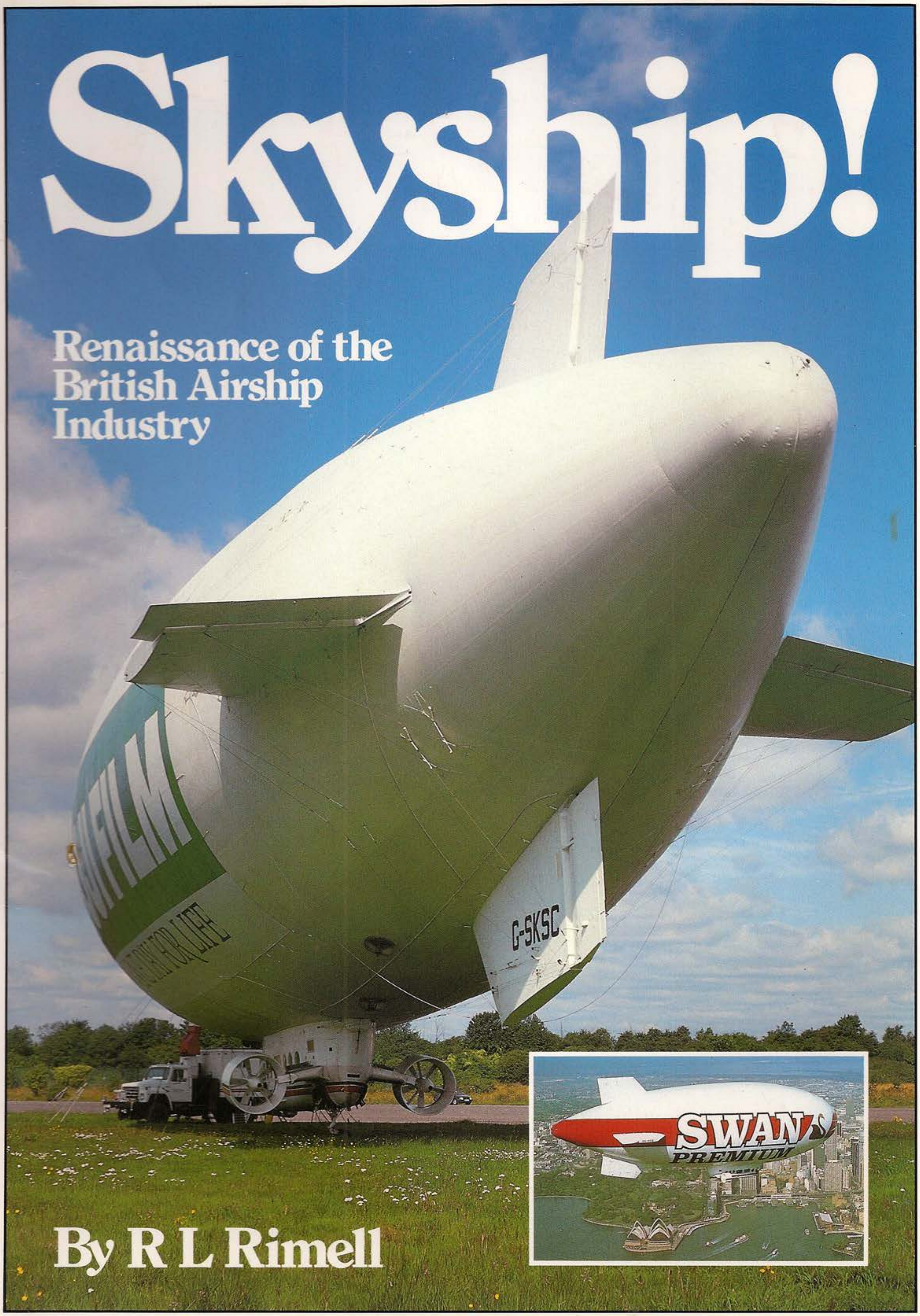
Skyship!

Renaissance of the British Airship Industry



By R L Rimell

The Sky Queens

'... I feel that our airship development is one of the most important things which is taking place in Aviation today and there are no bounds to what the success of these airships will mean to the British Empire if the experimental services work out all right. It is the greatest adventure in construction engineering of our time ...'
Sir Sefton Brancker, Director of Civil Aviation, 1926

The honour of being the first Englishman to build and fly an airship falls to one Stanley Spencer who began constructing small non-rigids in 1902. His first ship was 93 feet long, boasted a volume of 30,000 cubic feet and powered, somewhat marginally, by a 3.5 hp Simms water-cooled engine driving a wooden propeller via reduction gearing.

