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.

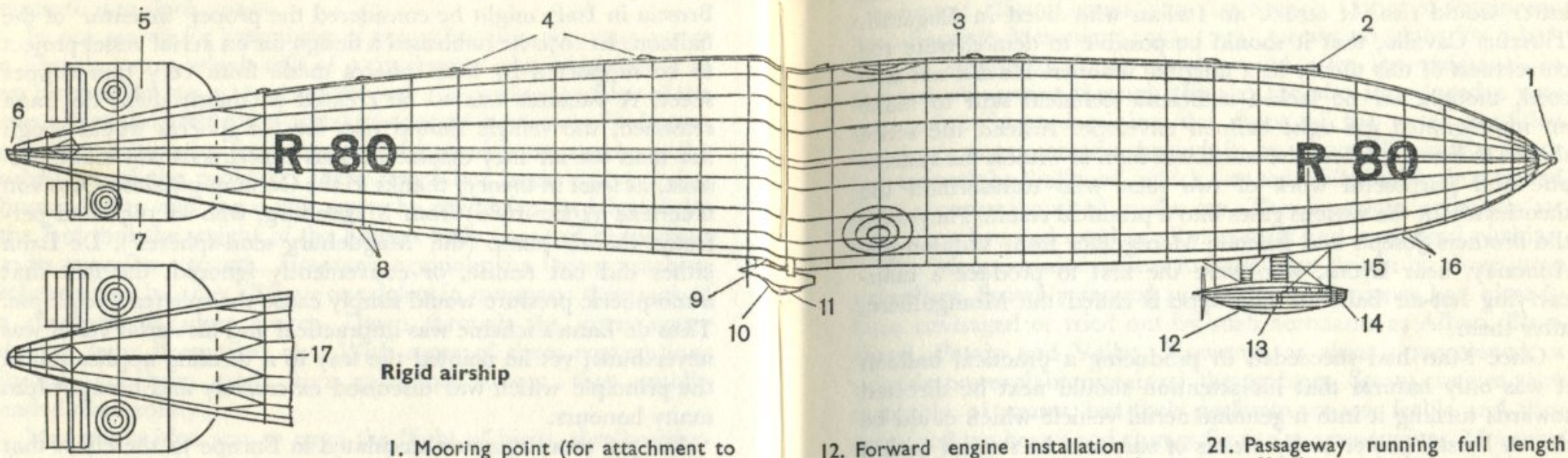
Man's first idea was to copy the flight of birds, the 'heavier-than-air' principle. It had to be abandoned for a while and at the beginning of the seventeenth century a new conception came about: air travel had to be tackled on the 'lighter-than-air' basis. The French author Jean-Savinien Cyrano de Bergerac (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.

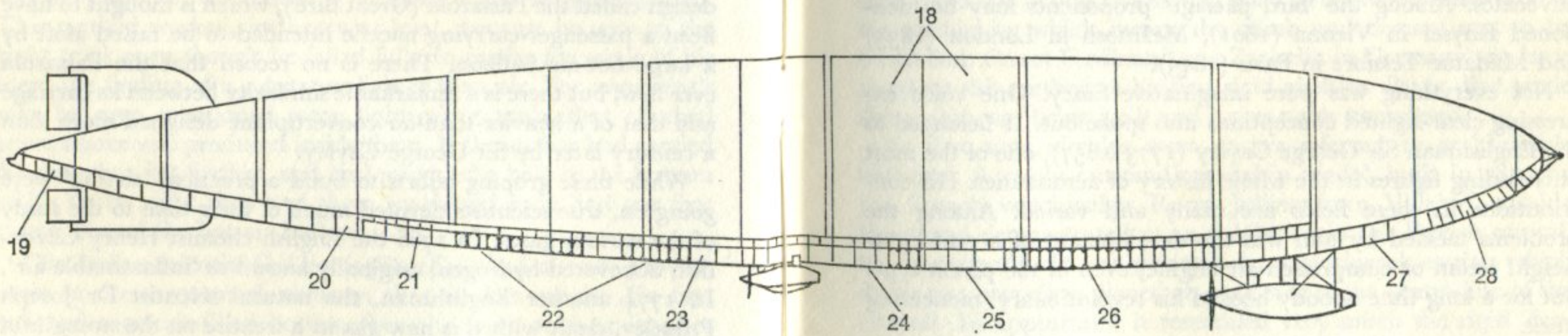
While these groping efforts to build a practical 'airship' were going on, true scientists devoted much of their time to the study of the various gases. In 1766 the English chemist Henry Cavendish discovered hydrogen, originally known as 'inflammable air'. In 1774 another Englishman, the natural scientist 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.

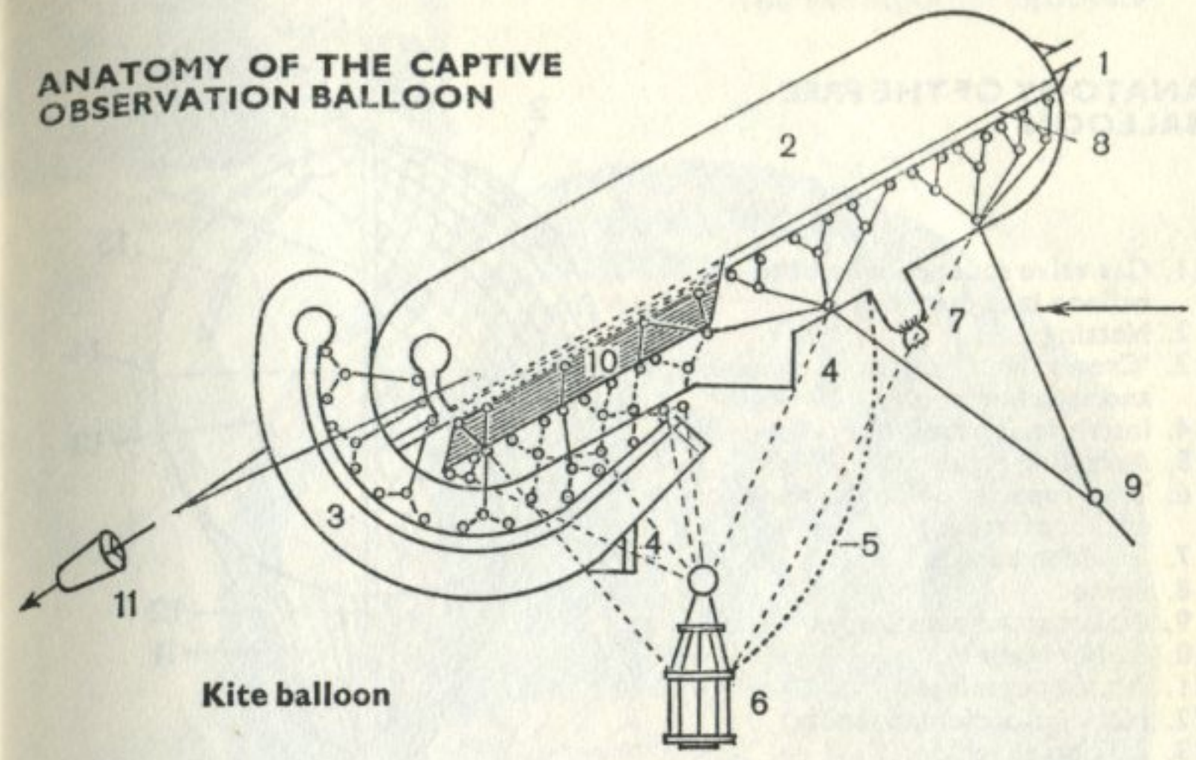
The advantages of the modern airship may be listed as follows: its frame can today be made of plastics materials, and the gas cells will be filled with helium. Today this element is available in much larger quantities than formerly; and, what is still more important, is now available outside the United 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.

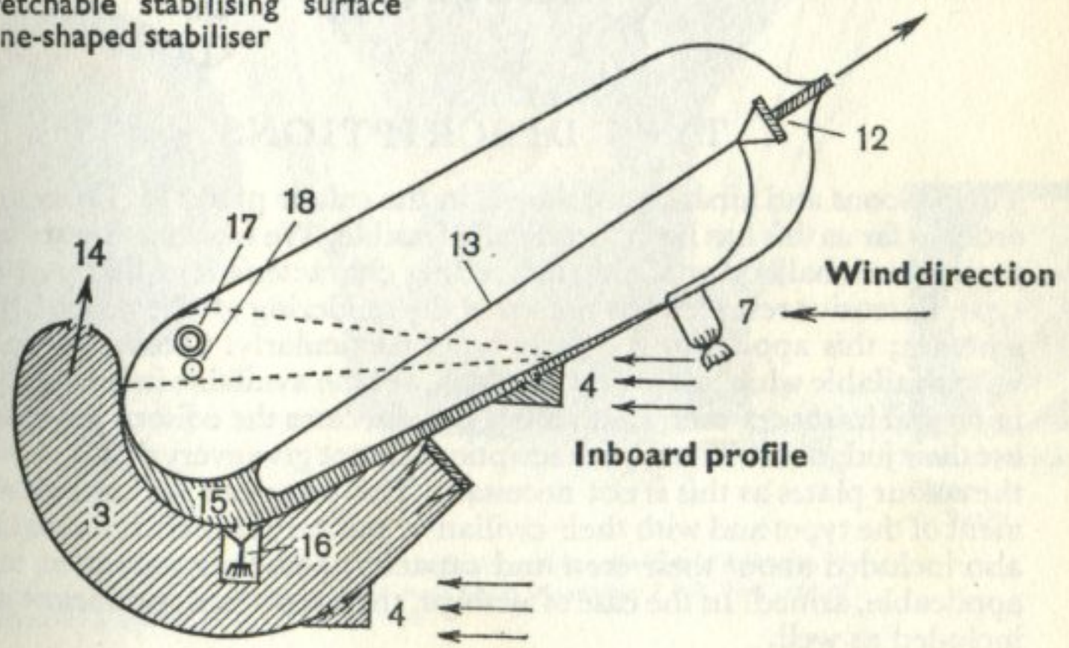
One point is not in dispute. It would be a great pity if people of today should be deprived of the magnificent sight which impressed former generations so much: to witness one of the 'Queens of the Sky' soar by across cities and countryside, unperturbed by noisy and smoke-trailing jet aeroplanes hurrying 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

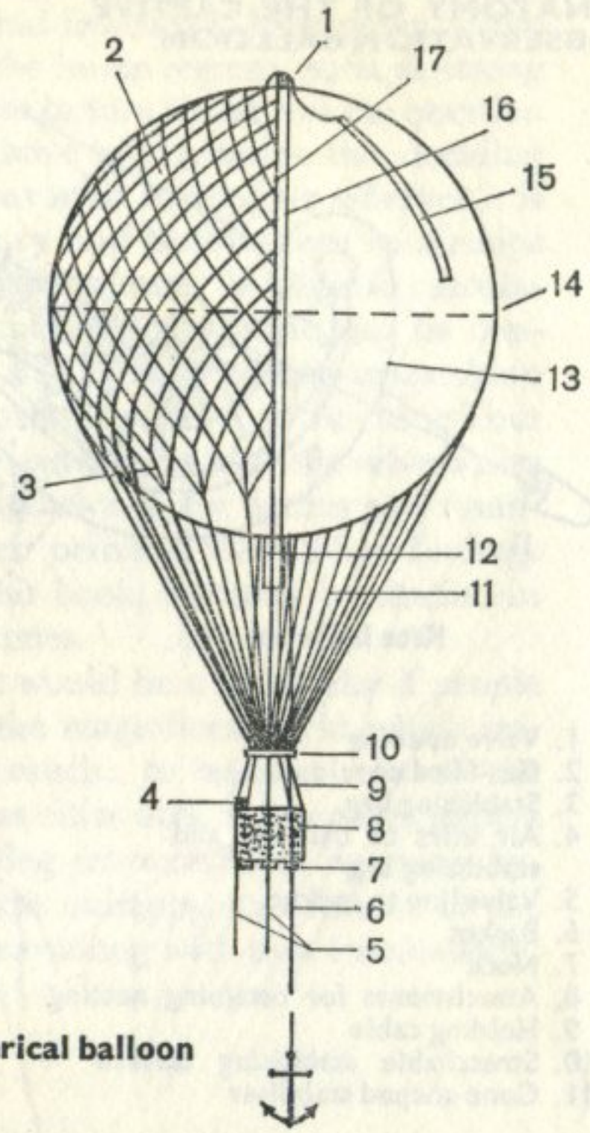
1. Valve opening
2. Gas-filled envelope
3. Stabilising bag
4. Air inlet to ballonet and stabilising bag
5. Valve line to basket
6. Basket
7. Neck
8. Attachments for retaining netting
9. Holding cable
10. Stretchable stabilising surface
11. Cone-shaped stabiliser
12. Main valve
13. Valve line inside balloon 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

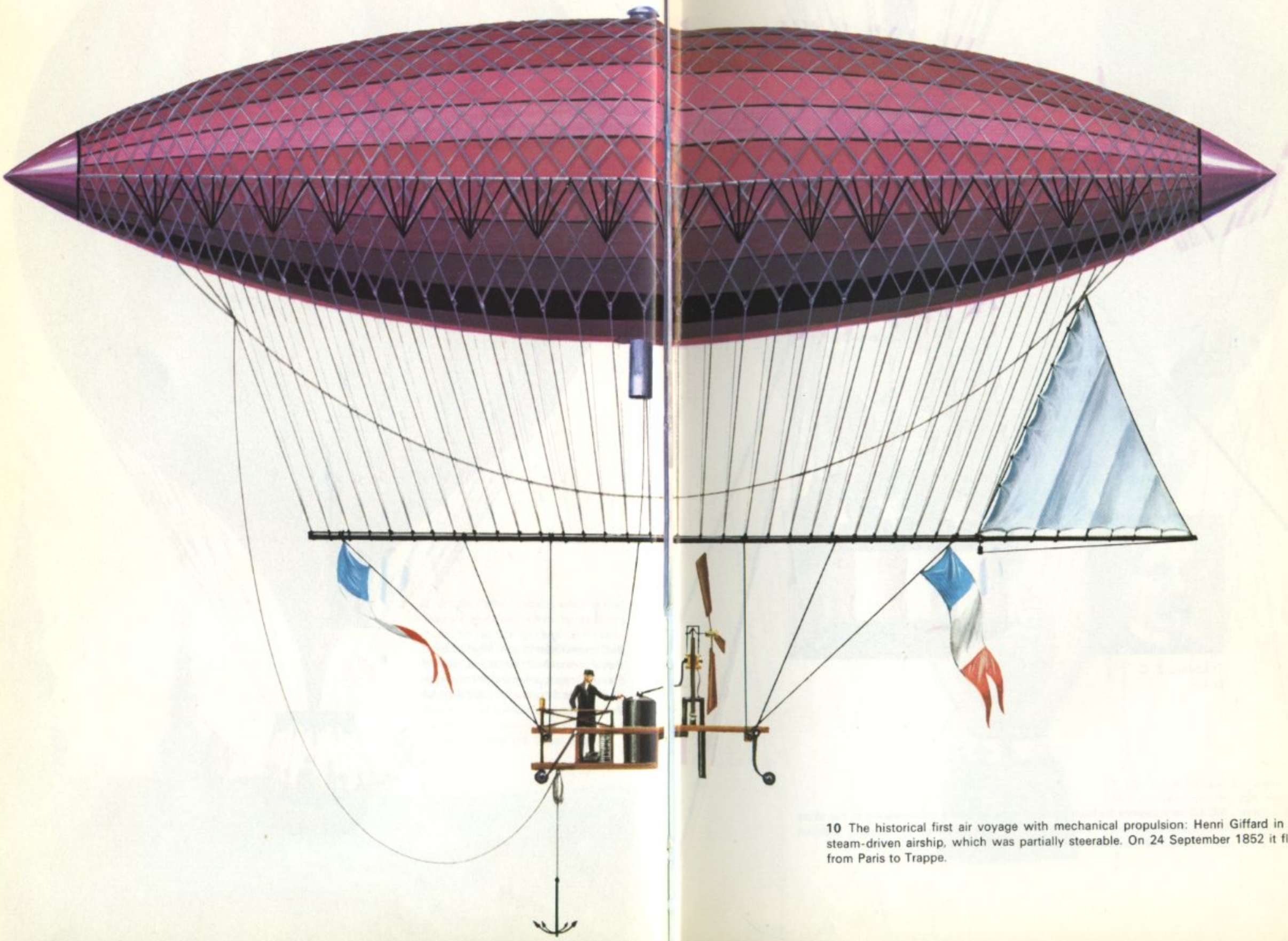
6 The balloon *L'Entreprenant* became the first aerial reconnaissance vehicle on record. It was sent aloft as a captive balloon observation post during the battle at Fleurus on 26 June 1794. The balloon basket was manned by Captain Jean Marie Joseph Coutelle, C.O. of the French Army Balloon Corps, and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

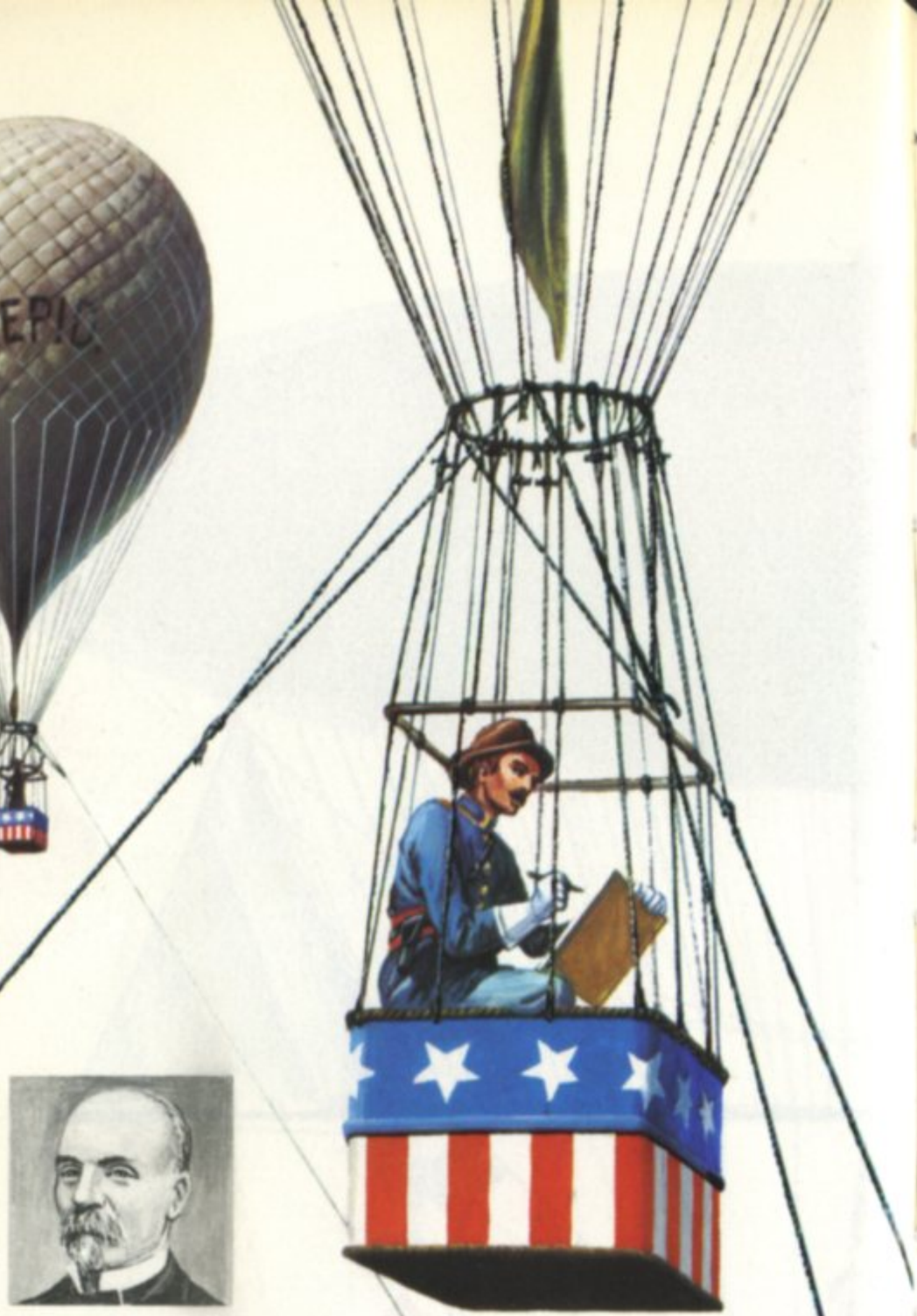
8 Johan Peter Colding was the first Danish aeronaut. Here he ascends from the parade ground of Rosenborg castle in Copenhagen on 10 November 1811. By royal command, in 1808 Colding experimented with air mail, sending letters to King Frederick VI by unmanned balloons between the islands of Funen and Zealand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

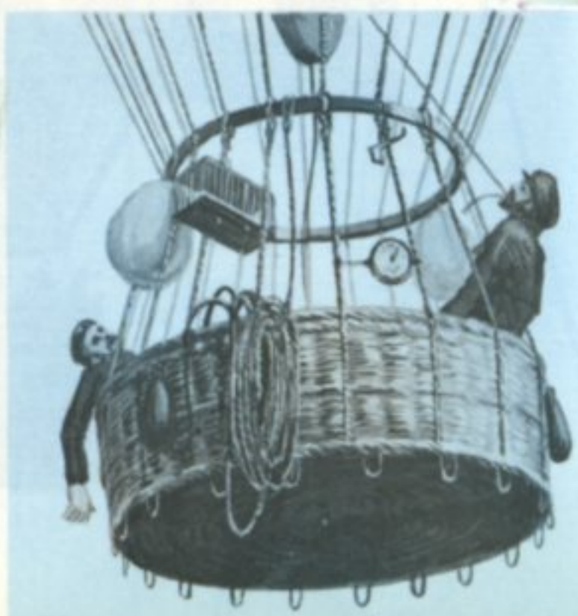
11 Lowe's captive balloon *Intrepid* making aerial observations in the skies above Maryland on 8 December 1861. The observer in the car is Colonel W. F. Small of the Federal Armies, sketching the enemy positions.

Le Géant

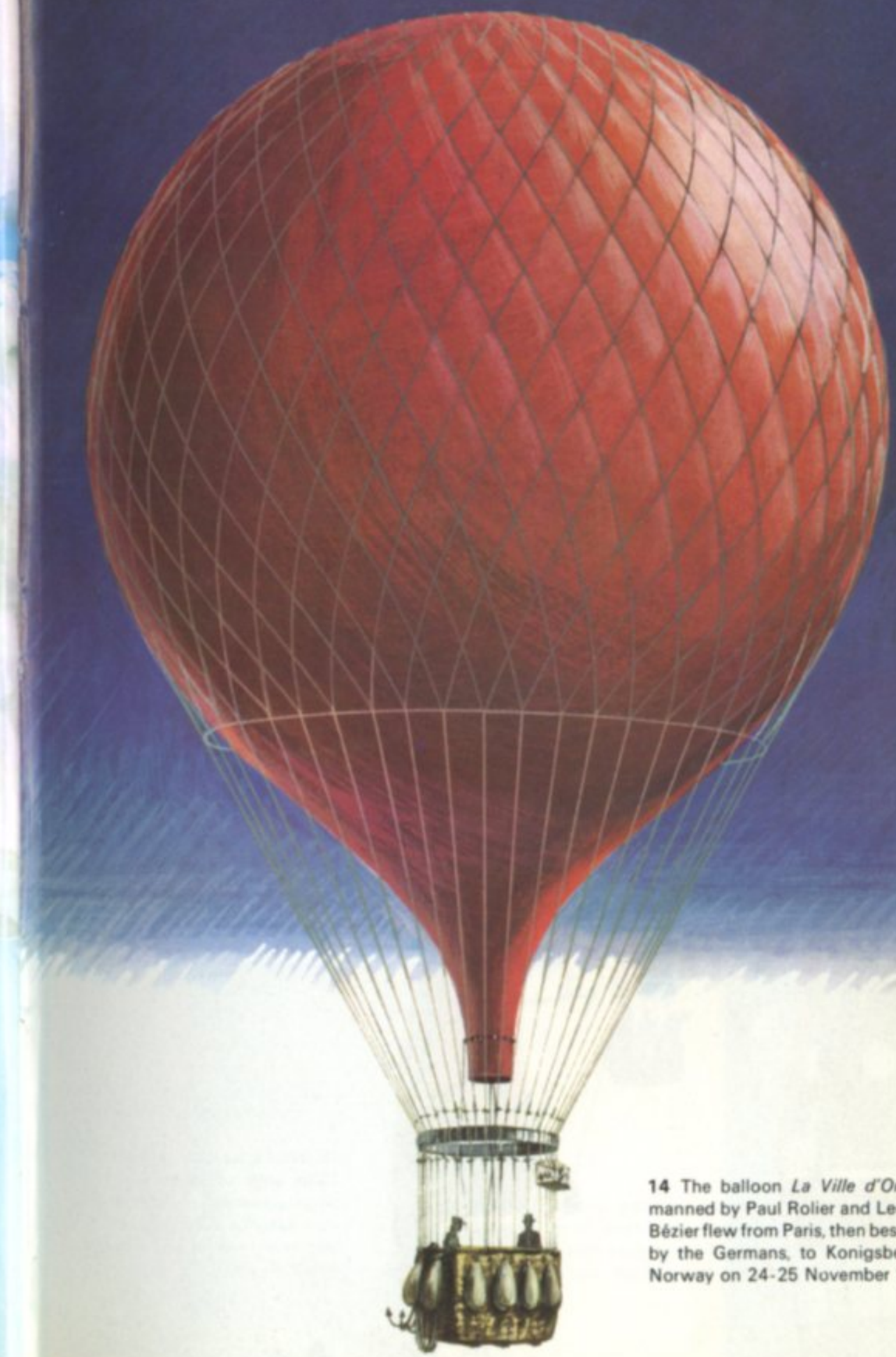
12 The huge balloon *Le Géant* of 1863. It belonged to the French photographer Nadar, whose real name was Gaspard Félix Tournachon.

