record for balloons, but this was beaten by his compatriot Hans Rudolf Berliner who, on 8–10 February 1914, followed very much the same route in his balloon *SS* of 59,330 cu.ft (1,680 cu.m) capacity. He managed on this occasion to cover a distance of 1,915 miles (3,082 km), which has never been surpassed. On this world's distance record for balloons Berliner stayed in the air for 47 hours.

The safari balloon *Jambo* provided striking evidence of the ability of the modern sports balloon to serve a practical purpose as well. In 1962 the British zoologist, traveller and newspaper reporter, Anthony Smith, conceived the idea of covering the eastern part of the African continent in a balloon by taking advantage of the predominant north-east winds blowing there during the early months of the year. The clever part of his reasoning was that his silently-drifting free balloon would enable him to observe and immortalise on film the copious and diversified wild animal life cavorting on the big plains without disturbing the animals in their natural environments. In Belgium Smith had a hydrogen balloon of 28,250 cu.ft (800 cu.m) capacity built with a total lifting capacity of 1,695 lb (769 kg). He selected the Zanzibar island off the east coast of Africa as his starting point, and there he established a depot with 60 steel bottles containing compressed hydrogen. Another 120 containers were stored in Arusha in Tanganyika.

At the outset of 1963 *Jambo* began its air crossing of the African continent. It extended over a number of weeks and called for several intermediate landings and refillings. The expedition consisted of four members, one of them being the well-known photographer Alan Root from Kenya. With his 16 mm Arriflex movie camera and 35 mm mirror reflex cameras, this expert secured a long succession of magnificent shots, with sound effects, of the undisturbed animals. The highlight was a series of all-encompassing views of enormous herds of animals in the National Park in Tanganyika, where the expedition finished. They were of a breath-taking character and demonstrated that Smith was right in considering the free balloon the ideal vehicle for an aerial safari. The animals not only tolerated

Jambo, but often even looked upon the balloon as belonging to their own herd.

80 The modern hot-air balloon

Today most people take it for granted that large, shining aeroplanes as speedy matter-of-fact vehicles transfer them to distant vacation spots in a few hours. One reflects then with respect that there are still singular individuals left who enjoy nothing better than to entrust themselves to a wicker basket slung below a feather-light balloon to be borne to such unpredictable destinations as the whims of the wind may whisk them. This assumes even more of a romantic aspect when the evolution returns to the point whence it started: for the aerial steeds mounted by these modern sky roamers often revert to the hot-air principle of the Montgolfier brothers' balloon.

The re-birth of the Montgolfière baltoon type is due mainly to economy, for the hot-air balloon is the cheapest way of indulging in this sport (working out to roughly £1·30 per hour per passenger.) In several countries aeronauts may still, by good fortune, be able to procure hydrogen cheaply for the filling of their balloons, if the gas chances to be a by-product of the local chemical works. Otherwise a filling with coal gas may run to about £200.

Today the biggest number of hot-air balloons is to be found in the United States, where some forty of them are privately owned. In Great Britain there are more than 20 hot-air balloons, and in several other countries two or three – though these figures may well be obsolete by the time these lines appear, as ballooning – not least with the hot-air type – steadily gains new adherents. In America Don Piccard, a nephew of the stratosphere explorer Auguste Piccard, has established himself as a manufacturer of hot-air balloons.

The envelope of a modern hot-air balloon is generally made of tear-proof nylon with panels of an almost semi-circular shape. There are both a valve opening and a ripping-panel in the envelope. Houses without connection to gas pipelines, and caravans often use a gas supply in the form of butane stored in steel bottles. Propane gas in liquid state is a similar heating source, generating much heat and used extensively for industrial applications; and Propane gas is well suited as a heating source for hot-air balloons. This gas is fed from pressure bottles mounted above the car into evaporation spiral tubes in the burner. These spirals surround the flames that are lit with a match. The balloon envelope is filled with hot air on the ground by placing the burner below the opening (mouth) in the envelope, and when the hot air has caused the envelope to rise the gas bottle is mounted in its place above the car. Then the balloon is ready to ascend. By applying the full pressure of the burner for some seconds, at intervals of about 30 seconds, the balloon will maintain its altitude or climb. When the air inside the envelope cools off the balloon descends.

Many look upon the combination of balloon envelope and open fire as the height of reckless folly, but the nylon material is often coated with polyurethane and does not ignite. Even if the fabric should be scorched, the holes created cause no ill effect. It is obvious that the occupant or occupants of the hot-air balloon are not anxious to run any undue risks, especially as their equipment represents a monetary value of some £2,000.

GLOSSARY

Appendix. The circular neck below the balloon envelope through which it is filled with gas. The appendix is left open during the trip to allow gas to escape when the balloon is heated by the sun.

Ballonet. A separate bag inside the envelope in most non-rigid and semi-rigid airships which, by means of a blower, can be filled with atmospheric air to maintain the pressure in the envelope if gas is lost, and thereby keep the envelope fully expanded.

Bottom valve. A valve mounted at the bottom of an airship envelope and acting as a safety valve, since it opens if the pressure inside the envelope exceeds the safety limit (from one-fifteenth to one-twentieth of the yield point of the envelope).

Captive balloon. A lighter-than-air craft with no propulsion means, normally moored to the ground.

Equator. The maximum horizontal circumference of the balloon envelope.

Free balloon. A lighter-than-air craft with no propulsion means, that is not moored.

Gas cell. A container, generally cylindrical and filled with gas, which provides part of the lift of an airship. The number of gas cells varies depending upon the size of the airship. They may also be of different sizes; then the largest cells will be found amidships. The more recent airships were provided with from 12 to 16 gas cells varying in size from about 99,000 to 990,000 cu.ft (2,800 to 28,000 cu.m).

Helium. The second lightest of all elements (35,315 cu.ft, 1 cu.m at 0°C weighs 0·353 lb, 0·16 kg), with a lifting capacity 93 per cent of that of hydrogen. Helium is derived from natural gas as a by-product and has the advantage of being non-inflammable.

Hydrogen. The lightest of all elements (35,315 cu.ft, 1 cu.m, at 0°C, weighs 0·242 lb, 0·11 kg). Can be produced by various methods and is inflammable. Hydrogen also becomes explosive by the addition of as little as 6 per cent of air.

Non-rigid airship. An airship in which the shape of the envelope is maintained only by the inside pressure.

Payload. The revenue-producing load comprising passengers and/or cargo.

Range. The longest distance that an aircraft can travel.

Rigid airship. An airship in which the shape of the hull is maintained by means of a rigid framework.

Ripping panel. A panel glued on the inside of the balloon envelope. When pulled during landing it serves to empty the balloon quickly of its gas content.

Semi-rigid airship. An airship with a non-rigid envelope that is attached to a component (keel) which is rigid or composed of connected, rigid sections that carry the load.

Top valve. A valve mounted on top of the balloon or airship envelope. Actuated automatically or by hand.

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The first part of this index lists all balloons and airships illustrated and described or referred to. The second part lists the balloon and airship pioneers and others who played an active part in the development of these types of aircraft, including designers, pilots, commanders, officers, passengers and crew members. The bold figures in brackets after the names and designations are the reference numbers of the colour plates and text descriptions of the various balloons, airships or personalities. Other figures in bold type indicate the pages on which the main text description falls; additional references, on other pages, are indicated in ordinary type.

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