Several successful flights were made in *Spencer 1*, as the ship was imaginatively named, and the handful of fading photographs that have survived the years show her hull sides adorned with slogans for Mellins Food. Getting the message across was obviously just as relevant in 1902 as it is today ...

Elsewhere in Great Britain during the early 1900s other designers were poring over the drawing boards, most notably ET Willows. In 1905 the first of five Willows airships was built and flown and *Willows 1* incorporated several interesting design features not the least of which was a swivelling twin propeller system.

Both the British Army and the Royal Navy took an early interest in the use of lighter-than-air craft for military purposes and neither arms were slow in developing non-rigids in the years leading up to the First World War. British rigid airship development, however, was tardy and by 1914 only one example had been built. This was the *Mayfly*, constructed at Barrow in Furness by Vickers and the first airship to use a mooring mast. That was *Mayfly*'s main distinction for on September 22 1911 she broke her back during preparations for her maiden flight. The airship was a total wreck and no more British rigids were built until 1916.

British Airships at War

At the outbreak of war in 1914 Britain had just five non-rigid airships at her disposal, all under naval control and most destined to become involved in coastal patrol and escort duties. In order to meet the German U-boat threat a great many patrolling airships would be required and so the reliable old Willows No. 4 became, following some modification, the prototype Submarine Scout in March 1915. This airship was the forerunner of a large fleet of scouting airships used for anti-submarine and mine-hunting operations.

Later came the larger Coastal-type airships, of which some 32 were eventually built, and the North Sea types which entered service in 1917. The NS airships, powered by a pair of 240 hp engines, could accommodate a crew of ten and remain airborne for over 48 hours.

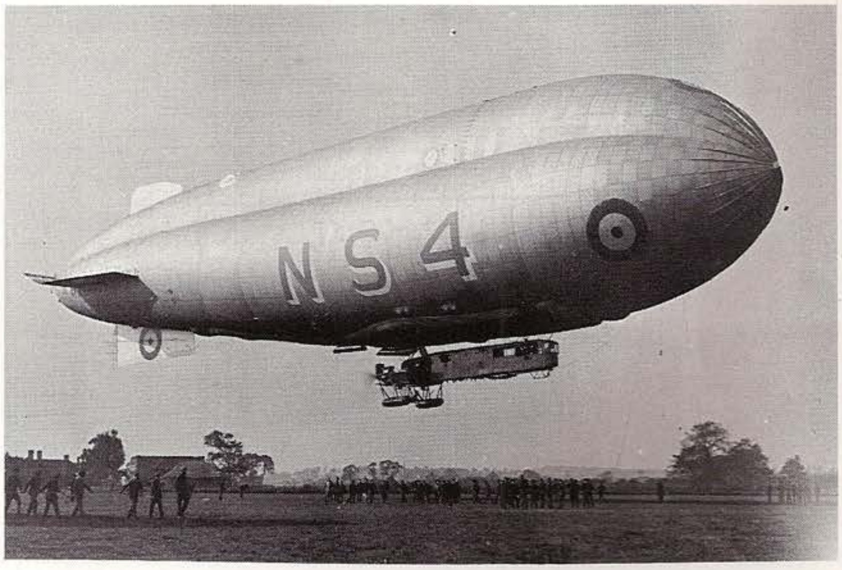
In 1916 Short Brothers were contracted to build a pair of wooden-framed rigid airships, *R31* and *R32*. The former was completed at Cardington two years later, making her maiden flight in August 1918 and obtaining a respectable speed of 70 mph.

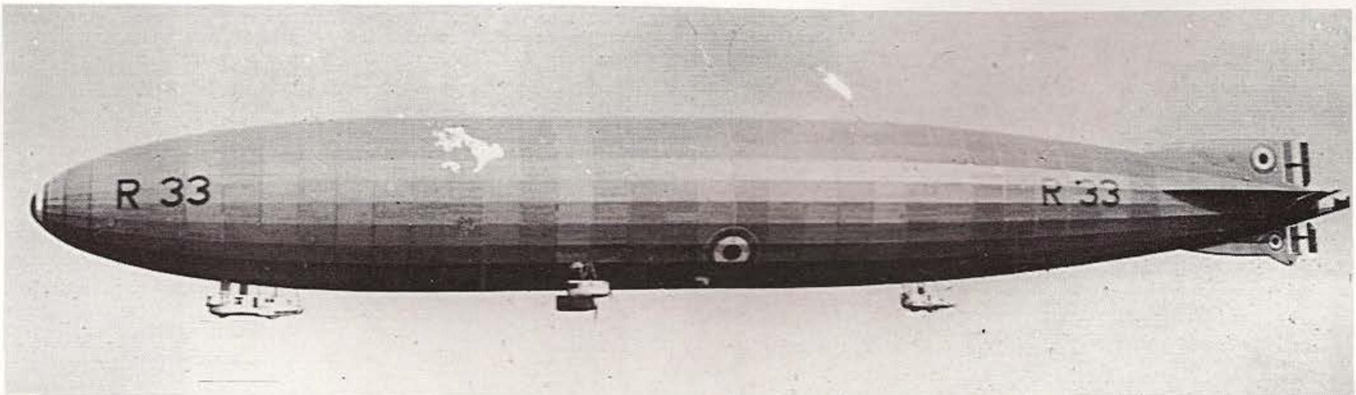
A further five British rigid airships were built before the Armistice but only one, *R29*, made any notable contribution to the war effort, aiding in the destruction of a U-boat off Sunderland on September 29 1918.