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

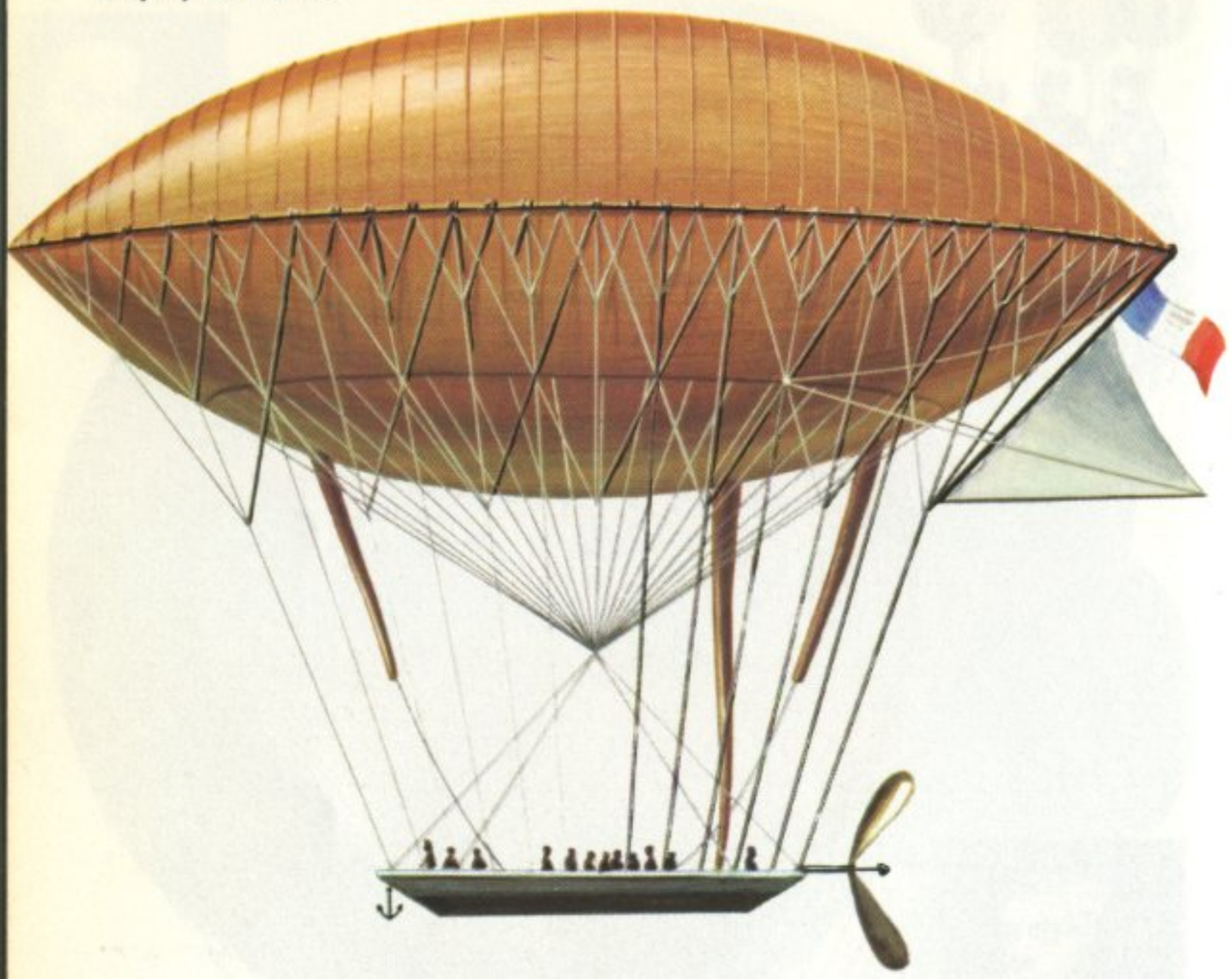
15 Wise's balloon *Atlantic* of 1859, with which he planned an aerial crossing of the Atlantic from America to Europe. *Left:* A sectional view of the cleverly designed car.

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

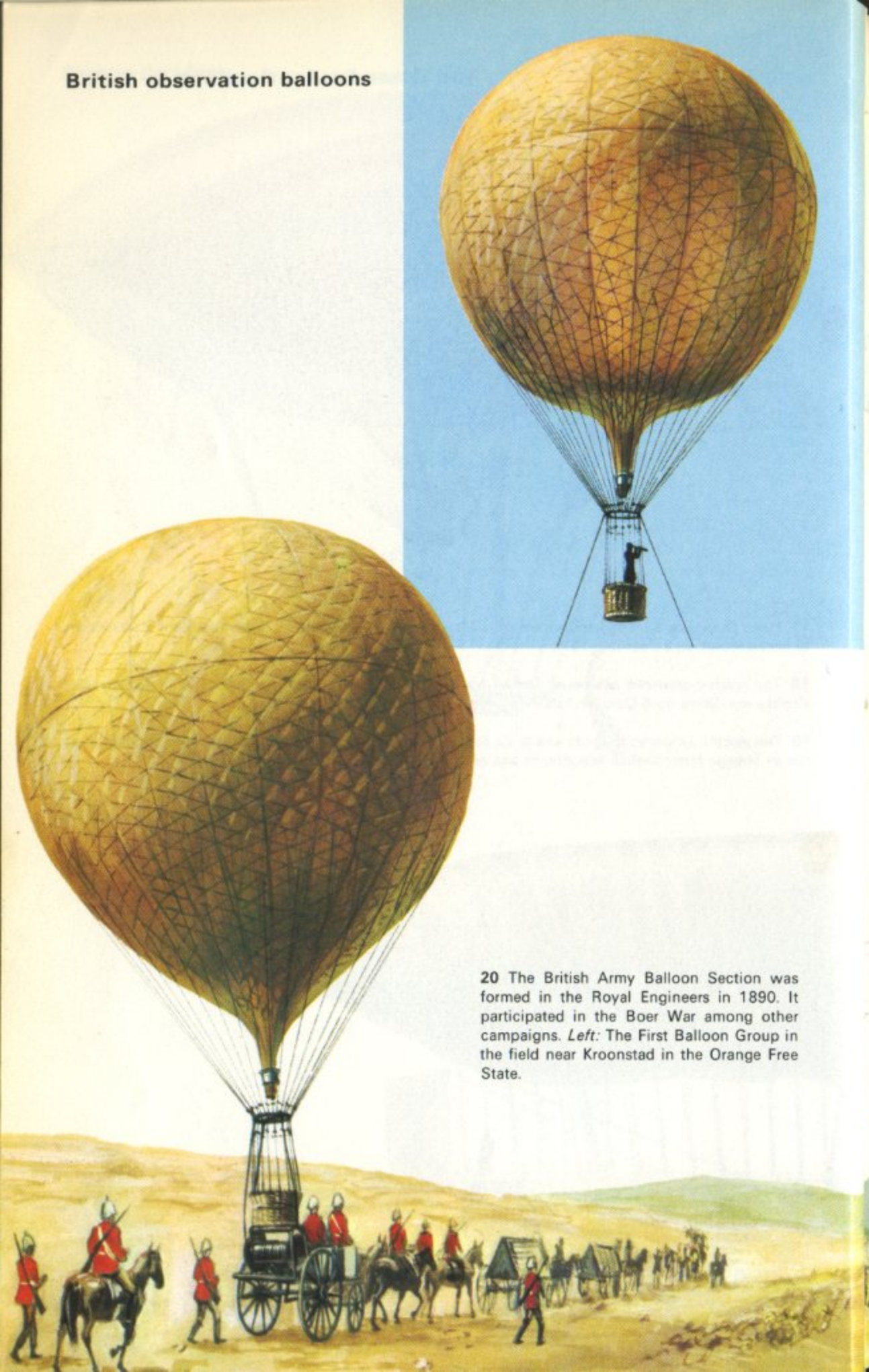


The Tissandier brothers and La France

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.

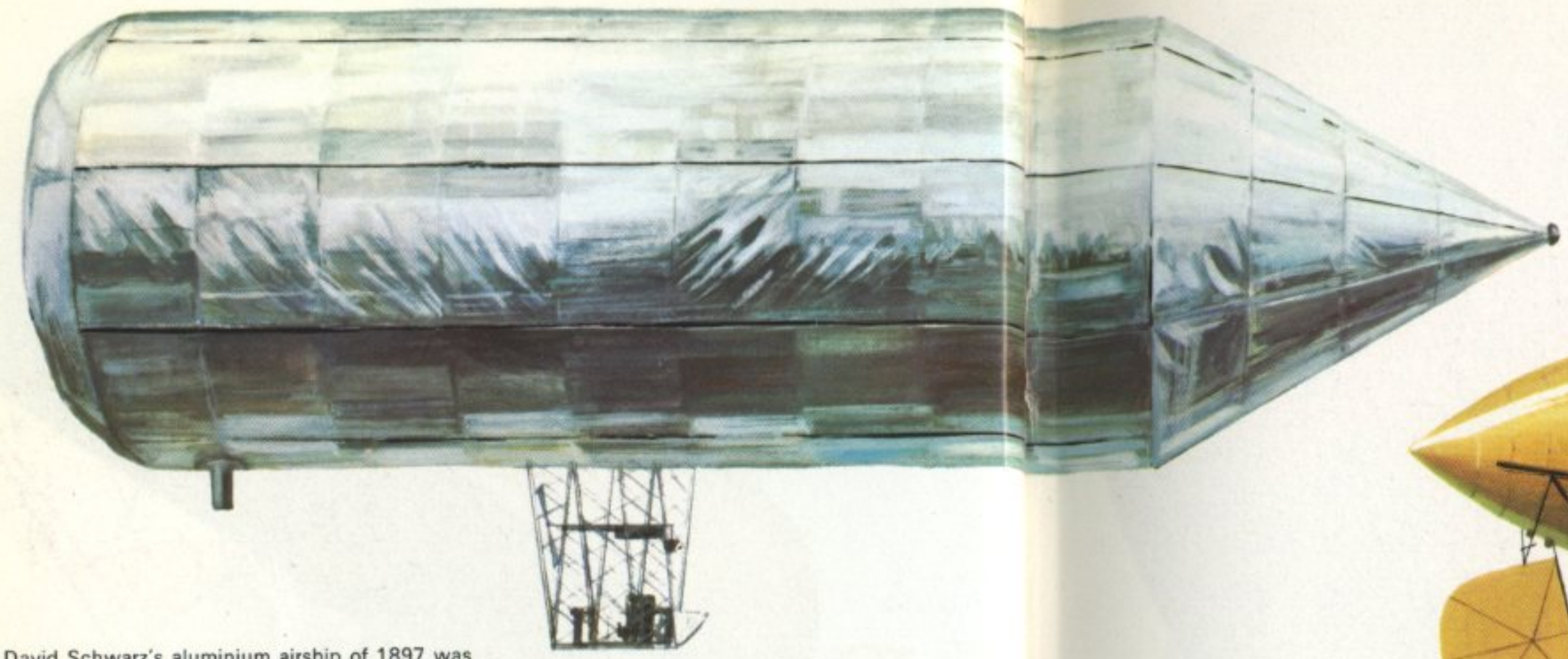
18 The electric-powered airship of Gaston and Albert Tissandier during its trial flight from Auteuil to Croissy-sur-Seine on 8 October 1883.

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.

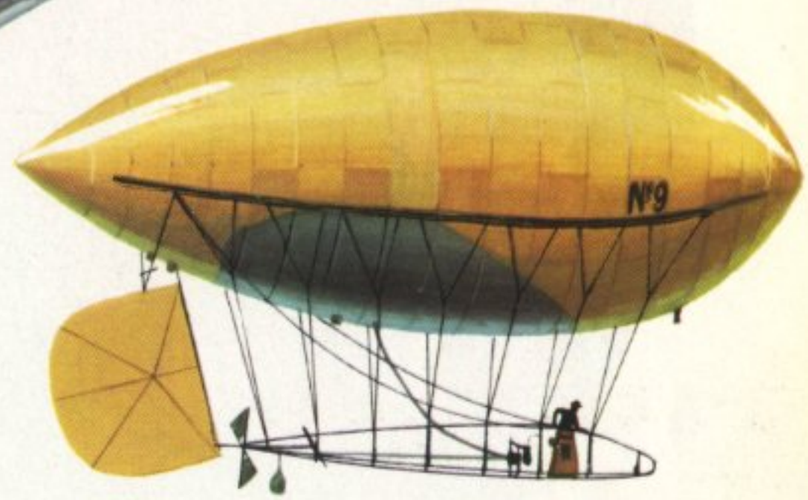


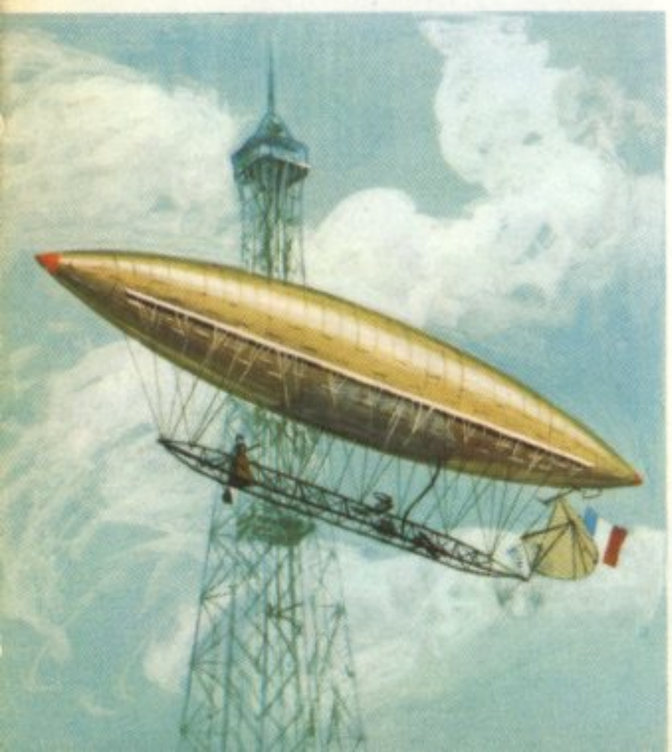
20 The British Army Balloon Section was formed in the Royal Engineers in 1890. It participated in the Boer War among other campaigns. *Left:* The First Balloon Group in the field near Kroonstad in the Orange Free State.

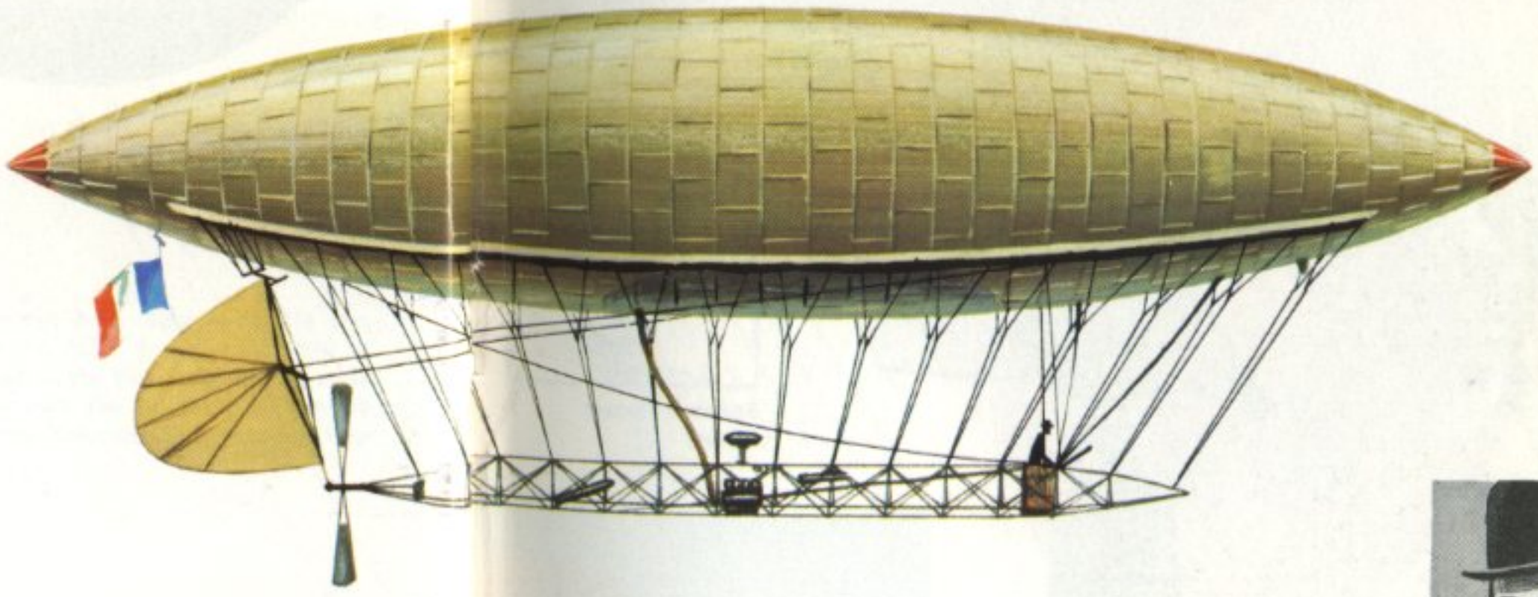
21 The Parseval-Sigsfeld kite-type observation balloon of the German Army, introduced in 1898. They were used in great numbers during the First World War.



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.



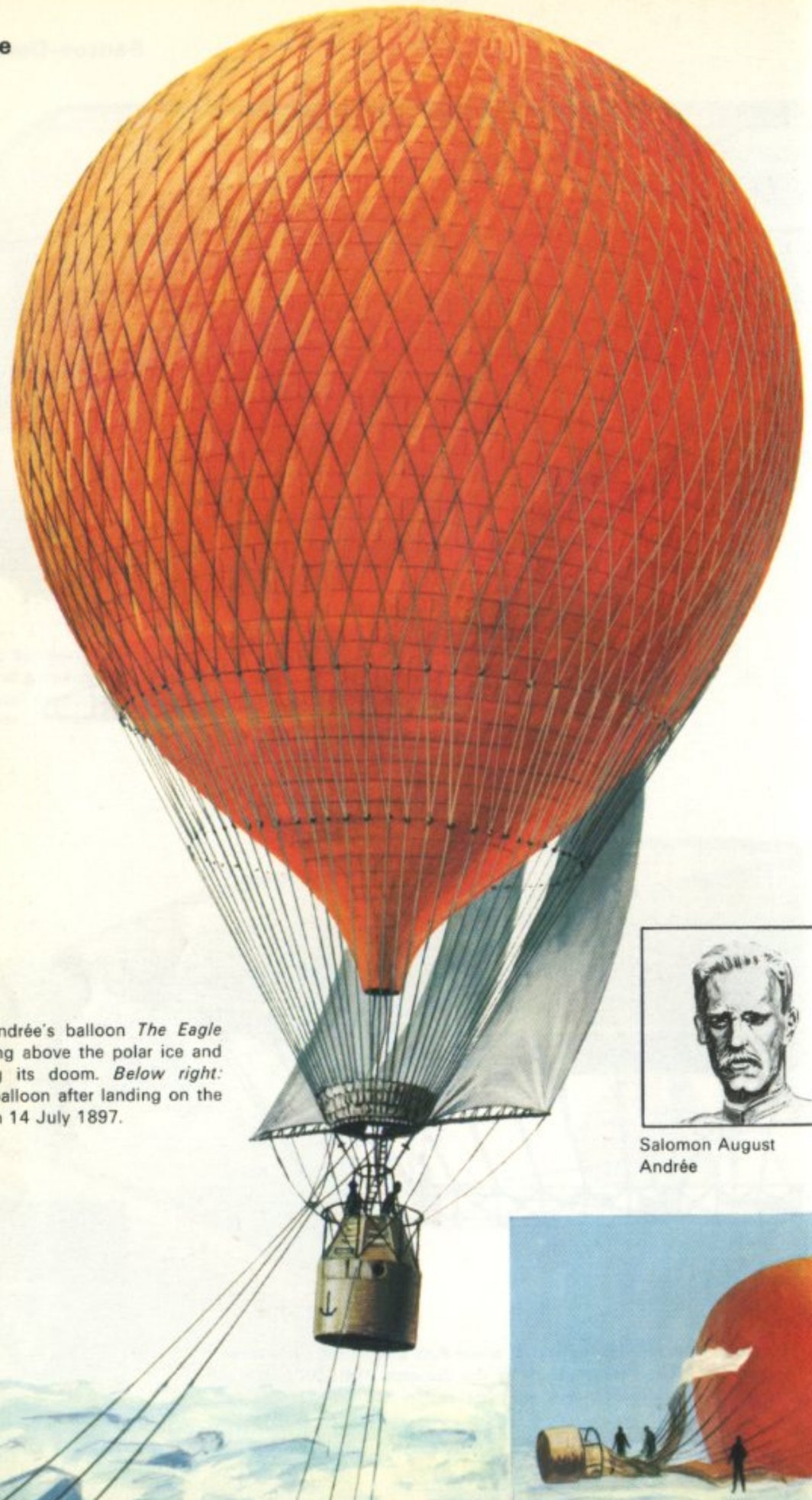




23 Santos-Dumont's airship 'No. 6' which flew around the Eiffel Tower on 19 October 1901, thereby winning the Deutsch 100,000 francs prize. *Above:* Santos-Dumont's small dirigible airship 'No. 9'

Alberto
Santos-Dumont

Eagle



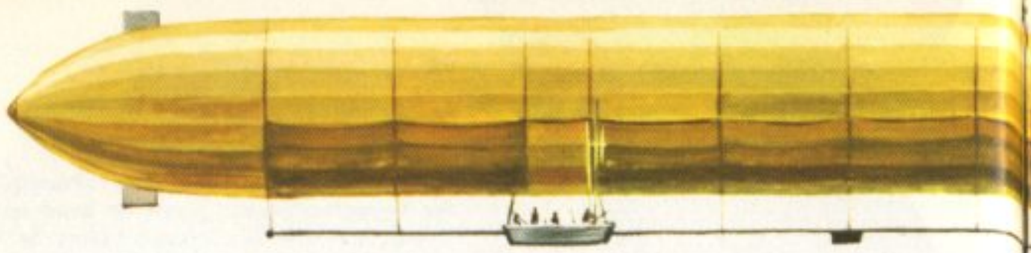
24 Andrée's balloon *The Eagle* floating above the polar ice and facing its doom. *Below right:* The balloon after landing on the ice on 14 July 1897.

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

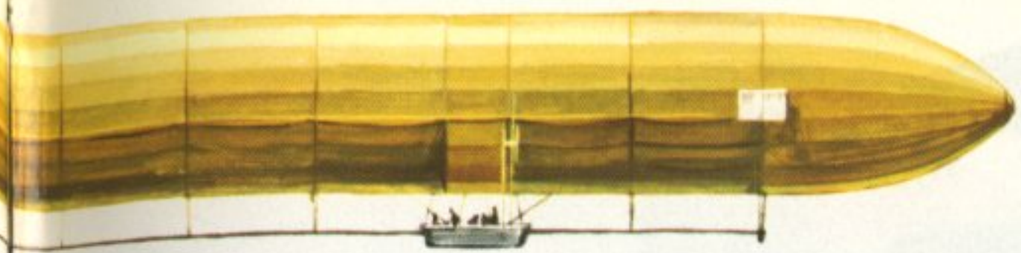


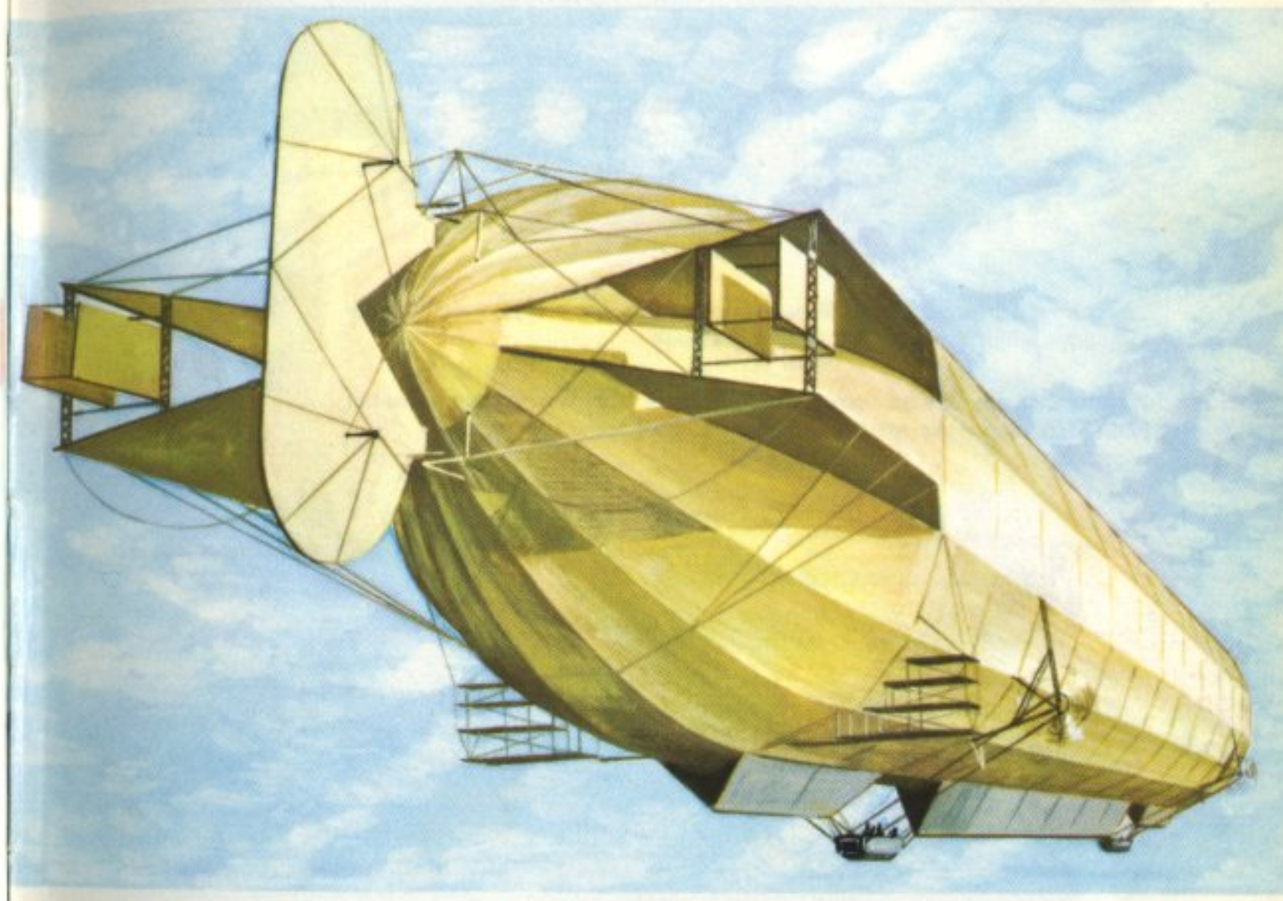
Ferdinand
von Zeppelin

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.

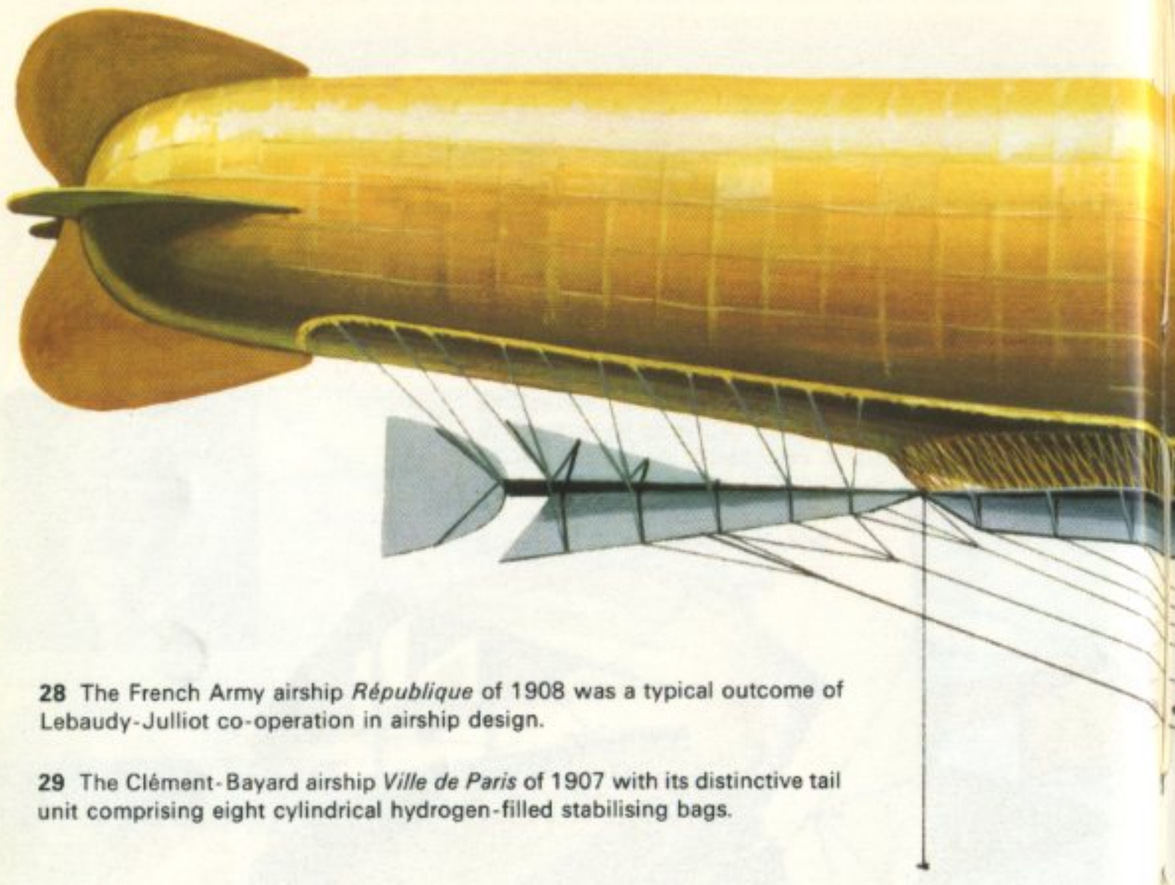
27 *Below and left:* Zeppelin LZ 7 *Deutschland* (Germany) of 1910, the first commercial airship, which carried a total of 220 passengers before it was wrecked over the Teutoburger forest near Osnabrück during a storm on 28 June the same year. *Right:* Zeppelin LZ 5 (Z II). This rear view shows the multiple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

Zeppelin LZ 7



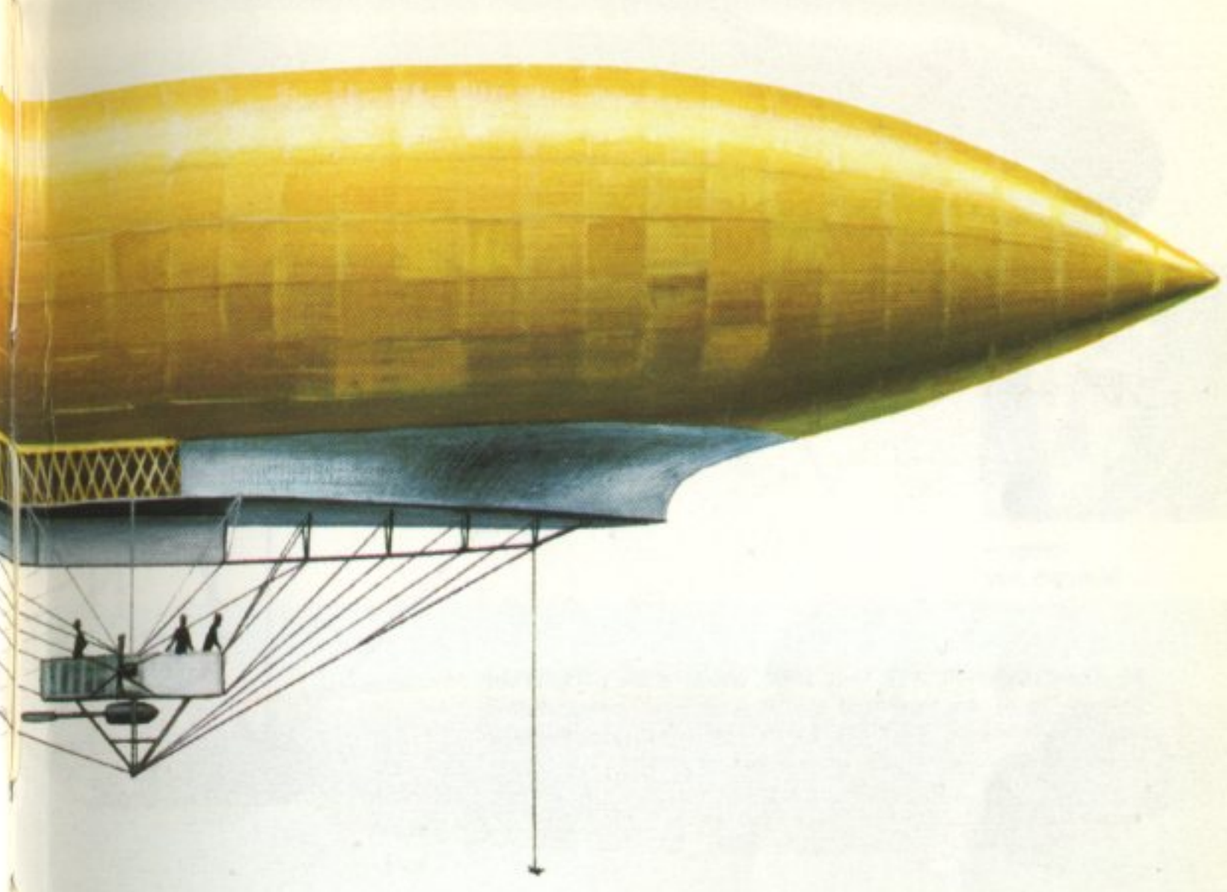


République

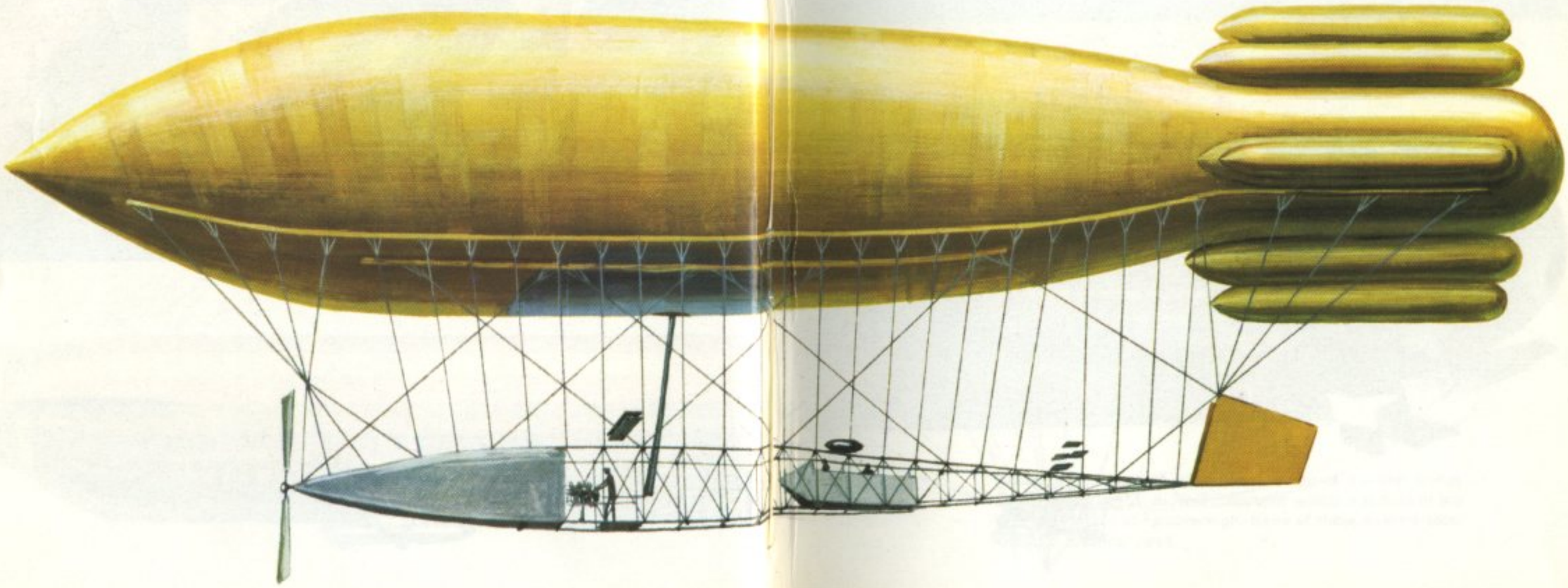


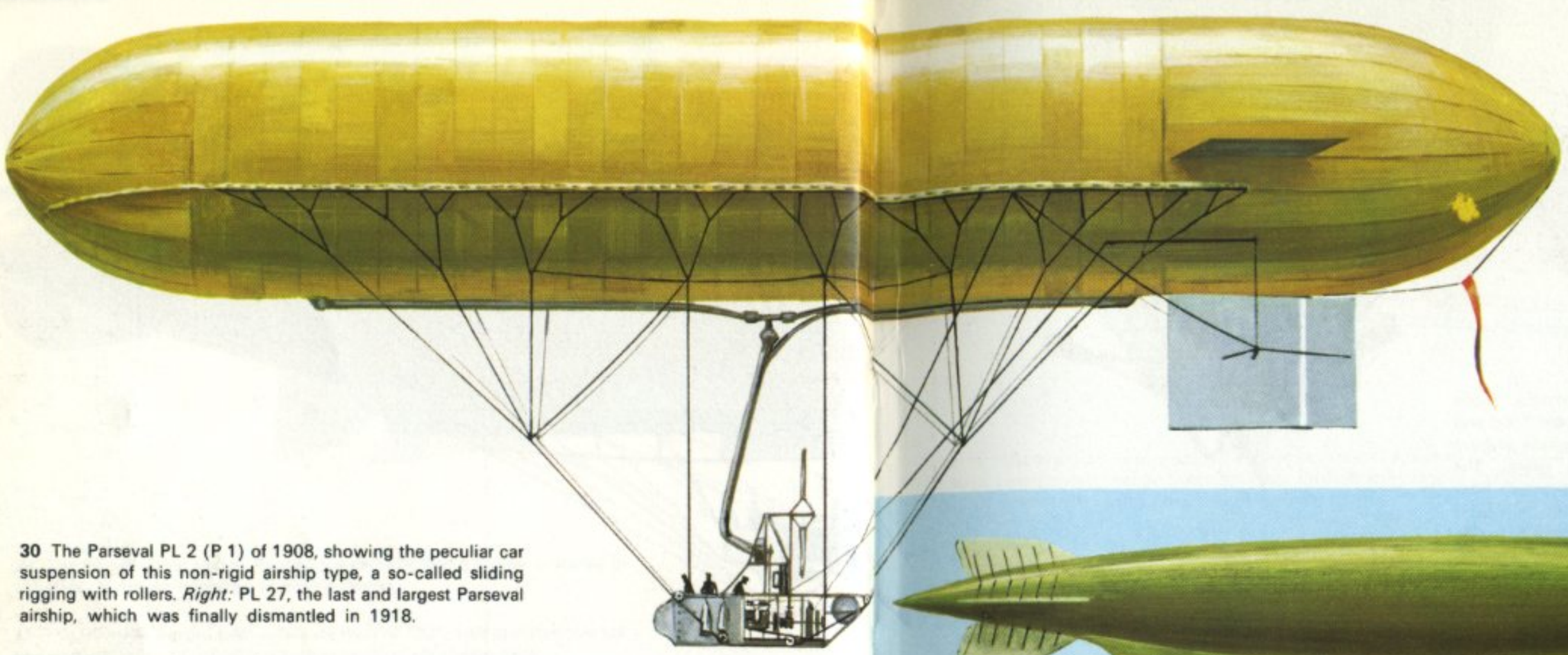
28 The French Army airship *République* of 1908 was a typical outcome of Lebaudy-Julliot co-operation in airship design.

Ville de Paris



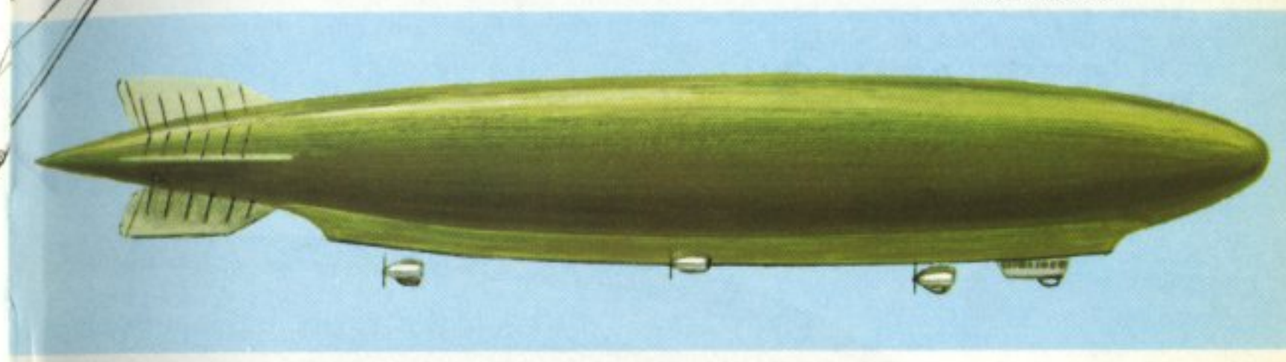
29 The Clément-Bayard airship *Ville de Paris* of 1907 with its distinctive tail unit comprising eight cylindrical hydrogen-filled stabilising bags.

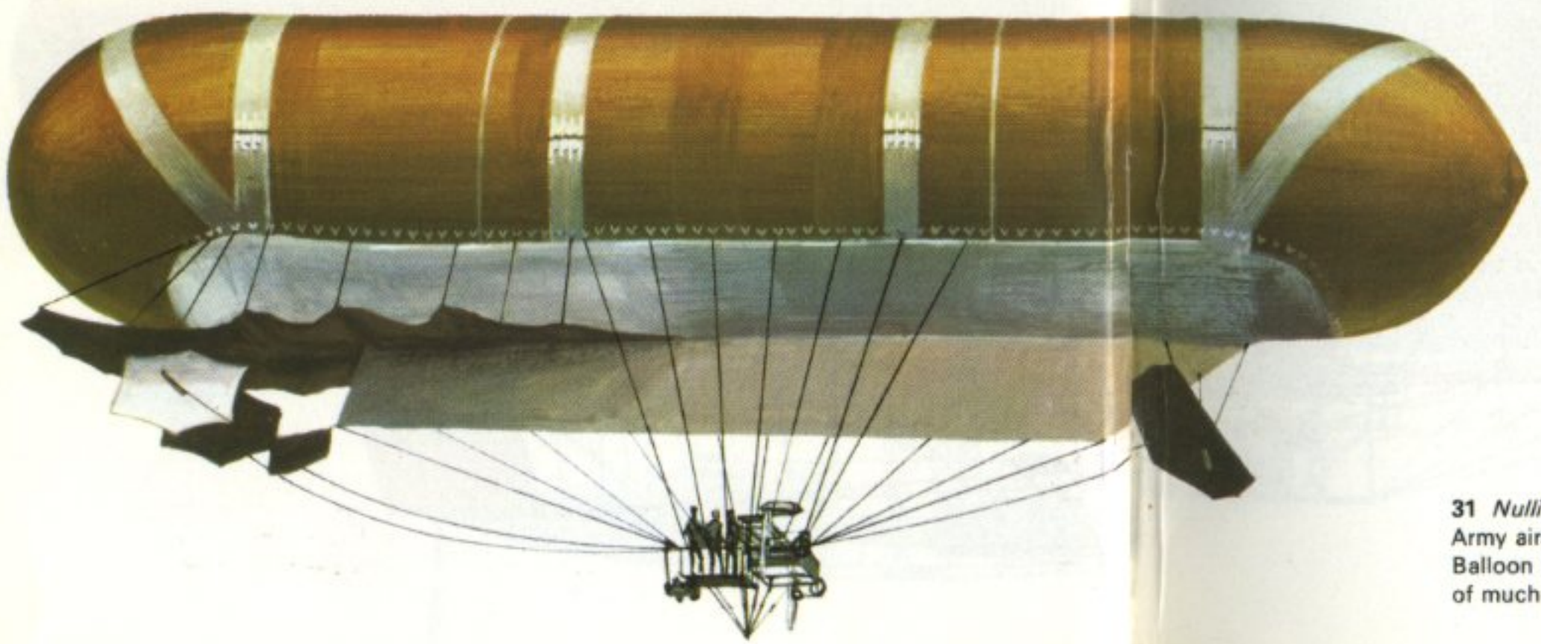




August
von Parseval

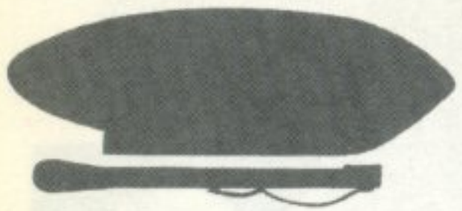
30 The Parseval PL 2 (P 1) of 1908, showing the peculiar car suspension of this non-rigid airship type, a so-called sliding rigging with rollers. *Right:* PL 27, the last and largest Parseval airship, which was finally dismantled in 1918.