Mixed Fortunes

The design of Britain's next rigids, *R33* and

Below, NS4, *one of the North Sea class of non-rigid airships built in 1917. At foot,* R33, *one of Britain's first rigid airships, owed much to German Zeppelin design. Laid down in 1917,* R33 *spent most of her life as a 'hangar queen' and was eventually broken up in 1928.*





R34, was largely based on the German Zeppelin *L33* which, crippled by gunfire and aeroplane attack, had crash-landed virtually intact near Mersea, Essex in September 1916*. Both *R33* and her sister were commissioned in 1919 and the former, based at Pulham, Norfolk, was used for masthead mooring experiments, quickly proving the many advantages of this concept. *R33* was also used for 'Skyhook' experiments in which RAF fighter biplanes were released from special slings under her hull. Today the complete front section of *R33*'s forward gondola is displayed at Hendon's RAF Museum, a unique and fascinating relic from a lost age.

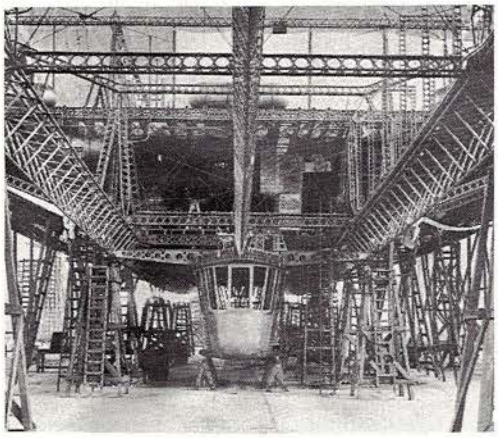
In July 1919, *R34* made the first ever trans-atlantic airship flight taking just over 108 hours to make the long haul from East Fortune, Scotland, to New York. Some months later the airship was seriously damaged after striking a Yorkshire hillside and although she managed to return to her base at Howden she could not be housed in the strong winds. Made fast to a three-wire mooring her fore-part was smashed to pieces and she had to be dismantled.

R35 was abandoned at the design stage — a victim of a post-war economy drive — and, although built, *R37* suffered a similar fate. *R36* was used in a variety of experiments but following a spate of minor accidents was eventually scrapped in 1926. *R38* was lost on August 23 1921 after breaking up in mid-air over the River Humber and crashing in flames.

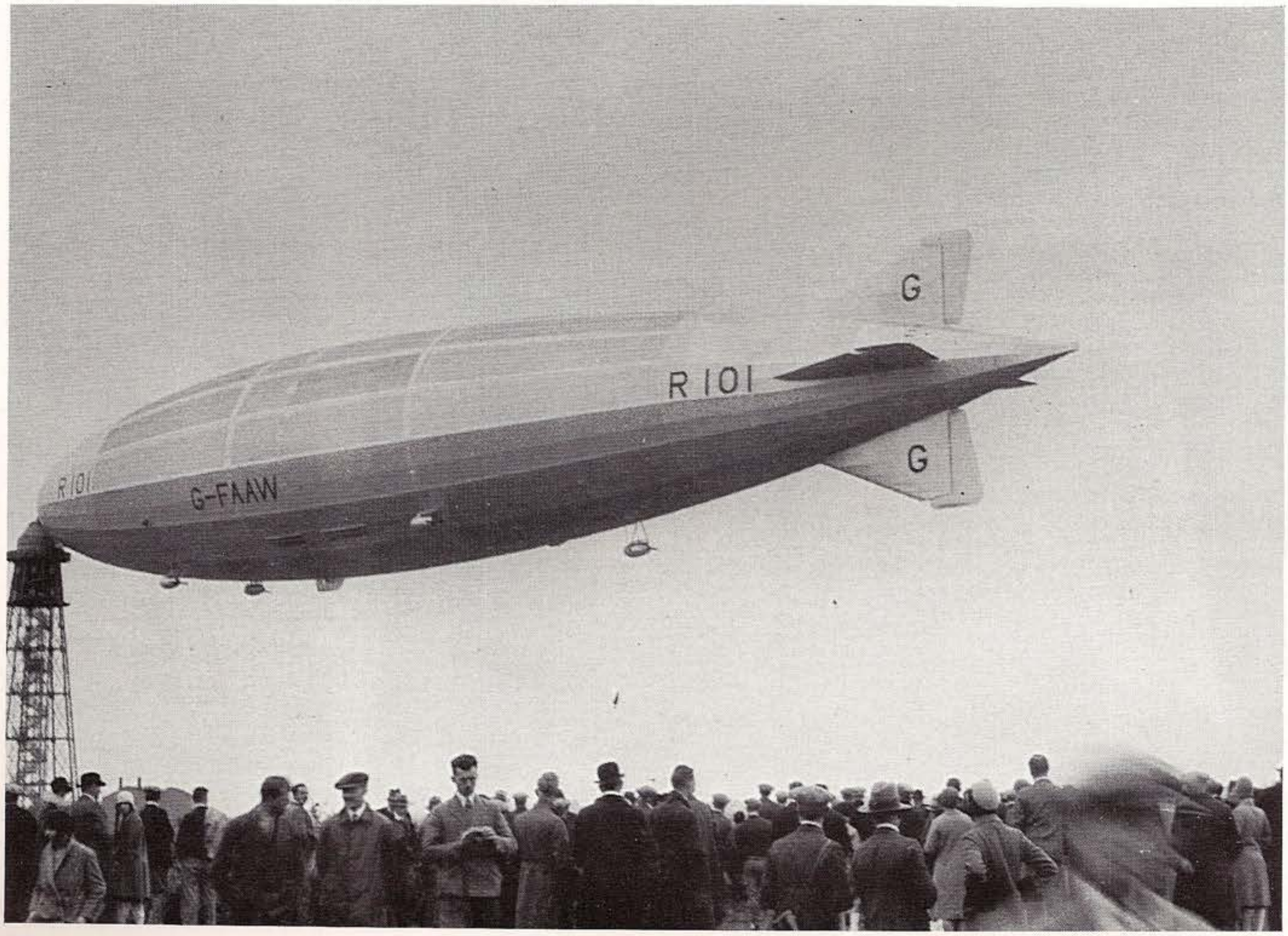
*See ZEPPELIN! by the same author.

There were only five survivors from her complement of 49. The tragedy discouraged a good many private airship projects, but in 1924 the Labour Government supported an ambitious research programme to prove the viability of large passenger-carrying rigid airships. Some £1,350,000 was allocated for this ambitious project which was to include the construction of two experimental ships capable of inter-continental flight.

The new vessels were to be developed independently from each other — *R100* would be built by the Airship Guarantee Company, a subsidiary of Vickers, and *R101* by the Royal Airship Works at Cardington which the Government had taken over from Short Brothers. *R100*'s design owed much to the genius of Dr Barnes Wallis who had developed a revolutionary geodetic form of



Far right, R101*'s control car is already in place as work progresses on the ill-fated ship. Below,* R101 *draws the crowds as she rides the mast at Cardington, October 1929.*

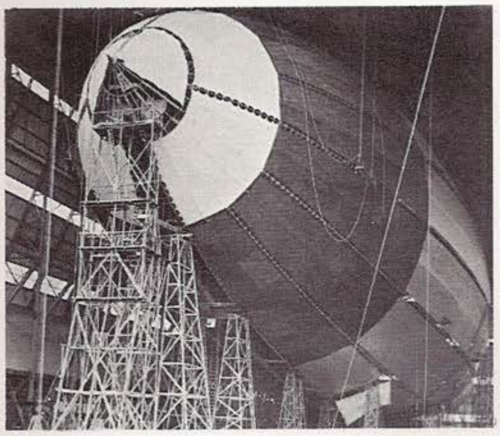


girder design.

Slowly the giant ships took shape and when trials were begun *R100* was found to be some 10 mph faster than her Cardington rival. As well as being underpowered, *R101* also proved to be overweight from the beginning and drastic measures were taken to compensate, including separation of the hull and insertion of an extra 55 foot section.