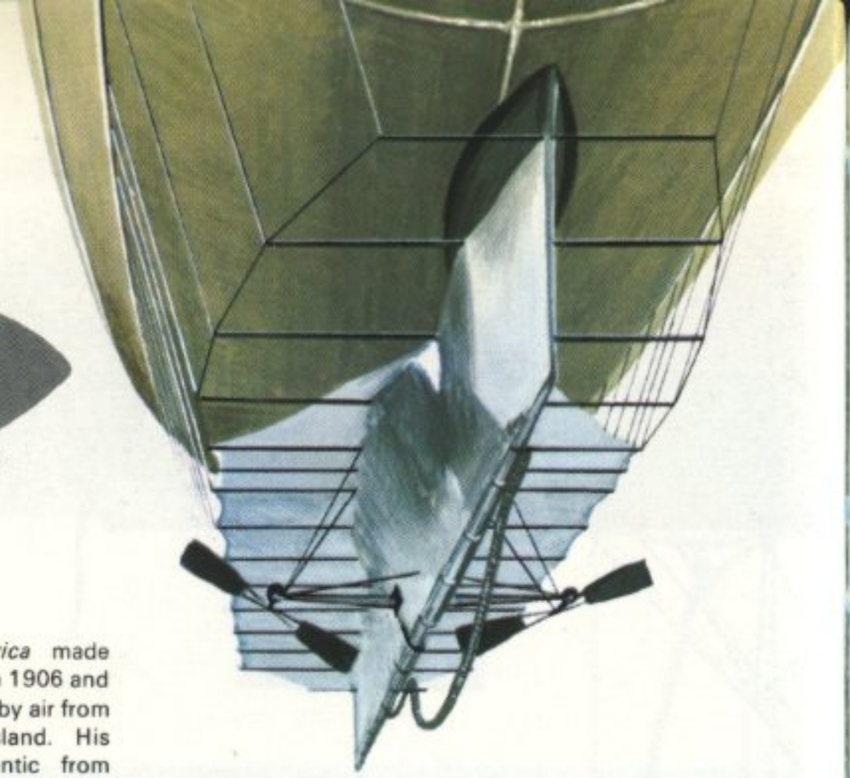




31 *Nulli Secundus II,* a modified version of the first British Army airship 'No. 1' or *Nulli Secundus* which was built at the Balloon Factory at Farnborough. None of these airships were of much practical value.

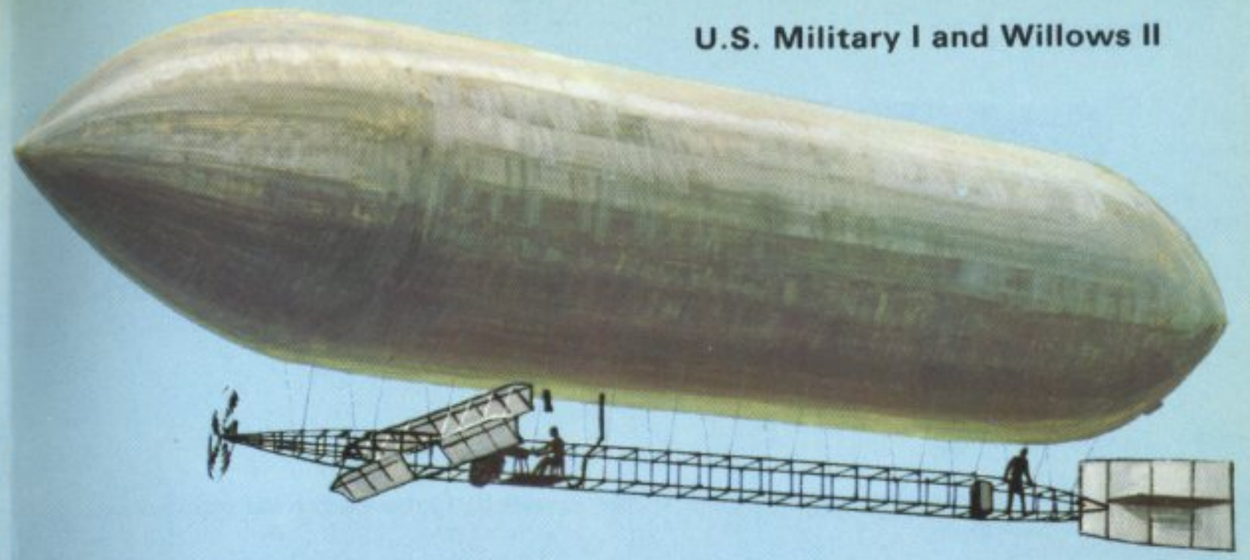
America



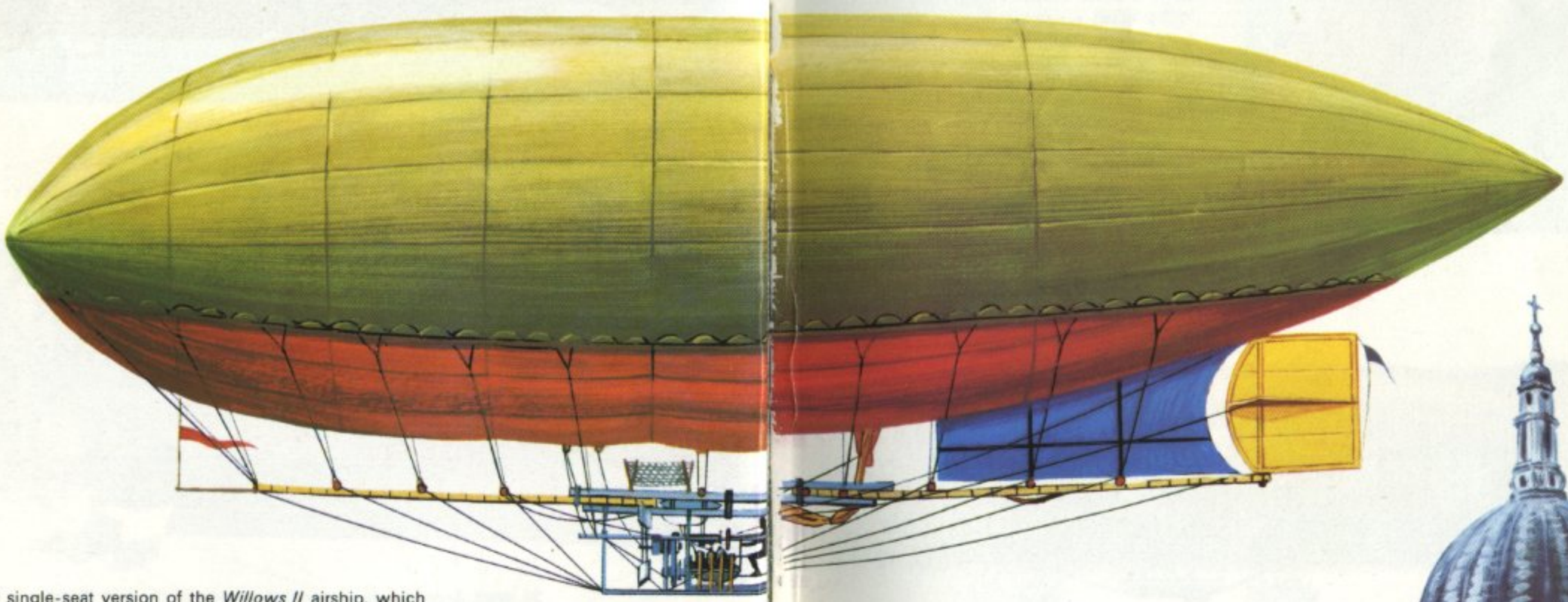


32 Walter Wellman's *America* made several vain attempts between 1906 and 1909 to reach the North Pole by air from a base on Spitsbergen island. His attempt to cross the Atlantic from America to Europe with this airship in 1910 likewise ended in failure; it was forced down at sea, but a steamer rescued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

U.S. Military I and Willows II



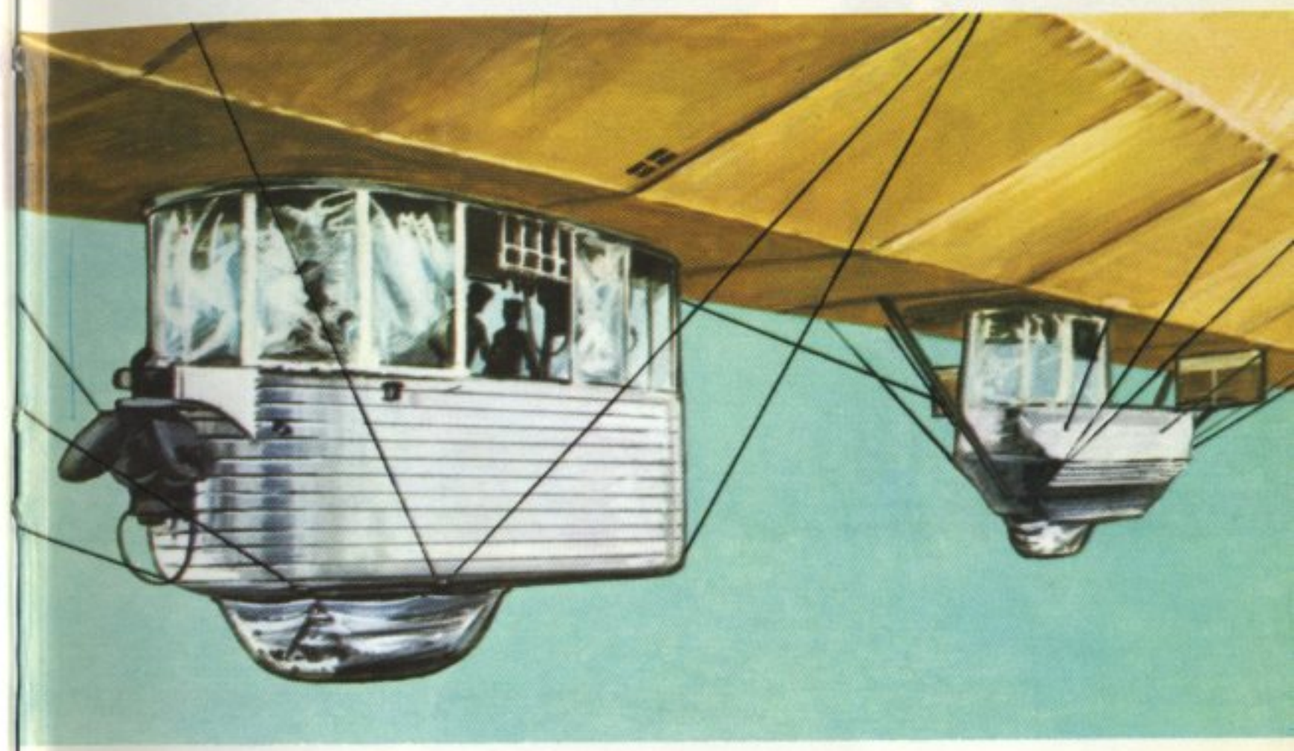
33 In 1908 the U.S. Army acquired its first airship and assigned it to the Signal Corps. The contract for it was awarded to Thomas Scott Baldwin, then an experienced balloonist and parachute jumper. The designation of this airship was *U.S. Military I*.



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.

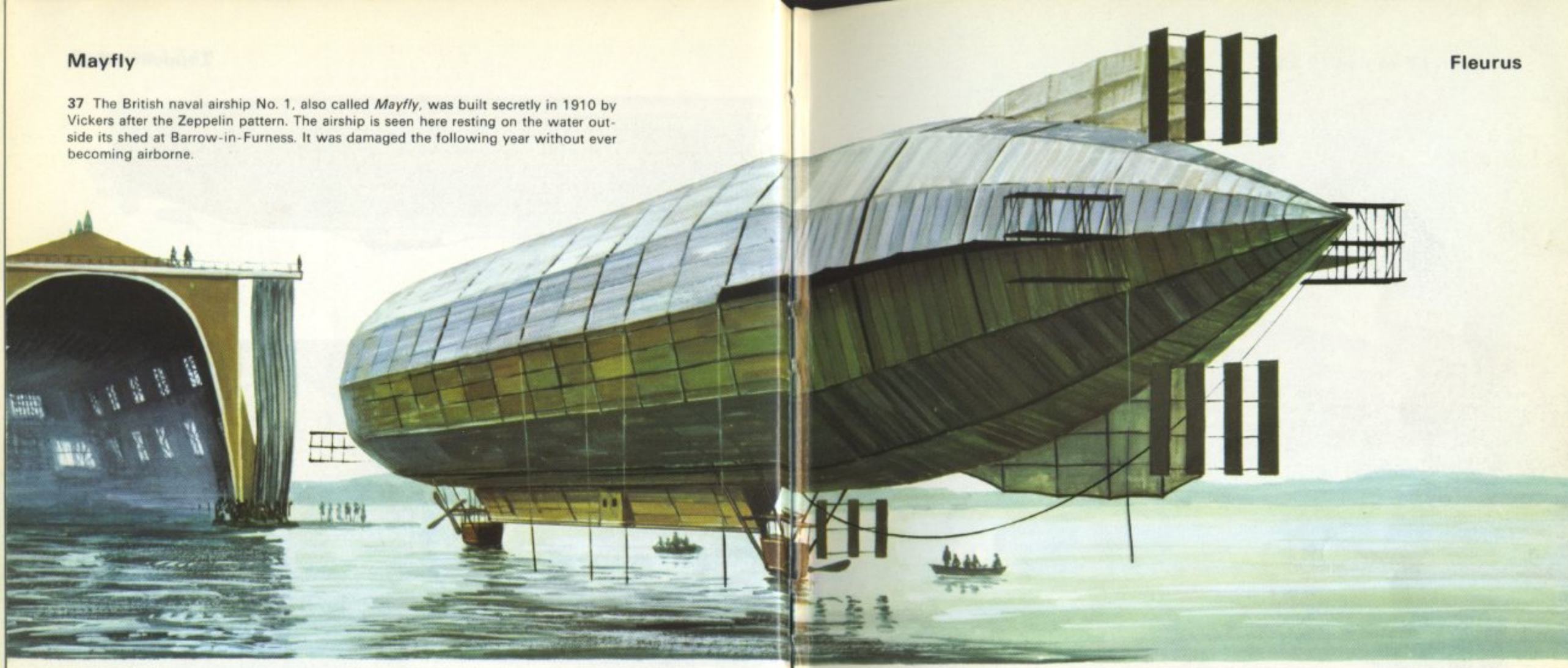
35 LZ 13, the commercial Zeppelin airship *Hansa* of 1912, which made 399 successful passenger trips before the outbreak of World War 1. In the autumn of 1914 this airship was taken over by the German Army and later transferred to the German Navy; both used it as a training vessel for turning out new 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.

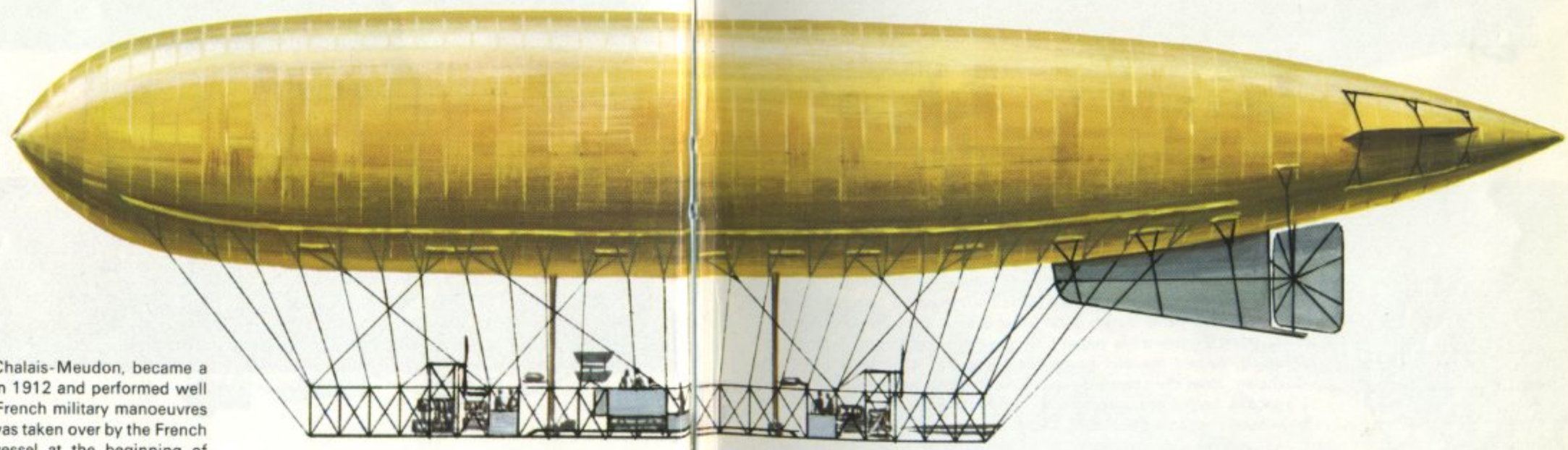


Mayfly

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.

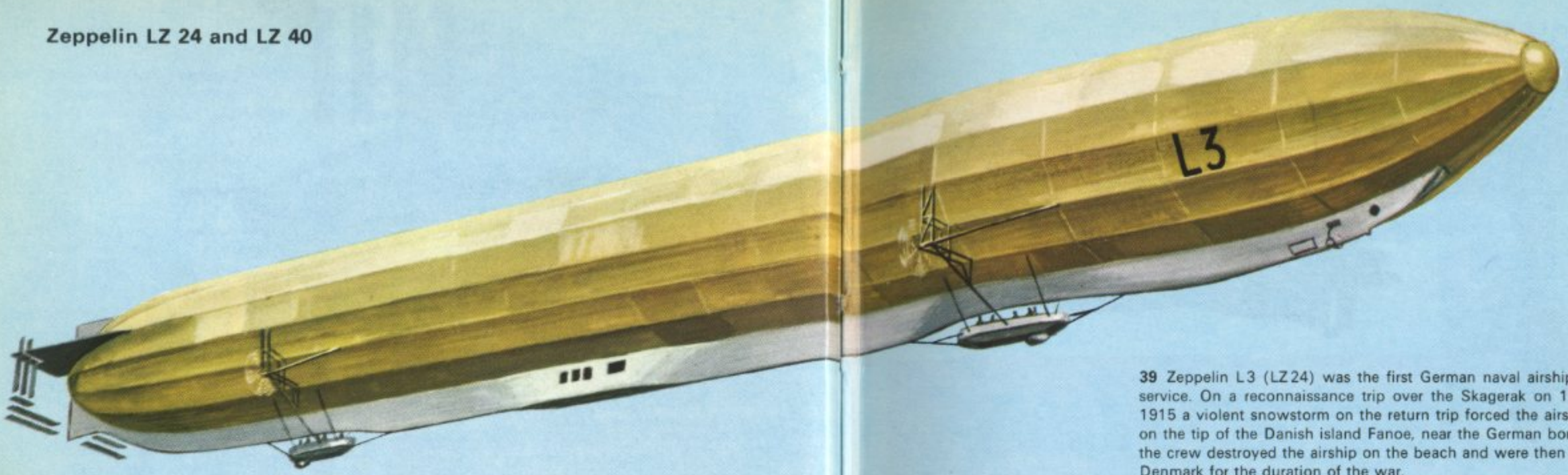


Fleurus

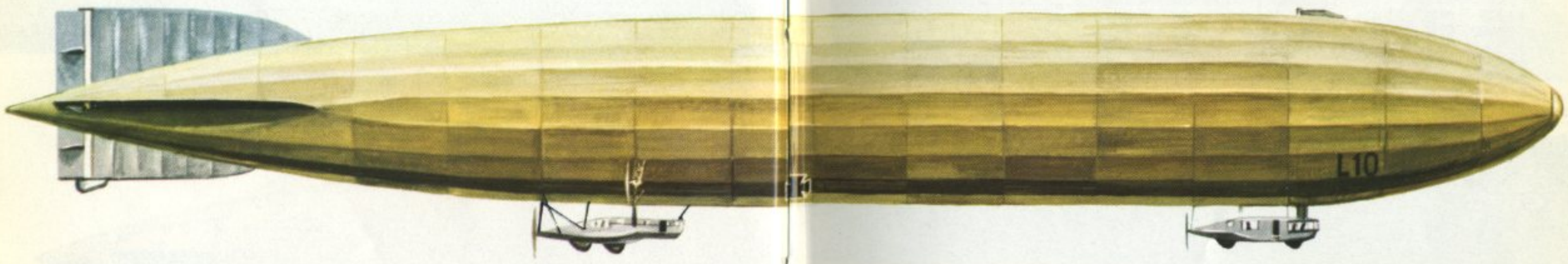


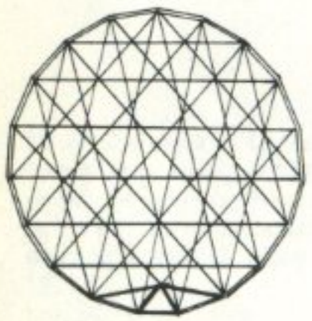
38 *Fleurus*, built at Chalais-Meudon, became a French Army airship in 1912 and performed well during the extensive French military manoeuvres in 1913. This airship was taken over by the French Navy as a training vessel at the beginning of 1917.