R100 made a demonstration flight to Canada in 1930 covering 3364 nautical miles in under 79 hours at an average speed of 42 knots. The Howden-built ship remained in Montreal for several days before setting off on her return journey arriving safely at Cardington on August 16 after an uneventful 57½ hours. She never flew again.

Meanwhile, *R101* was having more than her fair share of problems. Only one or two test flights were carried out following the addition of the extra bay and no high speed trials were ever undertaken. Substantial tearing of her outer cover occurred resulting in large areas being replaced although other sections were merely patched up.



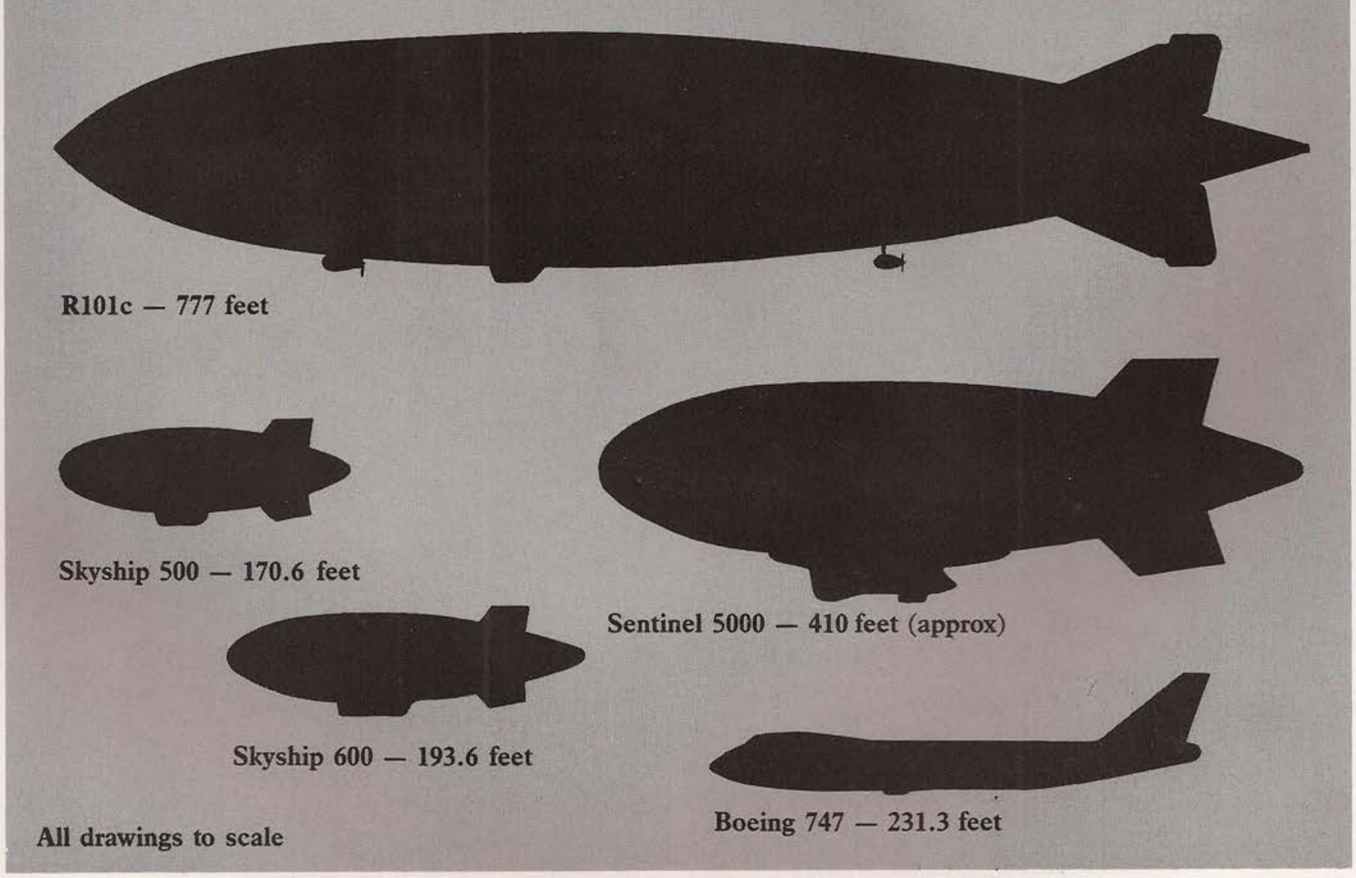
The then Secretary of State for Air, Lord Thomson of Cardington, a strong advocate of the airship programme, pressed hard for a spectacular demonstration flight to India in *R101* and October 4 1930 was the date set for departure. With Thomson aboard the *R101* that evening were five officers, 37 men, six officials from the RAW and six passengers including Sir Sefton Brancker, the Director of Civil Aviation.