Zeppelin LZ 24 and LZ 40

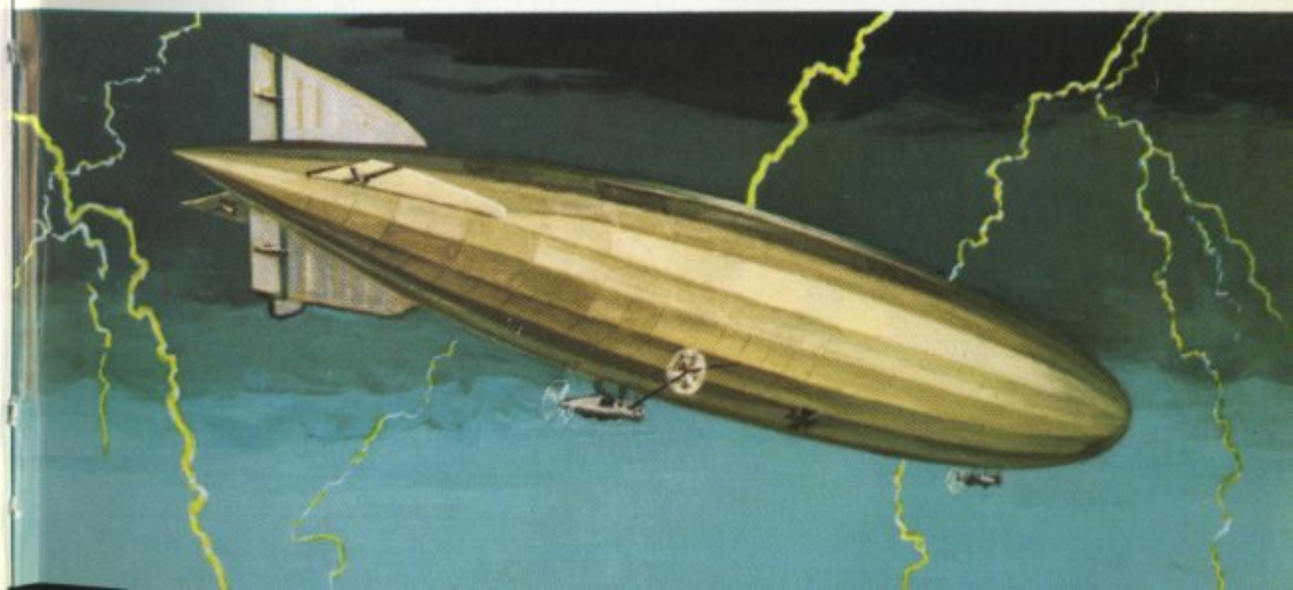


39 Zeppelin L3 (LZ24) was the first German naval airship on active service. On a reconnaissance trip over the Skagerak on 17 February 1915 a violent snowstorm on the return trip forced the airship to land on the tip of the Danish island Fanoe, near the German border, where the crew destroyed the airship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

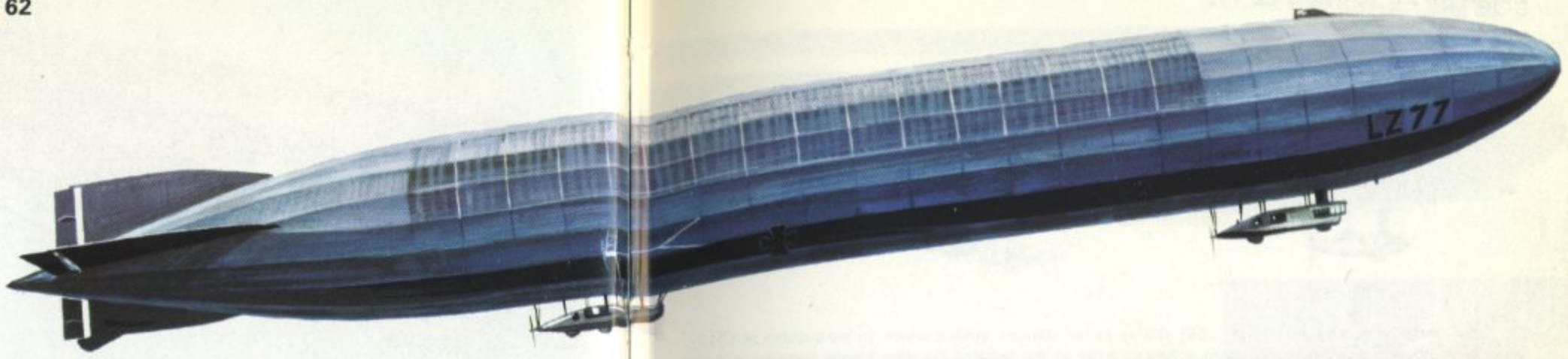


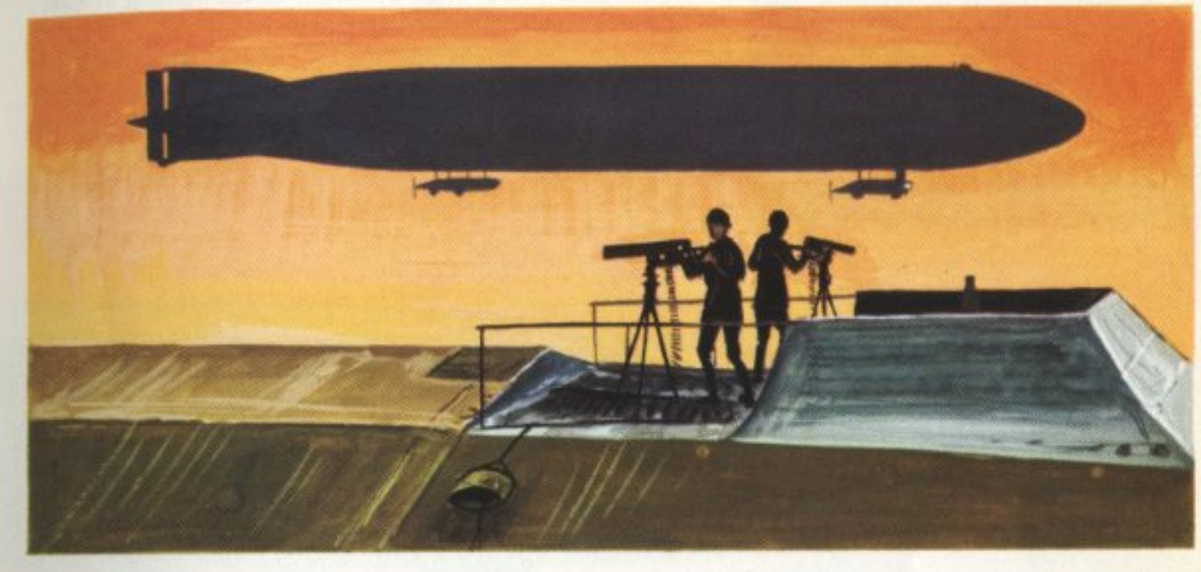


40 The naval Zeppelin airship L10 (LZ40) made a total of 28 war flights, including five raids against Great Britain. On 3 September 1915 it valved hydrogen while passing through a thunderstorm, was hit by lightning, caught fire and plunged burning into the North Sea near Cuxhafen. Note the changed tail 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



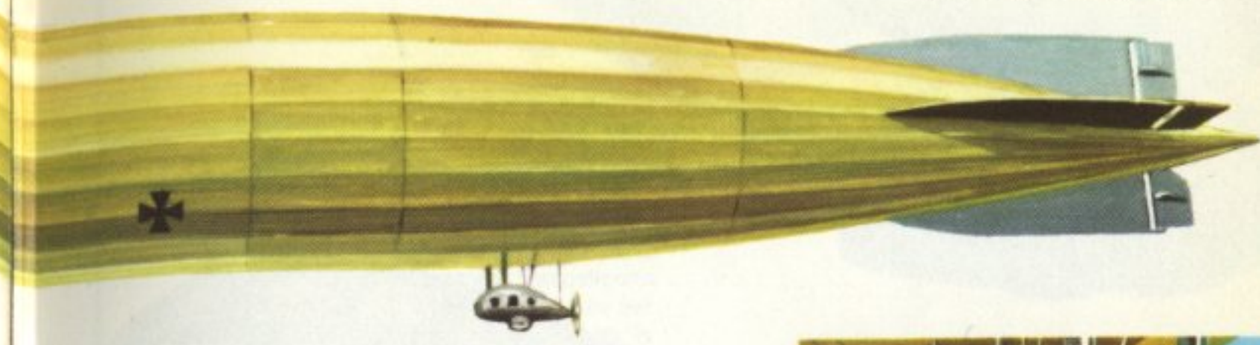


41 The German Army airship Zeppelin LZ77 (LZ47) in the camouflage painting applied to safeguard the airship against attacks over enemy territory on moonlight nights. *Left:* The interior passageway in LZ77. *Right:* The gunners' platform on top of the airship hull where two 8-mm Maxim machine-guns were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

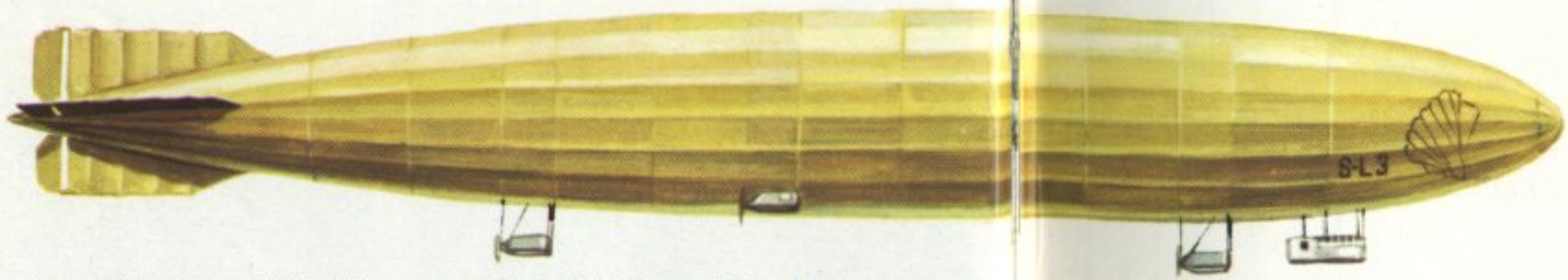
Zeppelin LZ 104 and LZ 112

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.

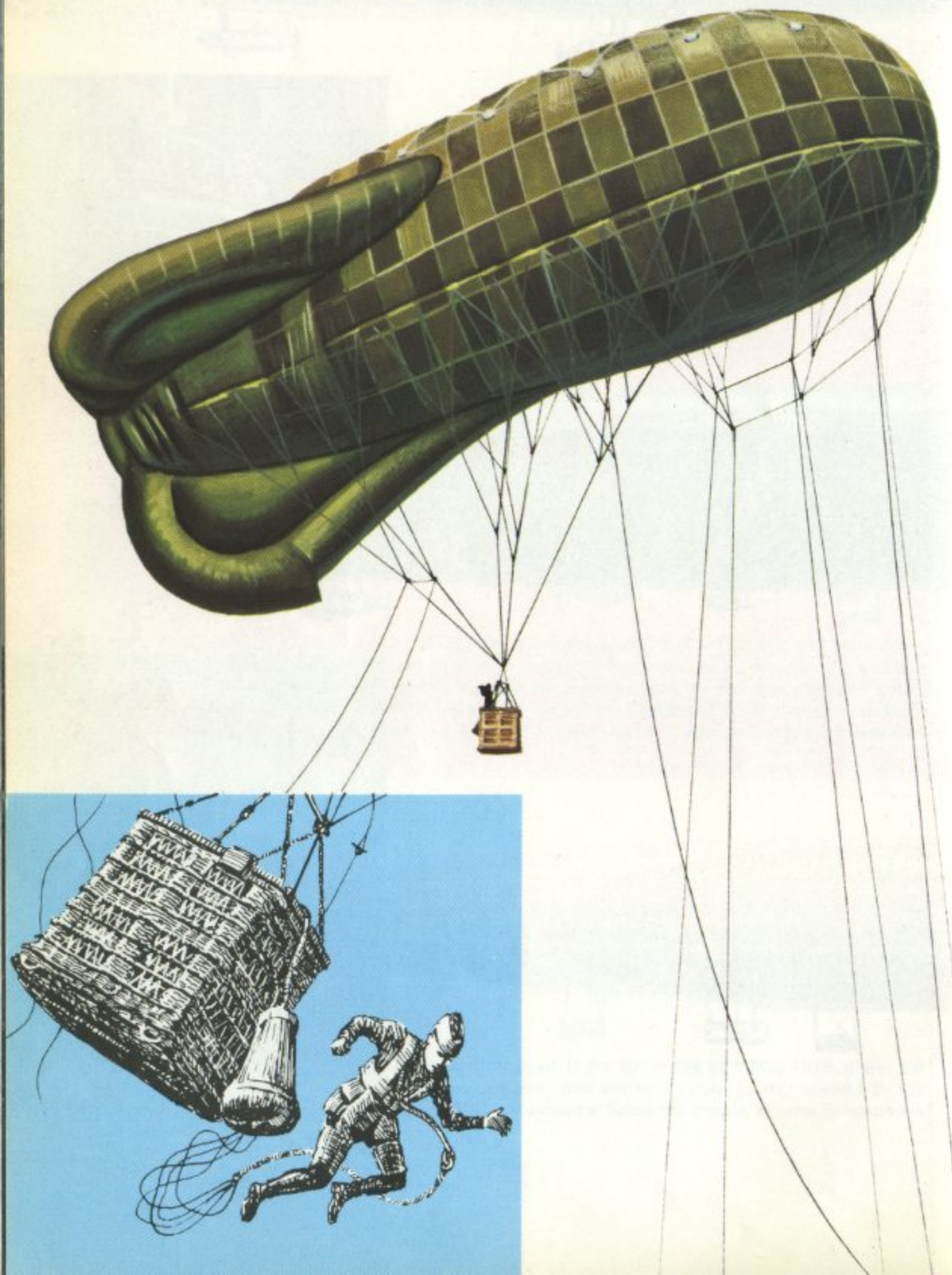
44 With the naval airship Zeppelin L70 (LZ112) and a few sister vessels of the same class the Zeppelin yard in Friedrichshafen attained the peak in military airship performance. But fate dealt this airship a cruel blow, for the Commander and driving spirit of the German naval airship fleet, Frigate-Captain 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.

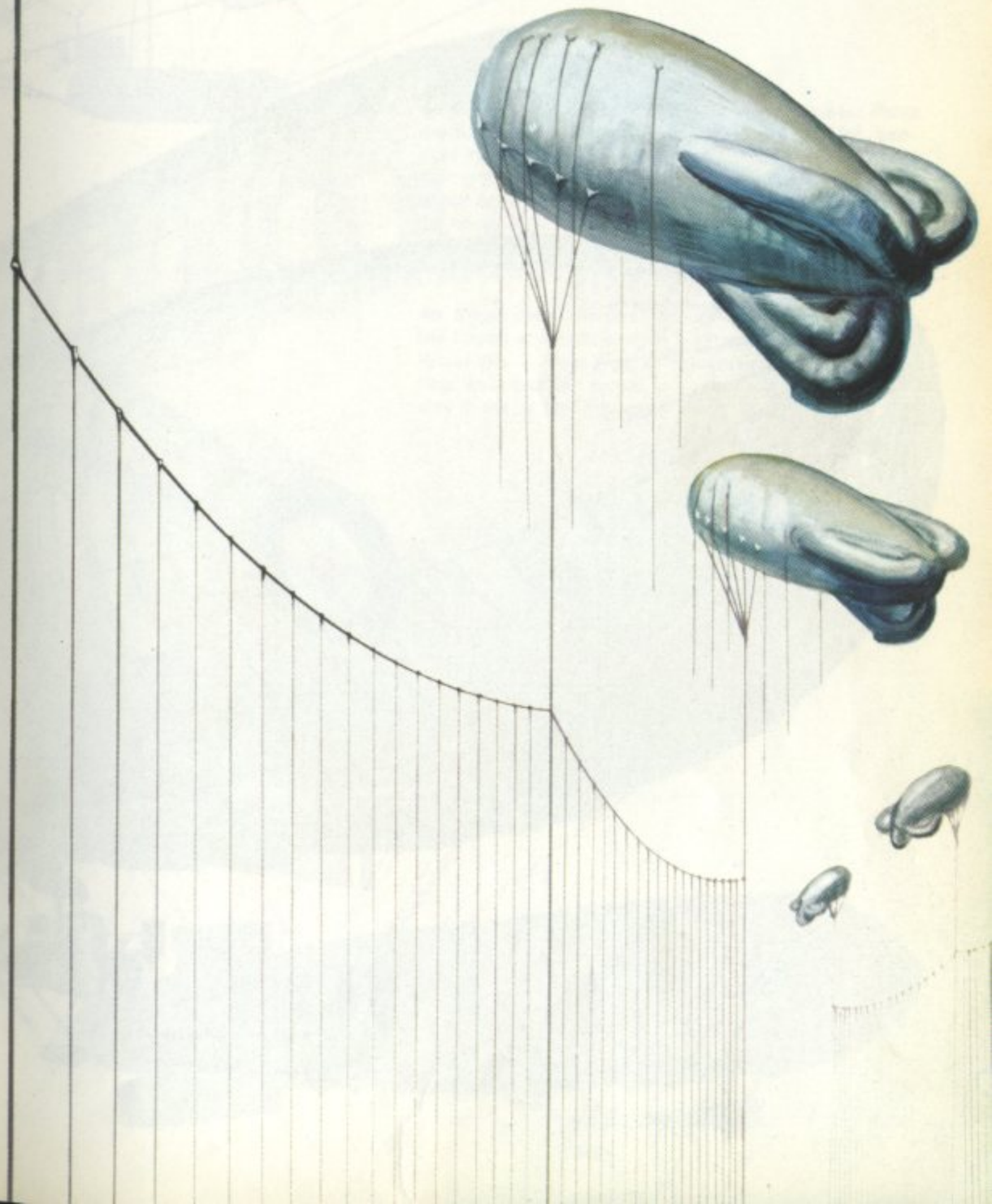
Caquot captive balloon

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.



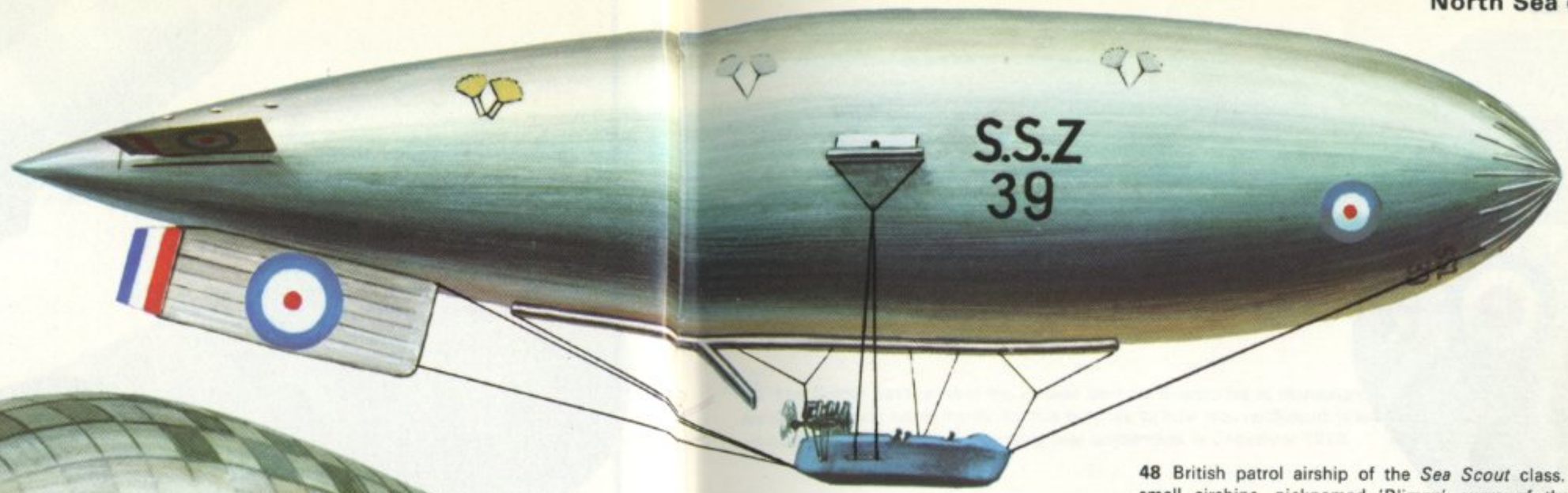
Barrage balloons

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.



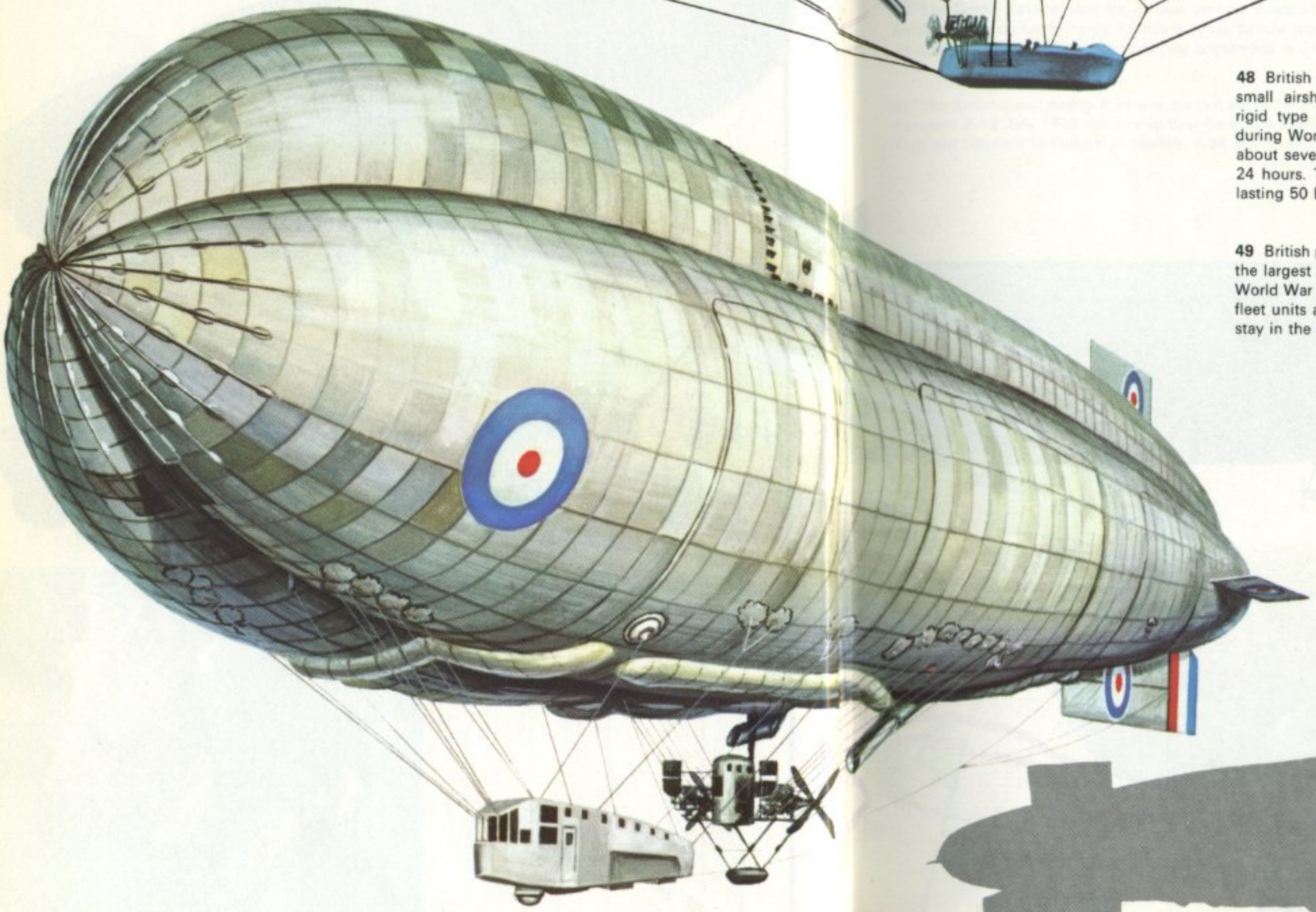
Sea Scout class

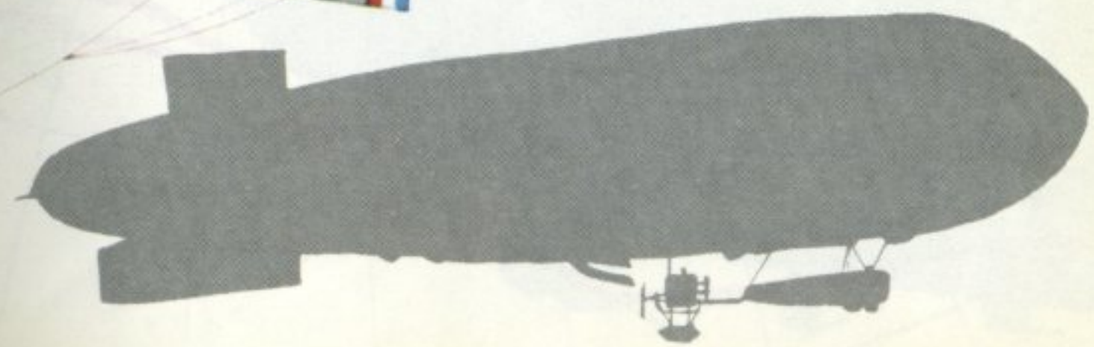
North Sea class

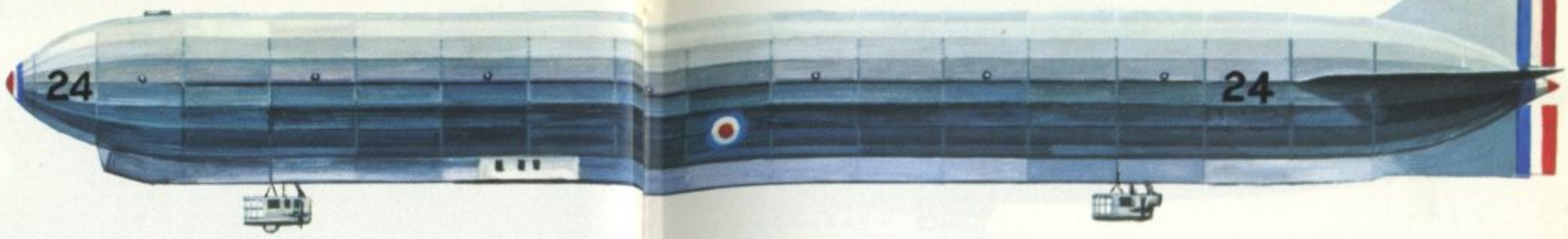


48 British patrol airship of the *Sea Scout* class. These small airships, nicknamed 'Blimps', were of the non-rigid type and performed extensive patrol work at sea during World War 1. They had a normal flight duration of about seven hours, but often stayed aloft for 12 or even 24 hours. The record was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

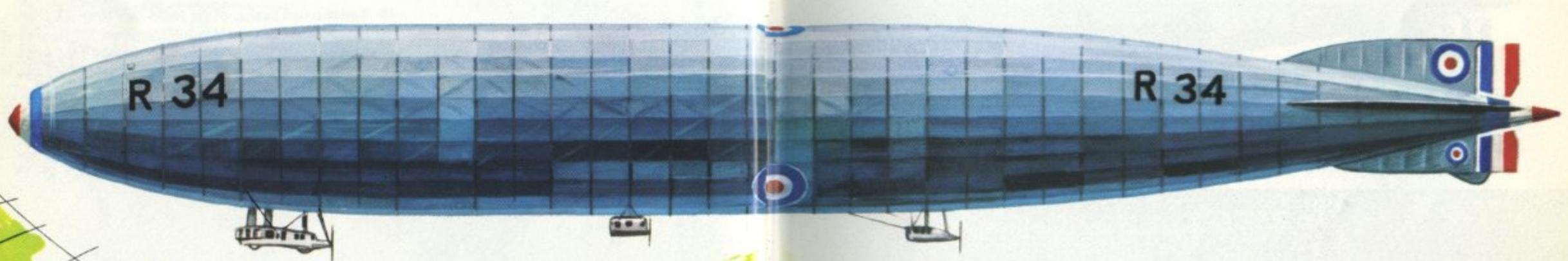


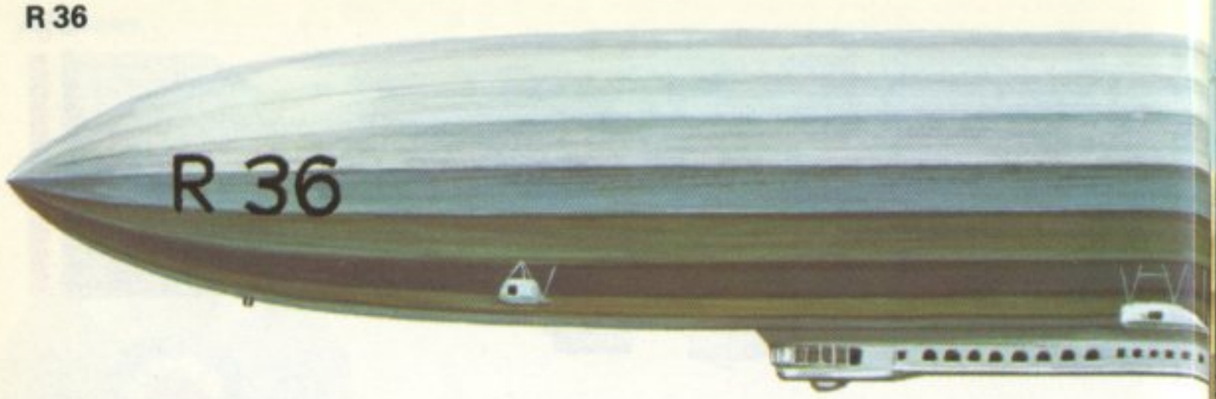




50 The British naval airship No. 24 was built by Beardmore at Inchinnan in 1917 and was used mainly for mooring mast experiments; for this purpose its bow was reinforced. It was relatively slow and was not an outstanding success. The airship was dismantled in December 1919.

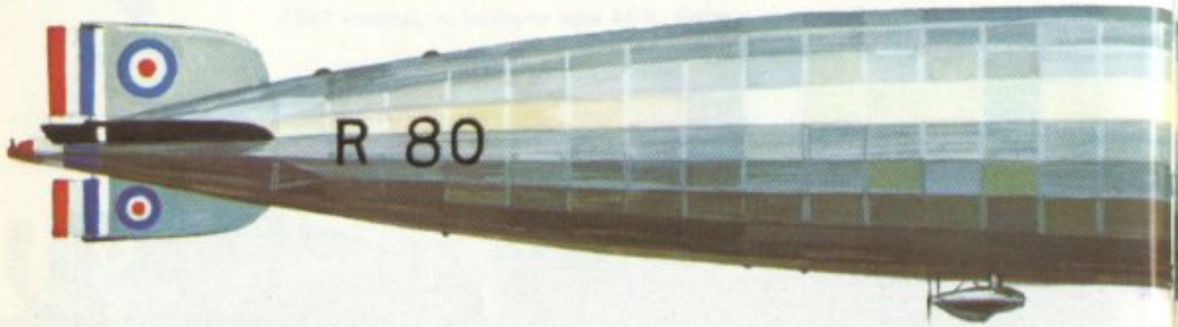
51 The British naval airship R 34 was the first aircraft in the world to cross the Atlantic in both directions. Between 2-13 July 1919 this airship flew from East Fortune on the Firth of Forth to Mineola near New York and returned to Pulham in Norfolk. R 34 was wrecked in January 1921.

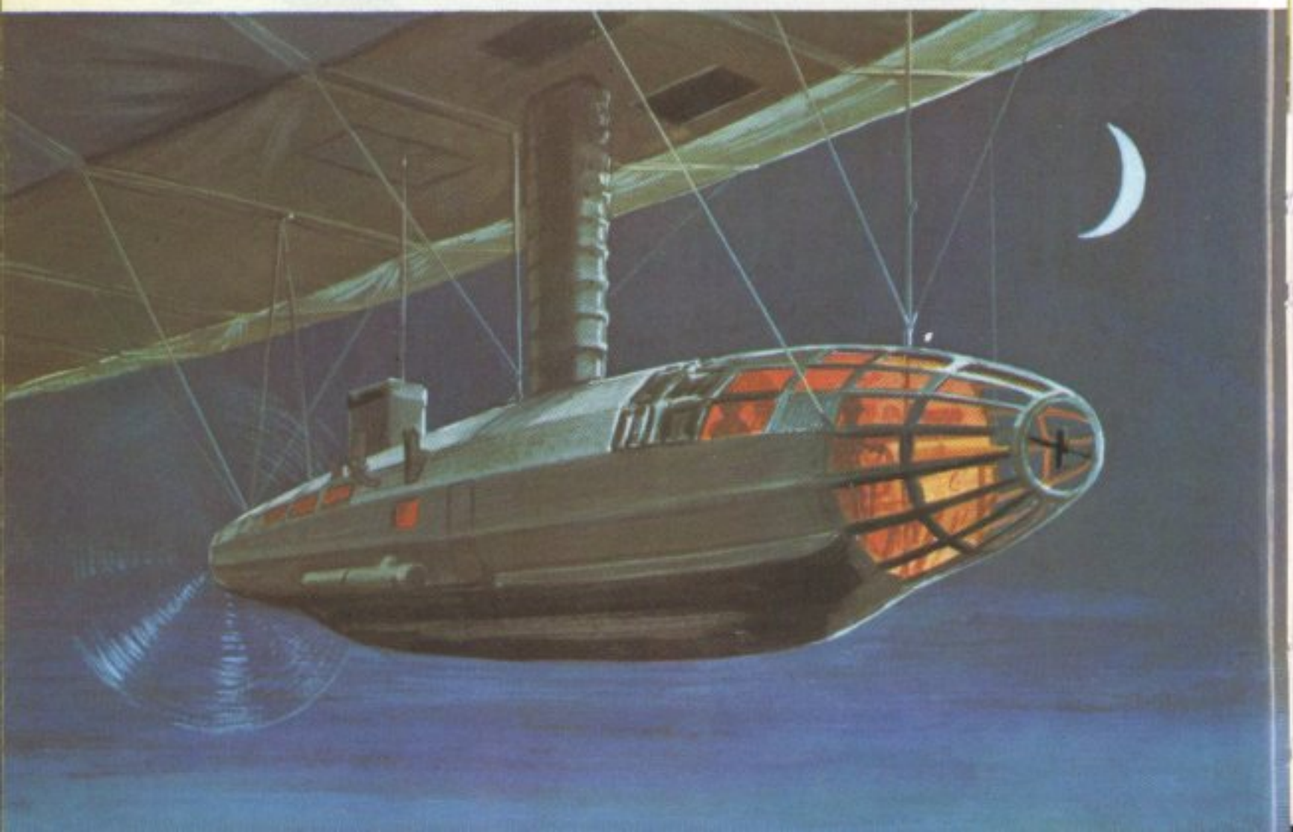




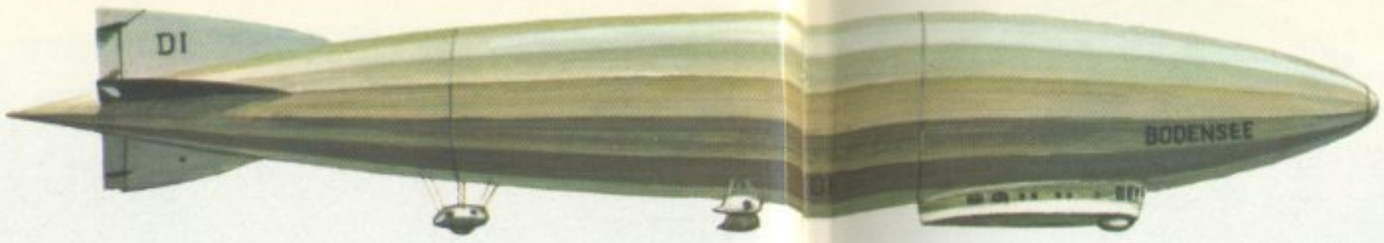
52 R 36 was the last rigid airship built to the order of the British Admiralty during World War 1. It was originally based upon the German Zeppelin L 48 (LZ 95), and although built to military specifications was equipped to carry passengers. It was planned to operate the airship between London and Cairo, 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.

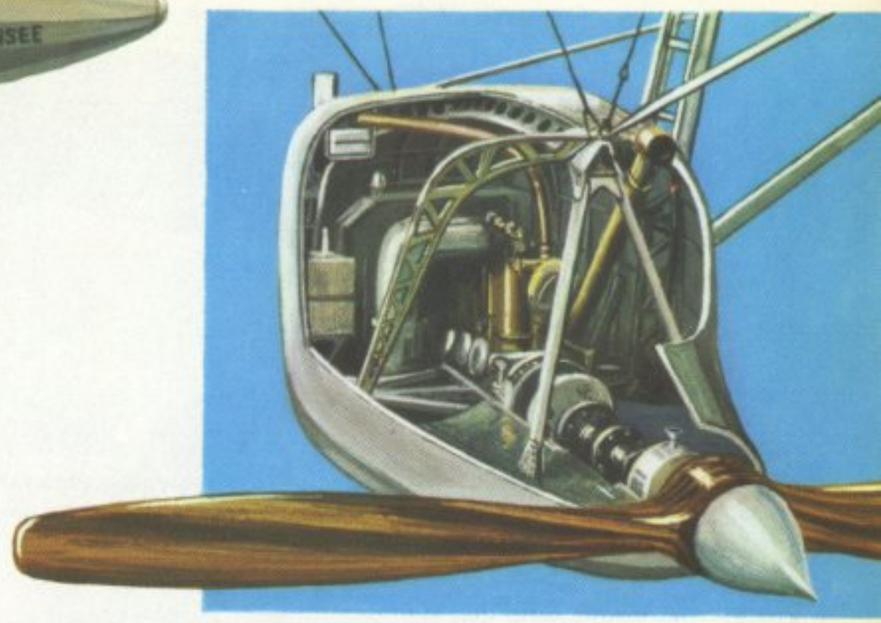




Zeppelin LZ 120

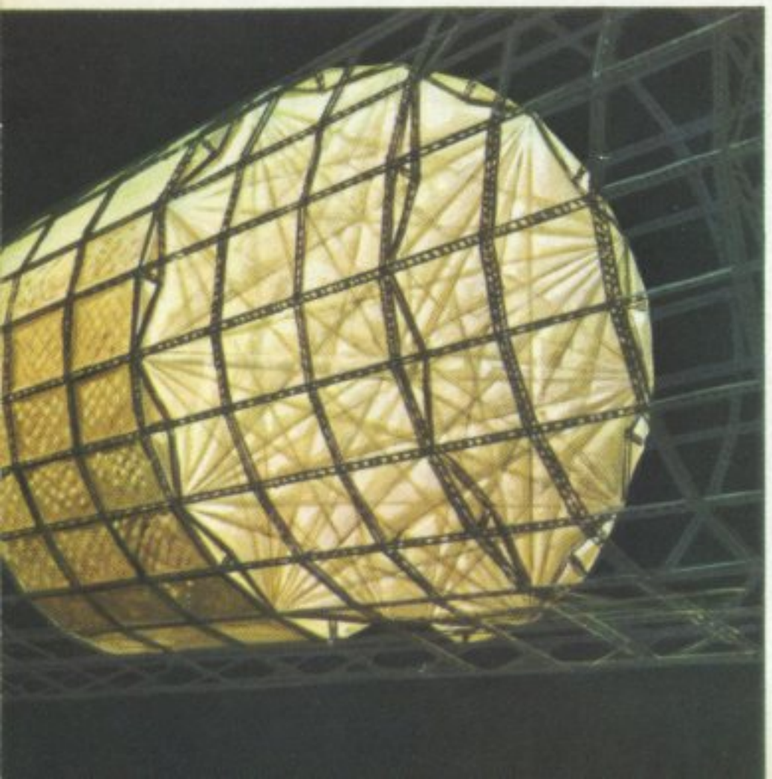


Zeppelin LZ 114

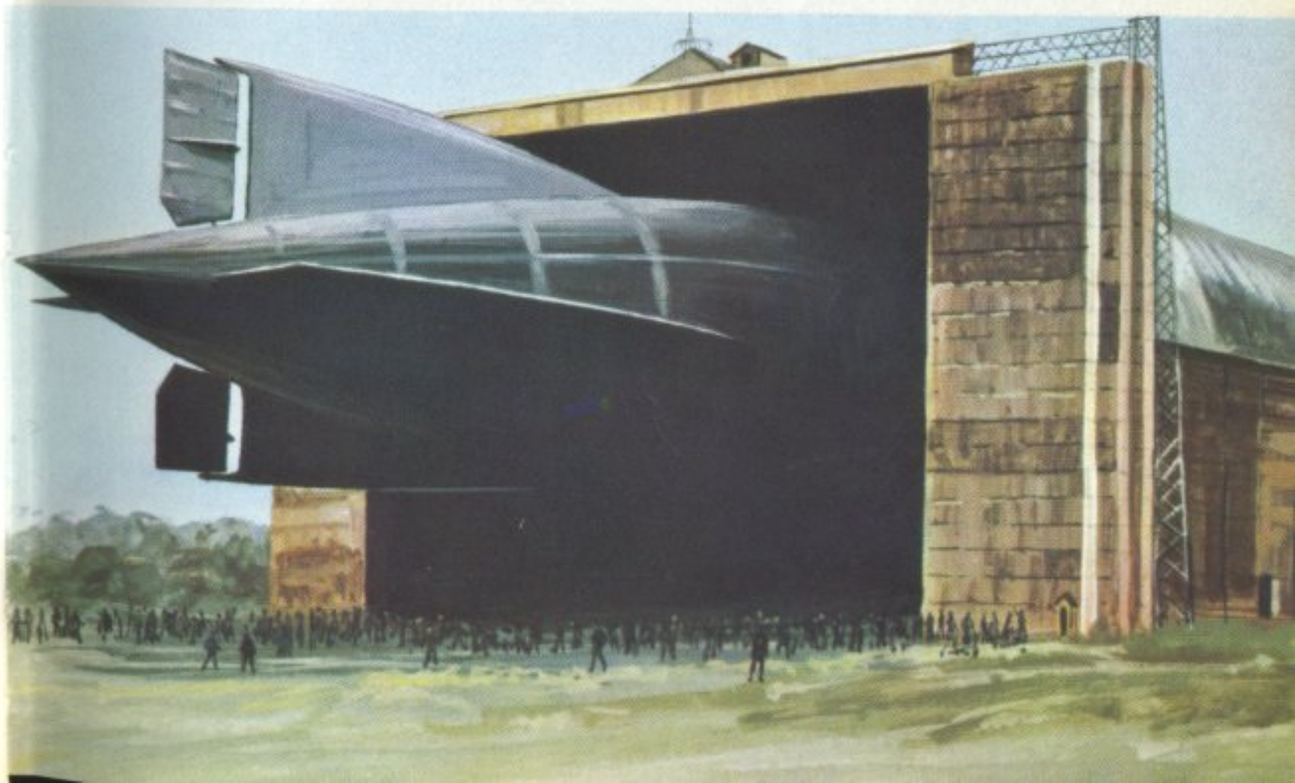


54 Zeppelin LZ120 *Bodensee*, the first small airship turned out by the yard at Friedrichshafen after World War 1. During the autumn of 1919 *Bodensee* maintained regular passenger services between Staaken, near Berlin, and Friedrichshafen on Lake Constance, making round trips on alternate days. In July 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.

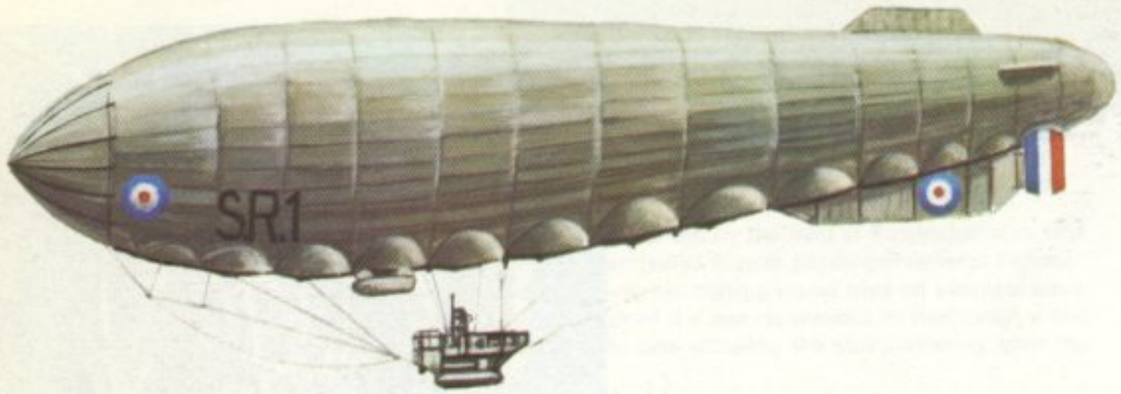
55 The German naval Zeppelin airship L 72 (LZ 114) survived the war and as part of the war reparations was turned over to France in July 1920, where it was named *Dixmude*. It carried out several long and successful flights, but disappeared without trace in December 1923, while on a Mediterranean cruise, 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

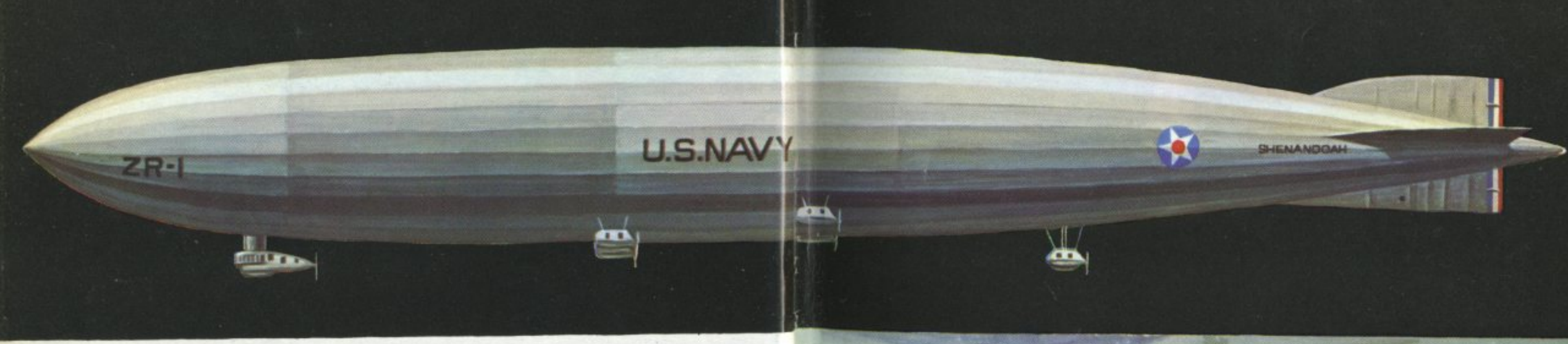


Italian M class



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.

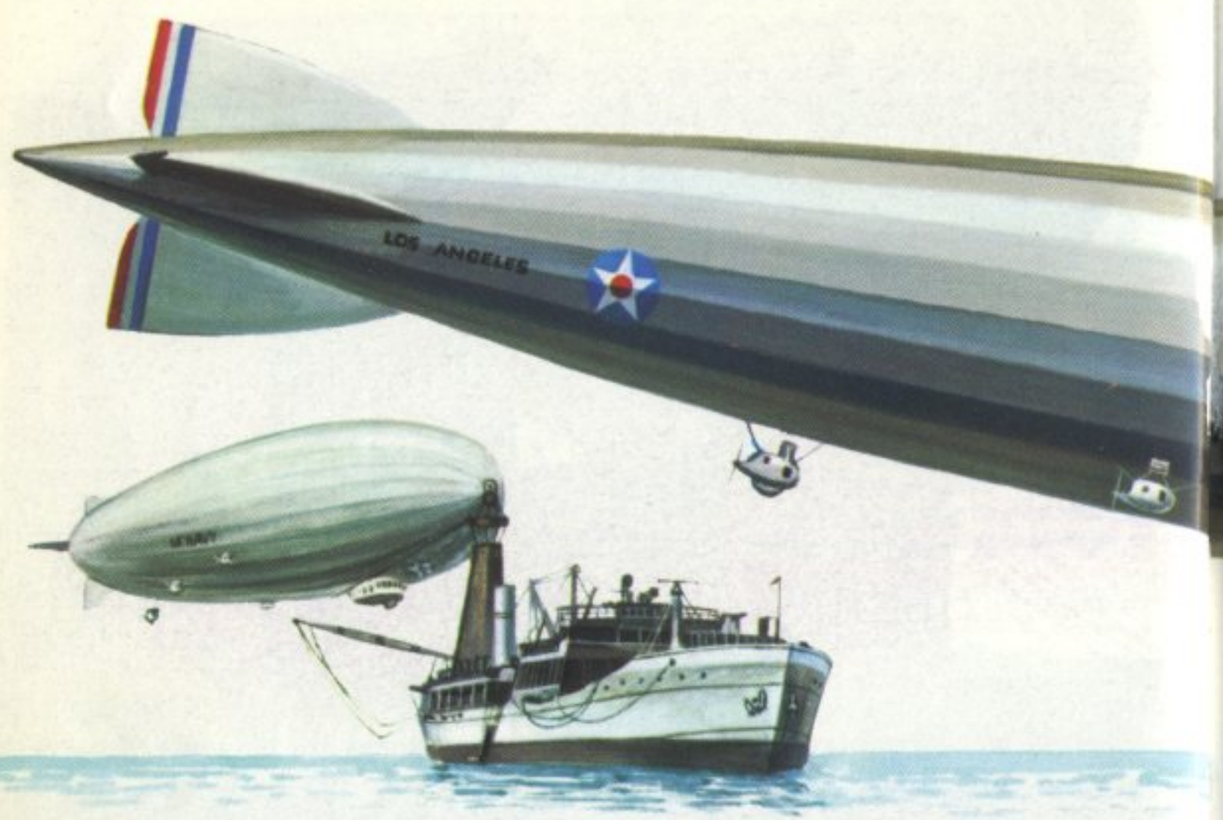
Shenandoah

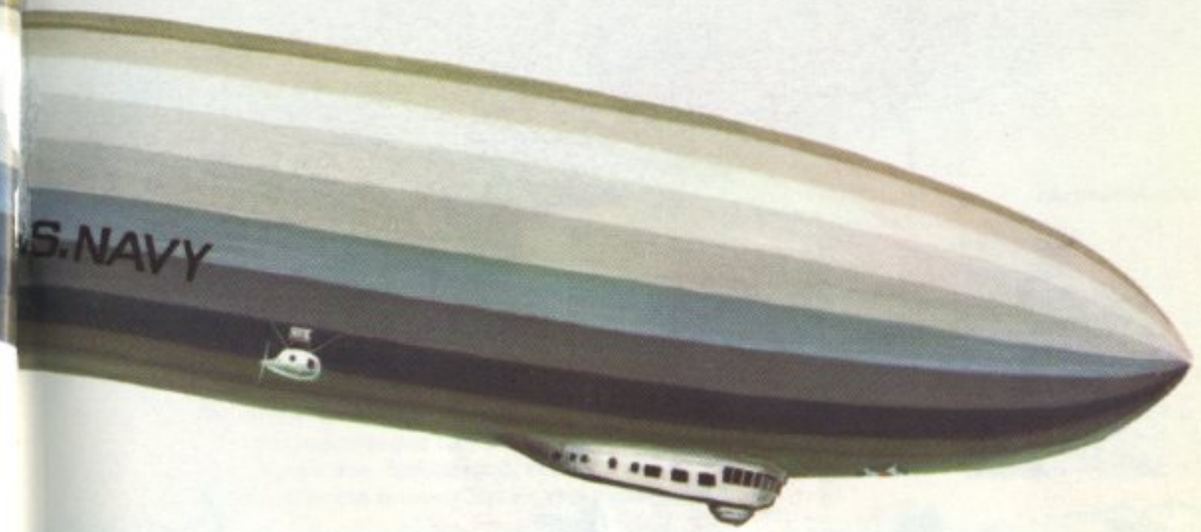


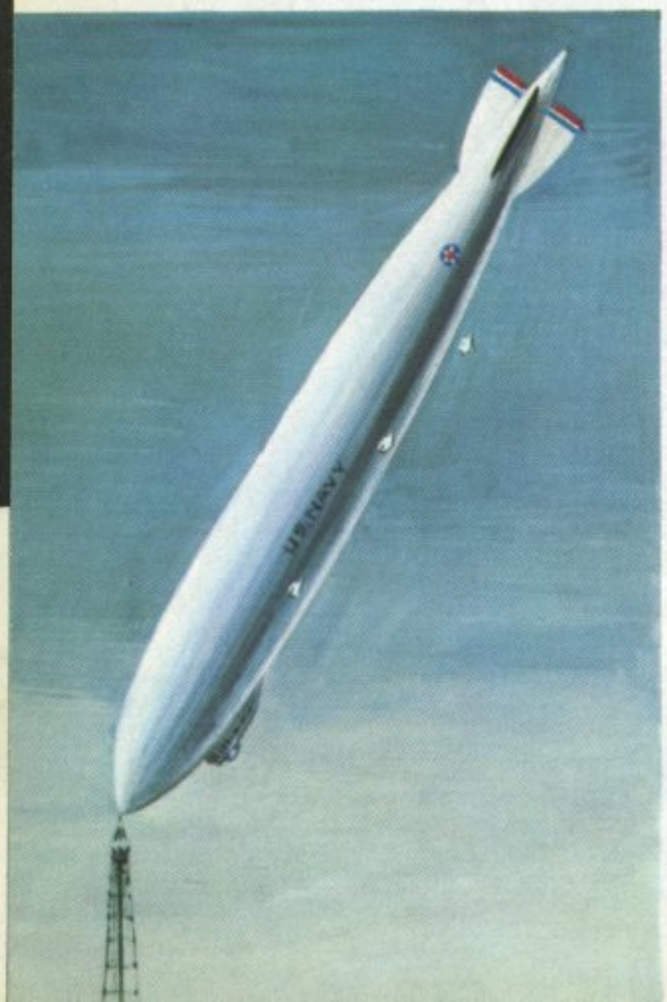
57 The U.S. Navy's airship ZR-1 *Shenandoah* was the first of the rigid type to be built in America and made its maiden voyage on 4 September 1923. During a cross-country flight on 3 September 1925 the airship was caught in a violent storm and a squall caused it to break into three parts. Fourteen crew 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