Shortly after leaving Cardington, *R101* encountered strengthening winds and rain squalls and with one recalcitrant engine she battled her way towards the French coast at an average height of about 1000 feet. By 2 am *R101* was over Beauvais and pitching badly in the strong headwinds. Five minutes later the airship fell into a steep dive from which she quickly recovered but a second dive proved fatal. *R101* struck the edge of Bois de Coutumes wood and exploded in a fireball. Only six members of the flight survived to tell the tale — Thomson and Brancker were not among them.

On August 31 1931 Ramsay MacDonald's Government abandoned its airship programme, Cardington was reduced to care and maintenance status and that, as far as most people were concerned, finally ended British airship development — or so it seemed . . .

Far left, R101.
In Cardington's No. 1 shed G-FAAW, the largest vessel to be built by the Royal Airship Works, nears completion. The same shed now houses the expanding production and support facilities of Airship Industries. Below, R101c *dwarfs contemporary airships and aircraft.*

How They Compare . . .



Renaissance!

'We recognised that to pioneer the renaissance of the commercial airship into the mainstream of modern aviation, it was necessary to do more than put forward elegant theories on glossy brochures.

Over the last few years it has been necessary to prove that our ships can be certificated to the highest levels of safety, that they can operate all around the world in vastly different conditions and operational circumstances.'
Alan Bond, Chairman, Airship Industries, 1987

Officially anyway, all future prospects for a British airship industry died with the smouldering skeleton of the ill-fated *R101*. In post-war years a handful of dedicated enthusiasts struggled to rekindle an airship revival but, a few notable exceptions notwithstanding, their ambitious plans failed to materialize beyond the drawing office. There was certainly no shortage of ideas. Several concepts were floated by a number of talented design teams yet failed to arouse any interest from major aerospace companies. If there was going to be a Phoenix at all, it seemed destined to remain a paper one.

By the early 1970s however, attitudes seemed to be shifting in the airship's favour and several industrial companies began to seriously consider the commercial viability of operating large airships, primarily as cargo carriers.

It was in September 1971 that two airship enthusiasts, John Wood and a naval architect, Roger Munk, formed Aerospace Developments, a partnership which later that year was awarded a study by the Shell Oil Co., to develop a large rigid airship capable of transporting pressurized natural gas.

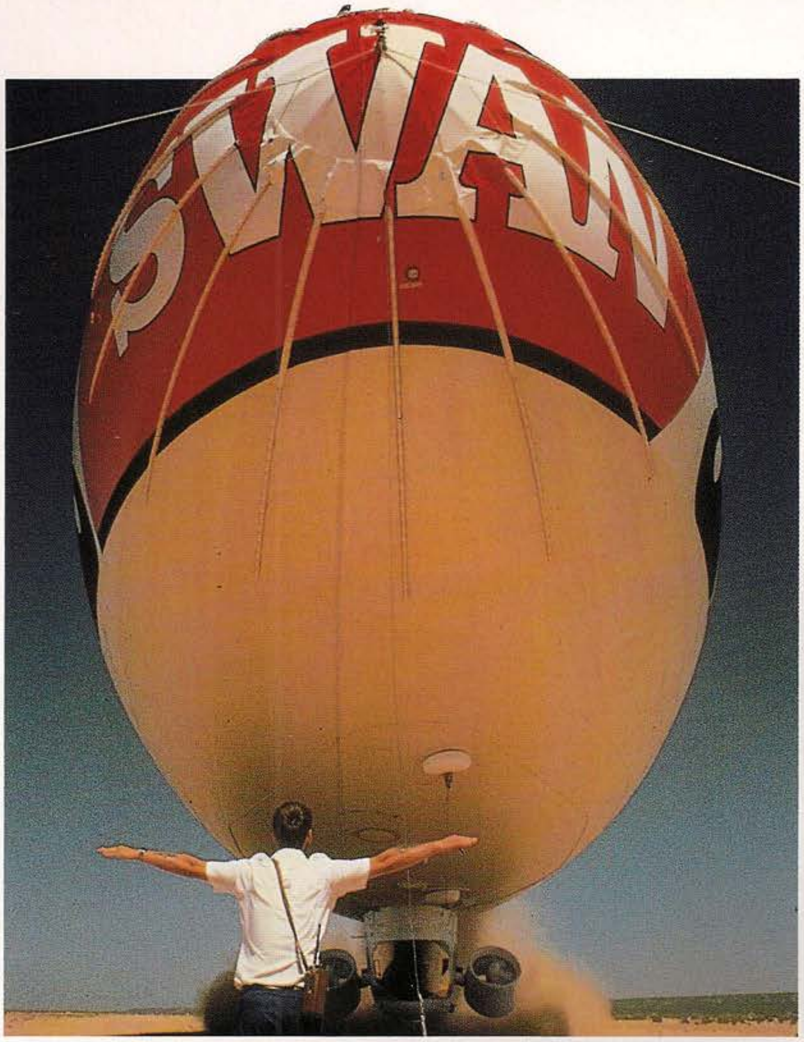
However in 1974, after a major budget review arising from the sharp escalation in oil prices, Shell resolved to cut back their long-term research and development expenditure and accordingly the airship project had to be shelved. As a result the Munk/Wood partnership was free to design and build their own airship prototype, albeit on a more modest scale.

AD500

The airship that was to become in effect the prototype for the Skyship 500 series first took shape on the drawing board in 1976 as a modest non-rigid of 181,000 cubic feet. From the outset, the designers were adamant that their ship would incorporate every possible advantage that modern materials and technology could offer.

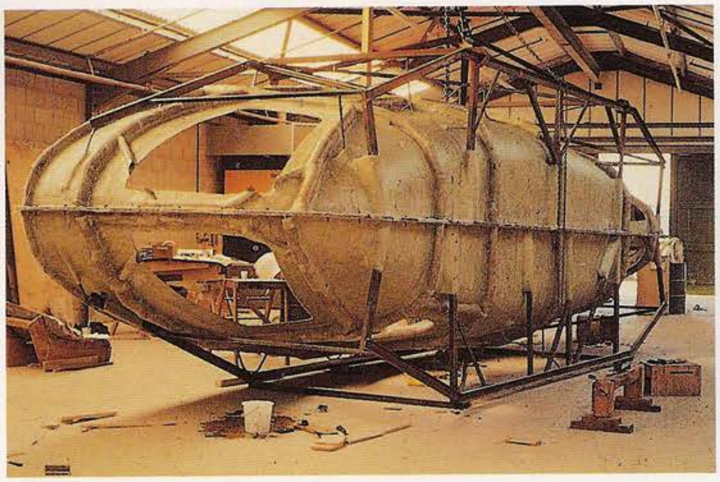
Perhaps one of the most important features

Below, with bow lines trailing, G-BIHN flies the flag for Fuji.



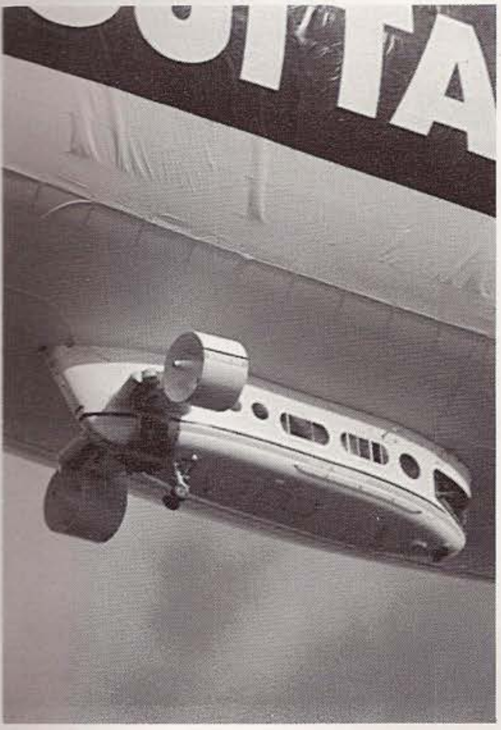
Left, *with engines vectored, Skyship 600-02 VH-HAA (G-SKSD) prepares for take-off, Australia 1987. Below, Skyship 500-06 (G-SKSH) took part in* Fuji-*sponsored Skytours around the United States in the mid 1980s.*

Skyship!



Skyships building. Top, a gondola moulding is prepared by Slingsby Aviation Ltd., of Yorkshire. Centre, inflation of a Skyship envelope and below, looking much like an enormous model kit, one of the more recent Skyships (G-SKSL) nears completion in Japan.

of the AD500 was the propulsion system — vectored thrust. The propellers (more accurately, ducted fans) tilted in order to drive the airship upwards or downwards; a principle much like that on which the V/STOL Harrier 'jump-jet' operates. As we have seen, the basic concept was hardly new, the Willows ships of the early 1900s had already pioneered this system, but John Wood and Roger Munk successfully updated it and it worked perfectly first time, confounding many critics who had forecast major problems.