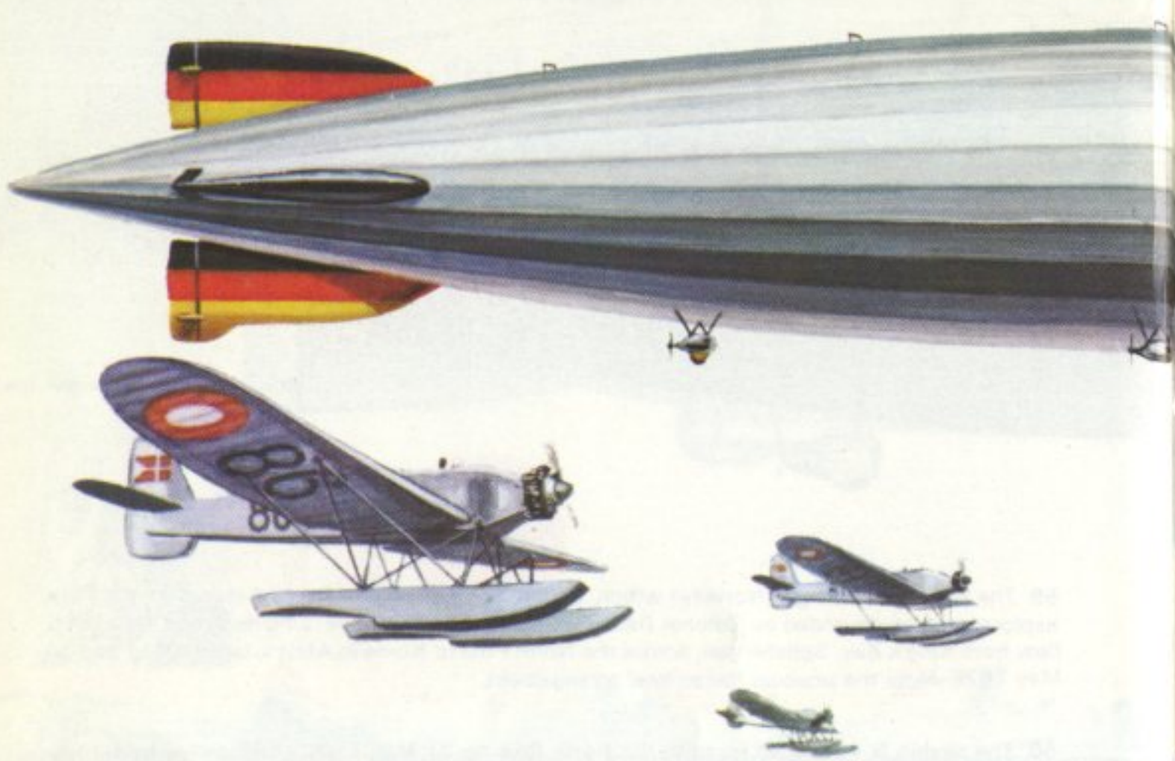
Italia

Roald Amundsen

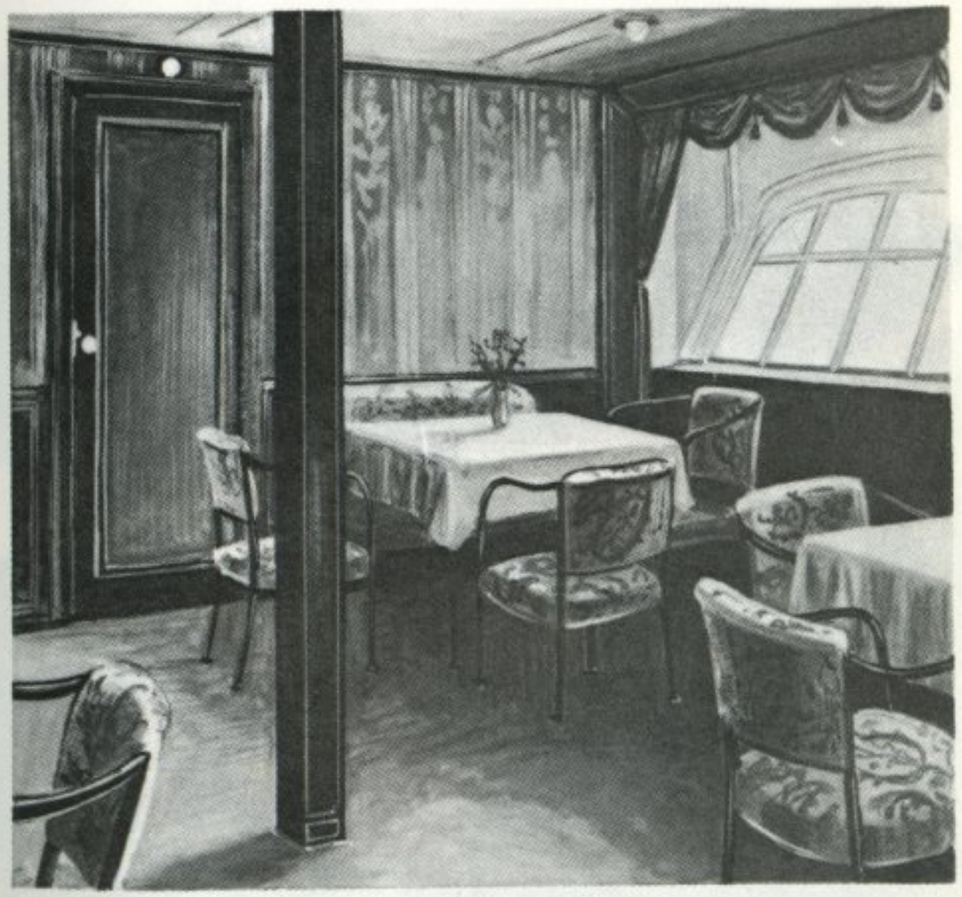
Umberto Nobile

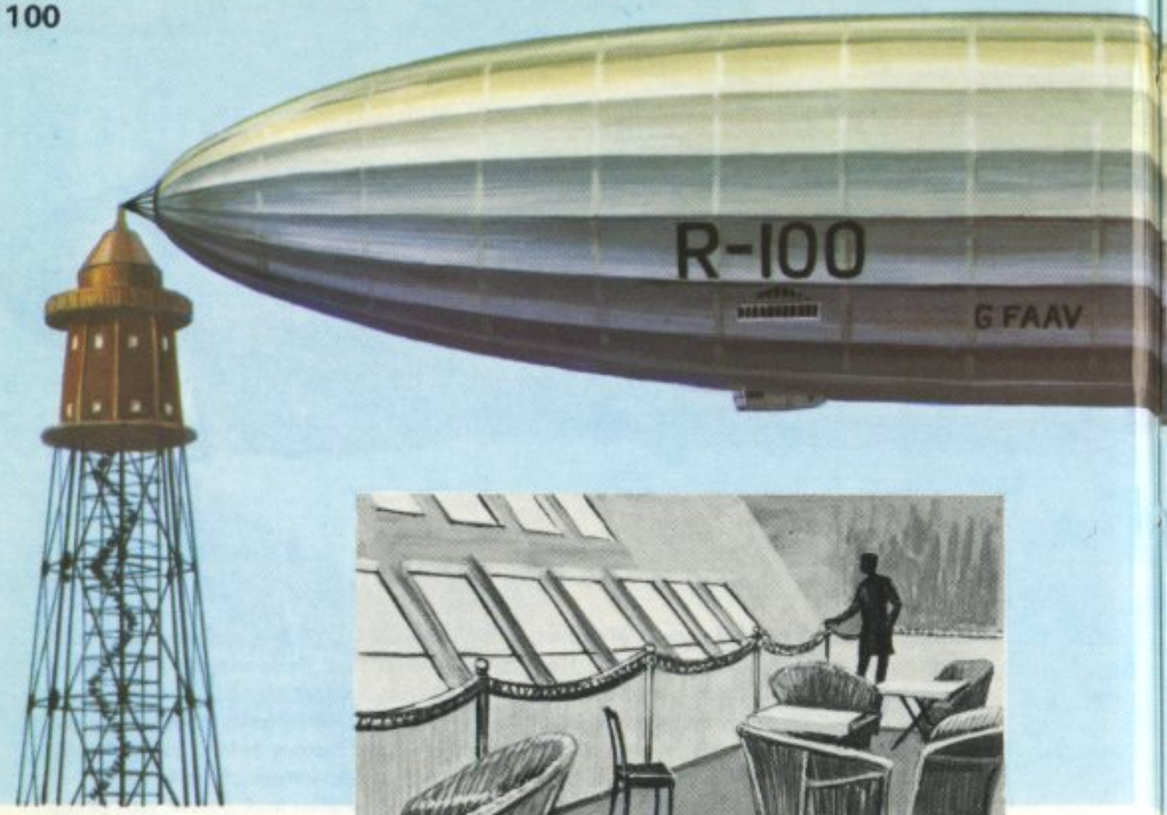
59 The airship N 1 *Norge* (Norway) which, under the leadership of Roald Amundsen, the Polar explorer, and commanded by Colonel (later General) Umberto Nobile, who designed the airship, flew from King's Bay, Spitsbergen, across the North Pole to Nome in Alaska, between 11 and 14 May 1926. Note the unusual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

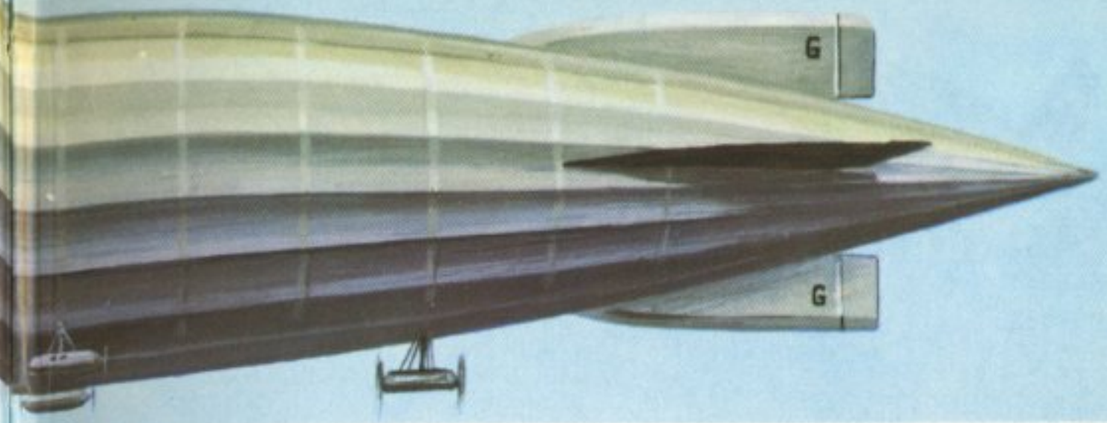
60 The airship N 4 *Italia* en route to the North Pole on 23 May 1928, commanded by General Nobile. On 25 May the airship collided with the ice and the control car was torn off. The rest of the ill-fated airship disappeared forever. *Left:* The survivors of the disaster in their red tent on the floating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

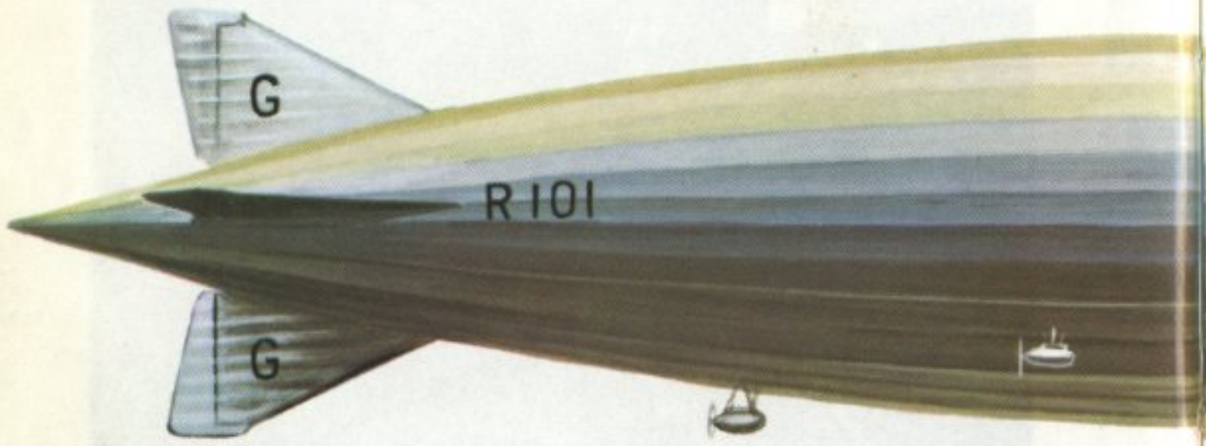




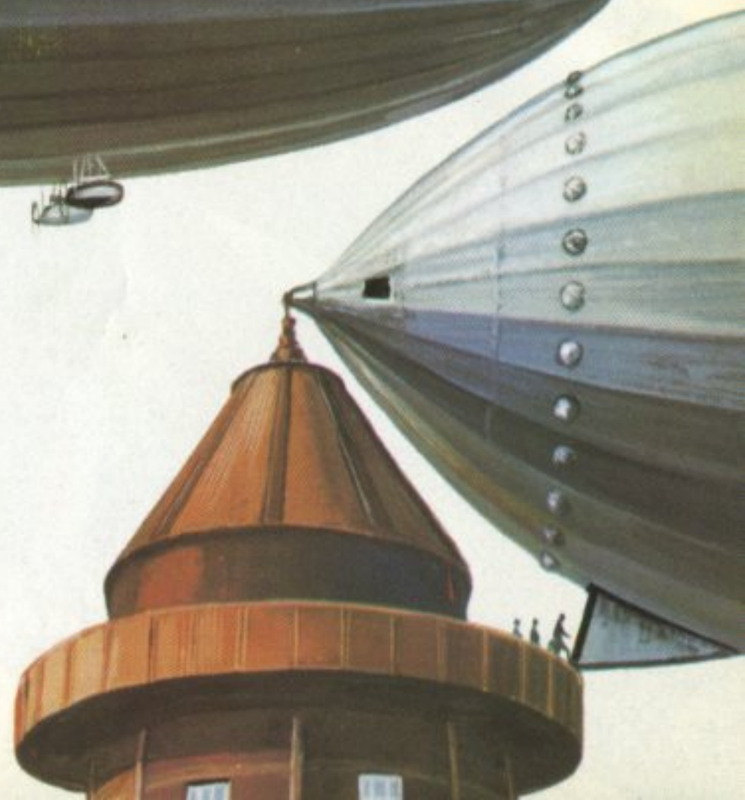


62 The passenger airship R 100 built by the Airship Guarantee Company in Howden and completed in 1928. This airship made several successful trips, including a double crossing of the Atlantic to Canada, but was dismantled in 1931. The inset shows a section of the passenger saloon.

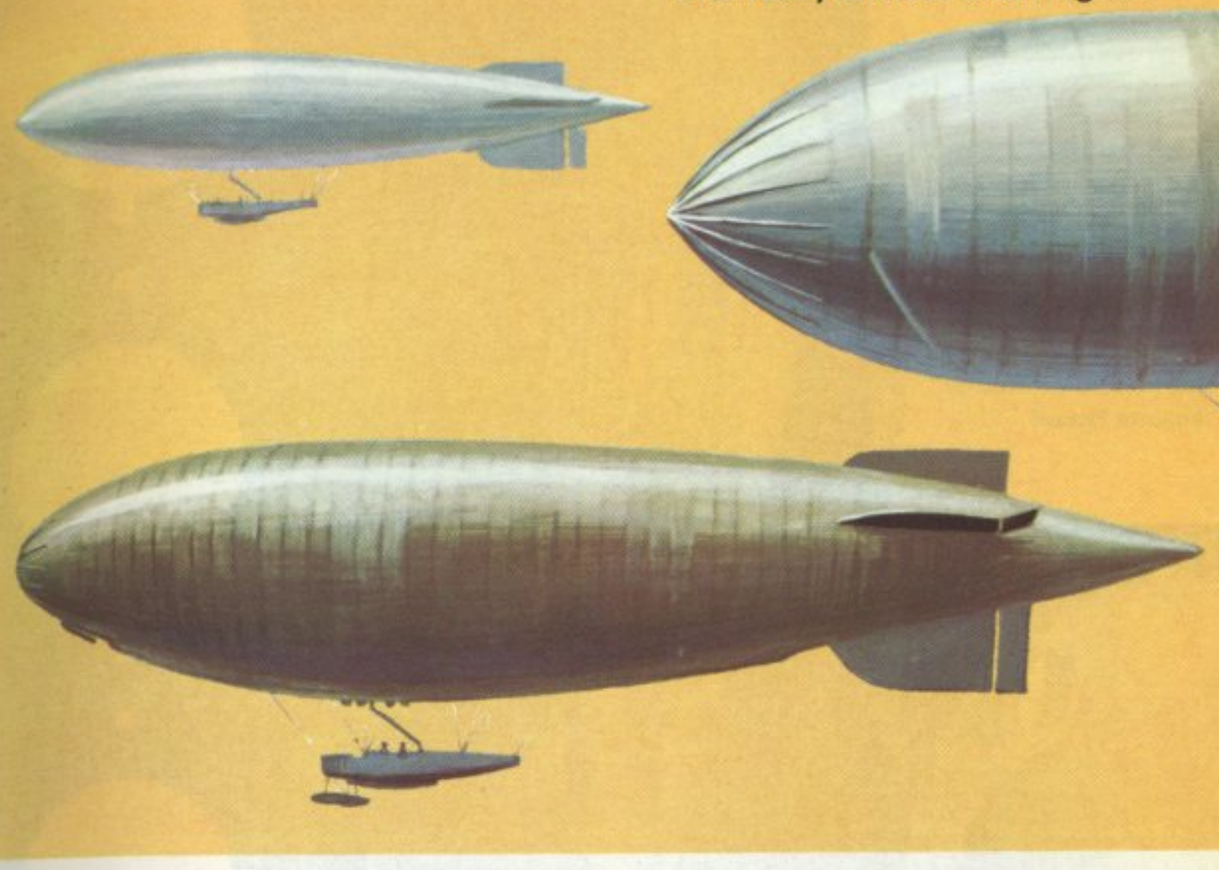
63 The passenger airship R 101 was built at the Cardington airship works of the British government and was completed in 1928. Without ample previous trial runs this airship left on an ill-considered flight to India on 5 October 1930. At Beauvais in France it struck the ground, caught fire and was totally 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



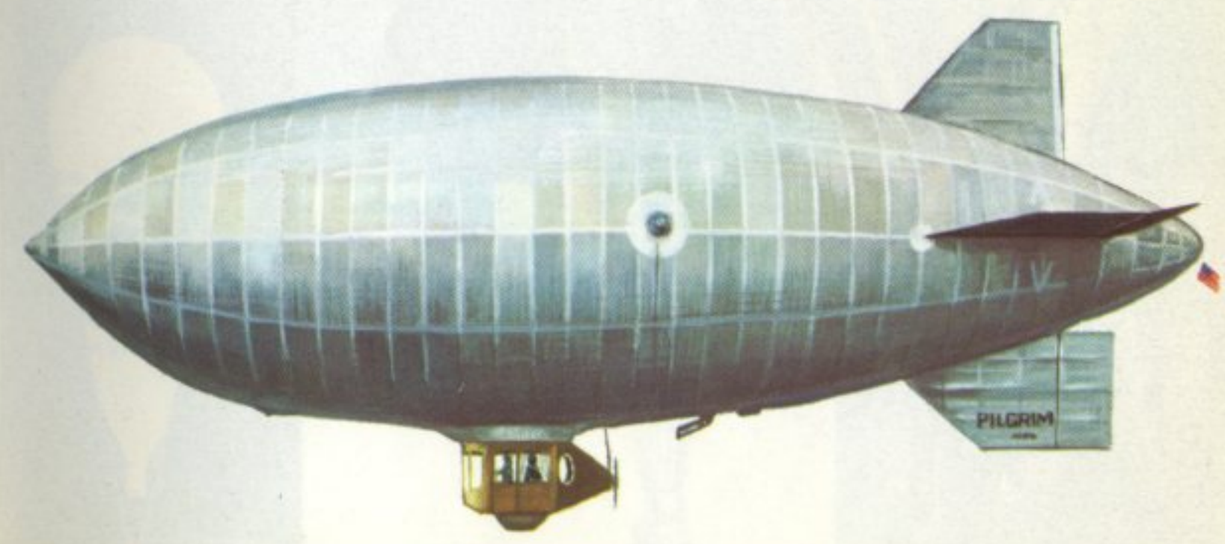
U.S. Navy B class and Pilgrim



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

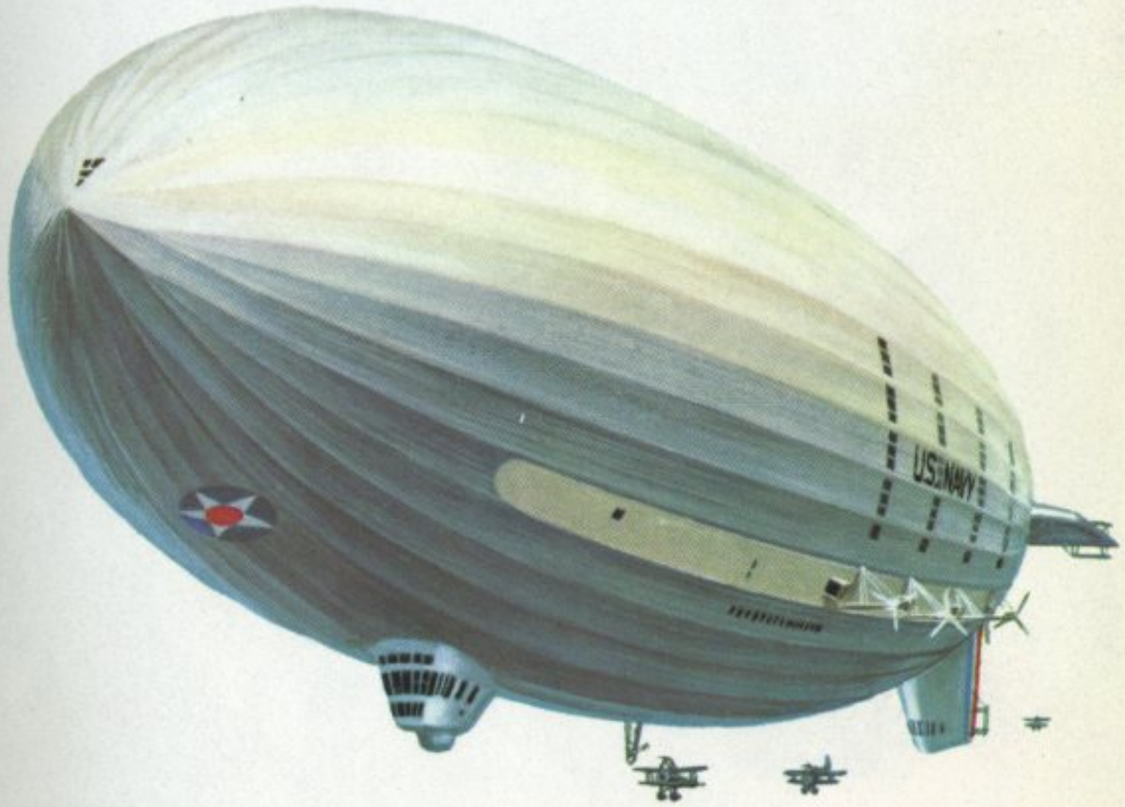
O. A. Anderson

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

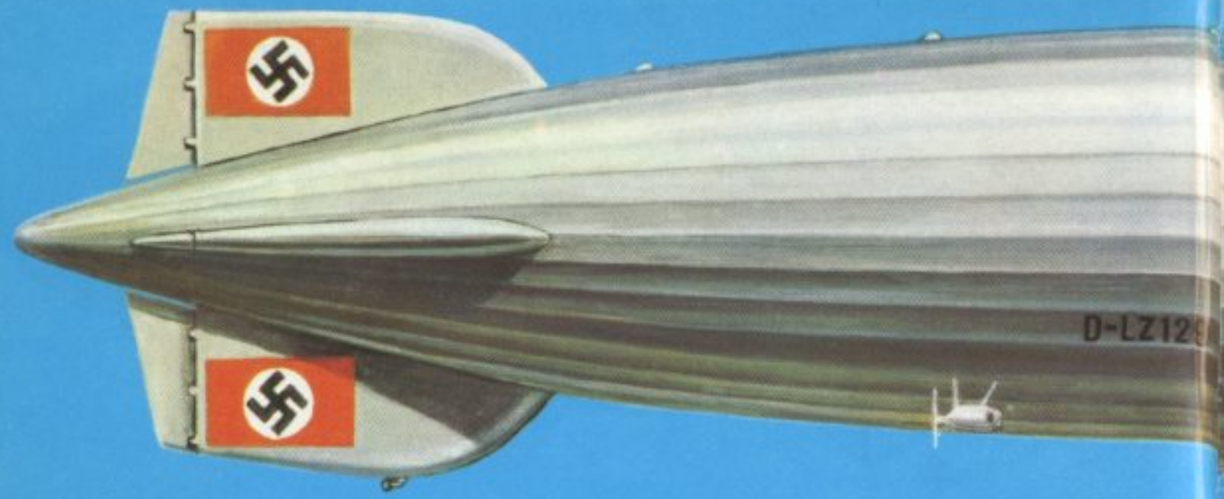
Macon

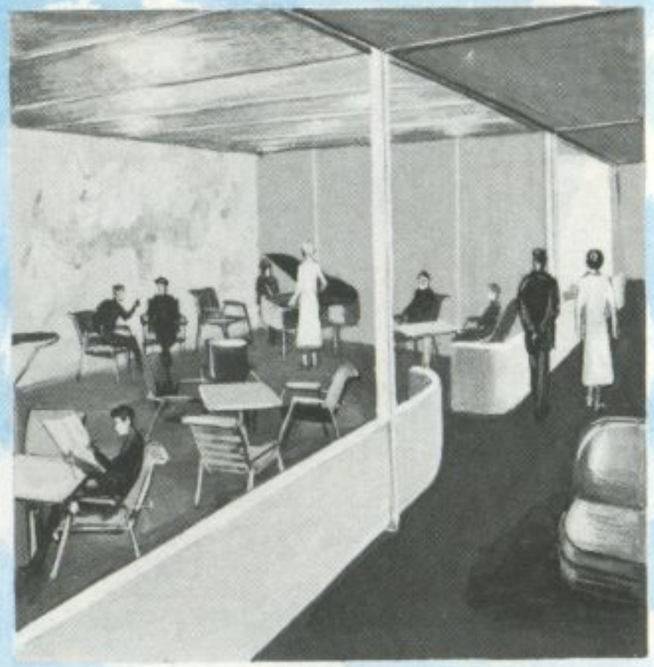
Charles E. Rosendahl

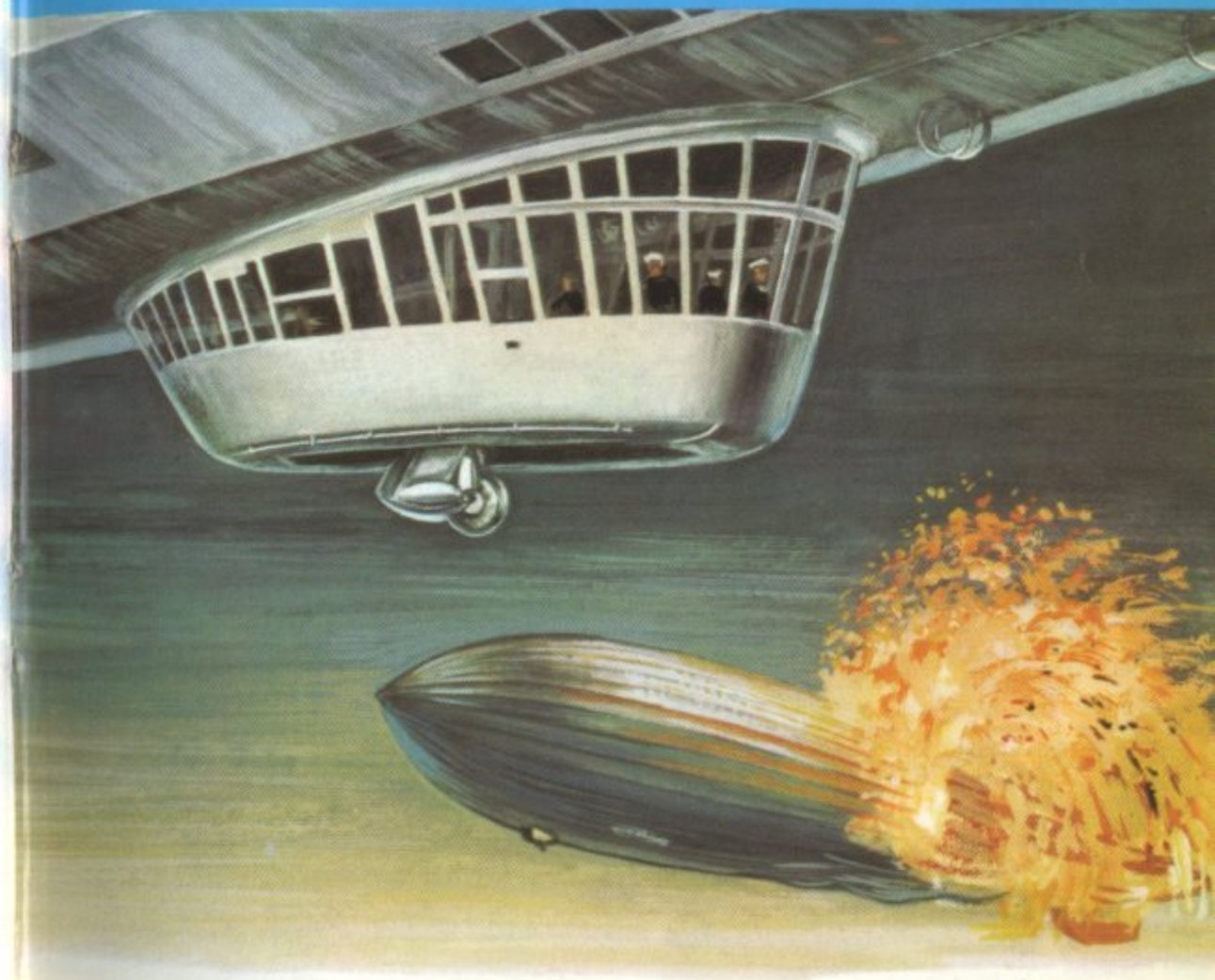


69 U.S. Navy airship ZRS-4 *Akron* was completed in September 1931. It was first under the command of Lieutenant Commander Charles E. Rosendahl, and carried four small Curtiss Fgc Sparrowhawk scouting biplanes which were released and later picked up again without any difficulties. This airship was considered 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.







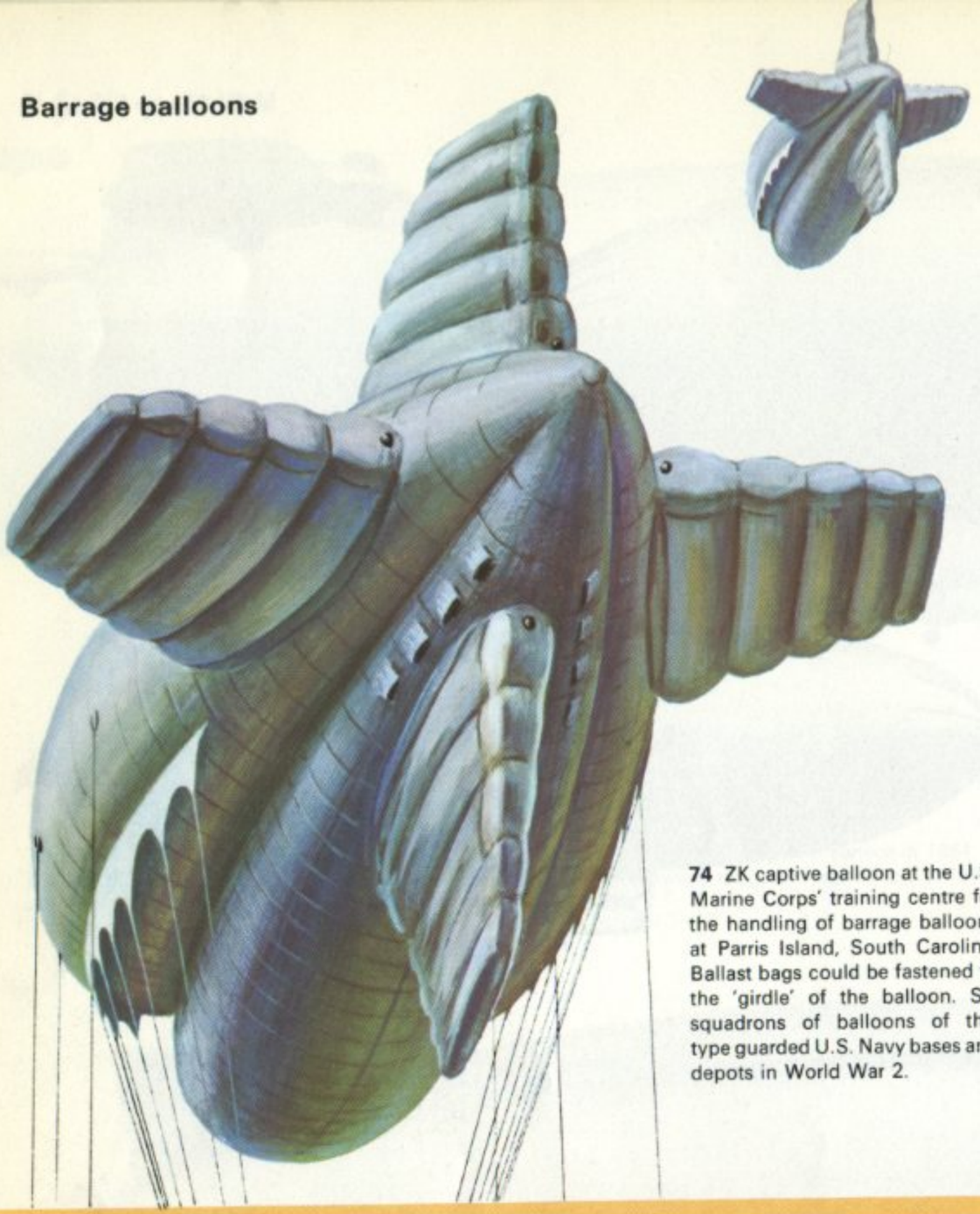
71 The passenger airship Zeppelin LZ 129 *Hindenburg* was the world's largest airship and was built expressly for trans-Atlantic operations. Its one weak feature eventually sealed the fate of this airship: it was filled with inflammable hydrogen instead of with helium, as planned. *Above:* One of the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

U.S. Navy K class

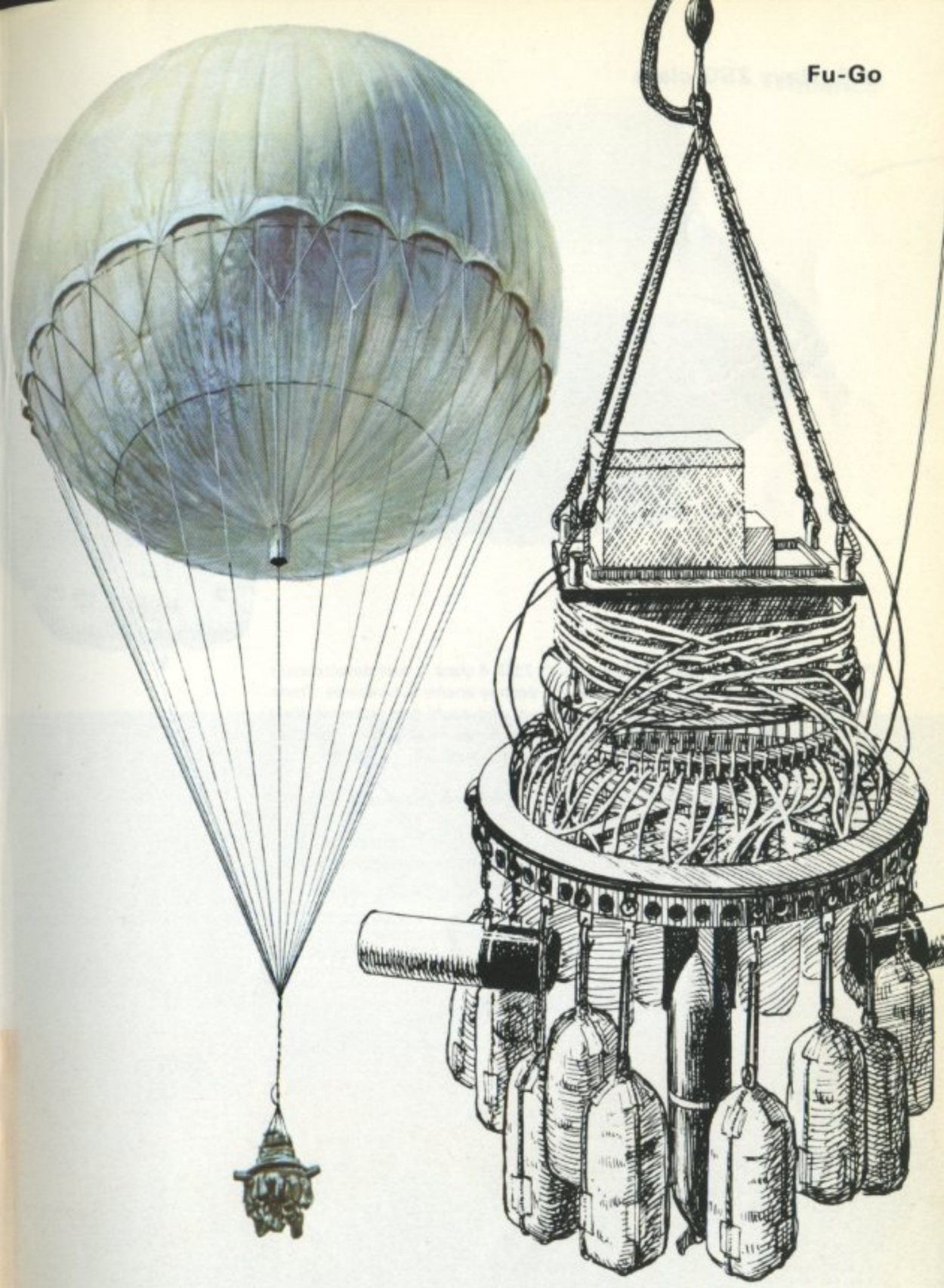
U.S. Navy N class

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.



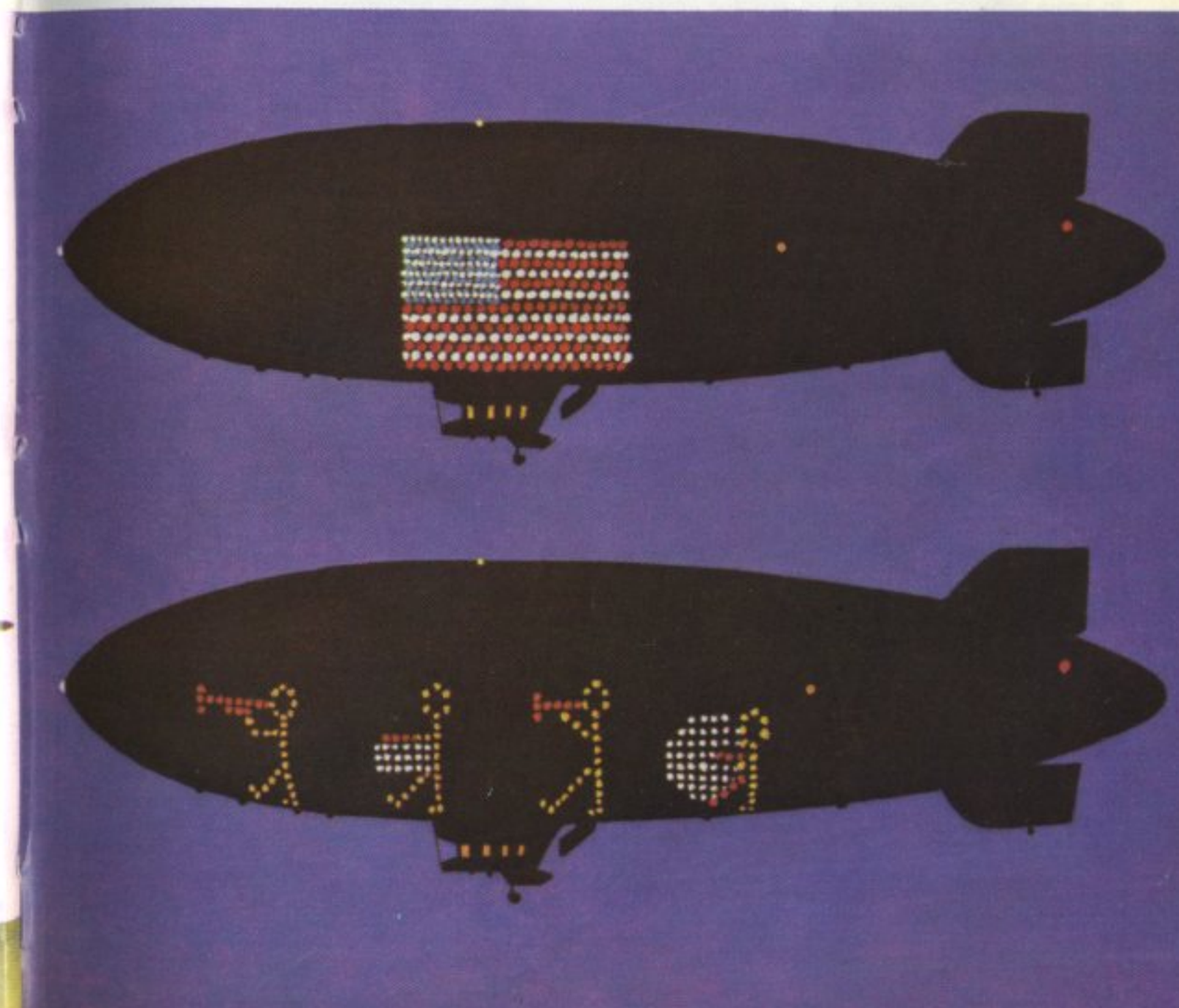
74 ZK captive balloon at the U.S. Marine Corps' training centre for the handling of barrage balloons at Parris Island, South Carolina. Ballast bags could be fastened to the 'girdle' of the balloon. Six squadrons of balloons of this type guarded U.S. Navy bases and depots in World War 2.



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.

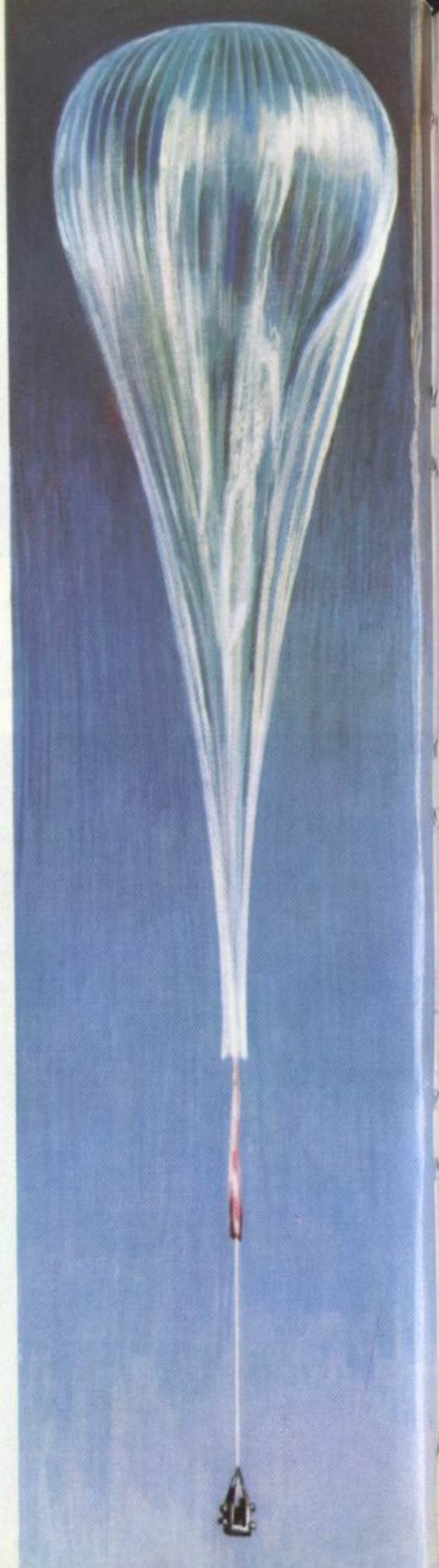
76 Experimental airship of the U.S. Navy's ZSG-4 class, a later development of the K class whose task was to track and destroy enemy submarines. These airships were fitted with refuelling equipment and could also replenish their water ballast in the air. They were also fitted with electrically driven 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