The use of composite materials was another breakthrough and Roger Munk designed the vessel's 30 foot gondola as a giant Kevlar-reinforced plastic shell, the sturdy yet lightweight monocoque structure offering great design flexibility and maintenance savings.

By March 1978 all the major components had been brought together for final assembly in No. 1 hangar at Cardington, the same shed that, half a century earlier, had housed the *R101*. Despite many teething troubles, a fair share of frustrating moments, not to mention financial problems for the partnership, a date was finally set for the AD500's maiden flight.

On Saturday, February 3 1979 the airship, with ex-*Goodyear* pilot Giovanni Abratti at the controls, made a vectored-thrust take off climbing away rapidly on a 30 degree flight path. The short flight was uneventful and the AD500's performance met all expectations. All those aboard the new airship on that occasion: John Wood, Roger Munk, Ray Hall and electrical engineer Dick Cox, were greatly impressed by the ship's ability to bank swiftly into turns with none of the 'mushiness' usually associated with small airship handling. Success,however, was short-lived, for in the early hours of March 8, the AD500 failed to ride the storm. Moored out on the field at Cardington, worsening winds took their toll and the nose cone began to break up. Despite every effort it was impossible to get the ship

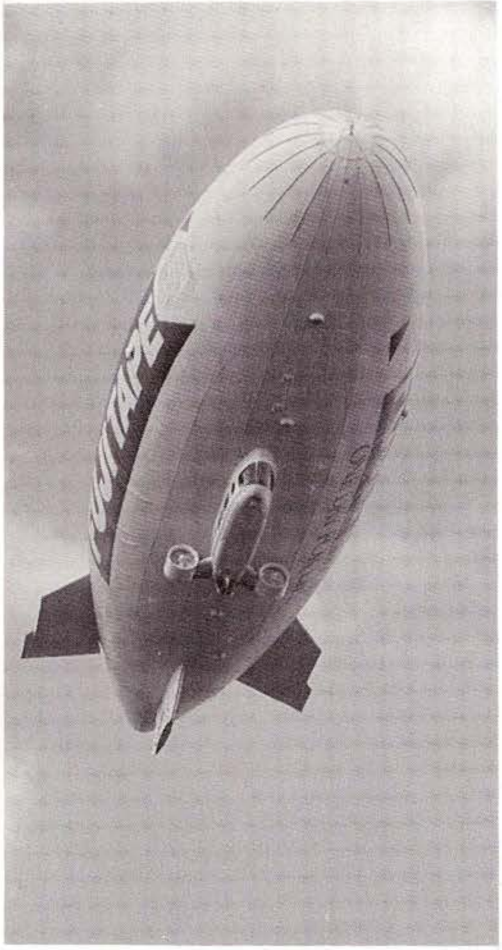
Far left, *G-SKSC over Radlett, August 1987. It's the* Fuji *advertising banner that's full of creases — not the envelope! Below, 600-01 at an earlier stage, being inflated in the No. 1 shed at Cardington with 500-02 in the background.*

inside the hangar and Roger Munk himself had the unenviable task of making the final decision. The emergency rip was operated and the ship deflated but not quickly enough to prevent the gale force winds from seriously damaging the gondola. The disaster finished off Aerospace Developments financially but with the promise of new funds, they reformed themselves as Airship Developments Ltd., in September of that year.

During 1979 Malcolm Wren had already established Thermoskyships on the Isle of Man and both he and Roger Munk realised the value in joining forces. The resulting merger took place a year later, and the new company chose the Skyship 500 for its sole development project. The company was successful in raising capital from city backers and the redesigned Skyship 500-02 made its maiden flight on Monday, September 28 1981.

By the following year Malcolm Wren had left the company to pursue alternative airship projects while Airship Industries, as it was now known, concentrated on the low-lift capability airship realised by the Skyship 500 and its sister ship the Skyship 600. (This being essentially a 'stretched' version of the 500 with a 30% increase in envelope volume providing a 50% increase in disposable load. Although larger, the 600 nevertheless retains the same performance as the 500 by uprating from naturally-aspirated to turbo-charged Porsche engines.)

When the company chairman, Keith Wickenden, was killed in his own light aircraft, the managing director, Andrew Millar,



Far right, G-SKSC, September 1987. Below, G-SKSB provided Fuji *with a high profile during the 1984 Olympic Games in Los Angeles.*

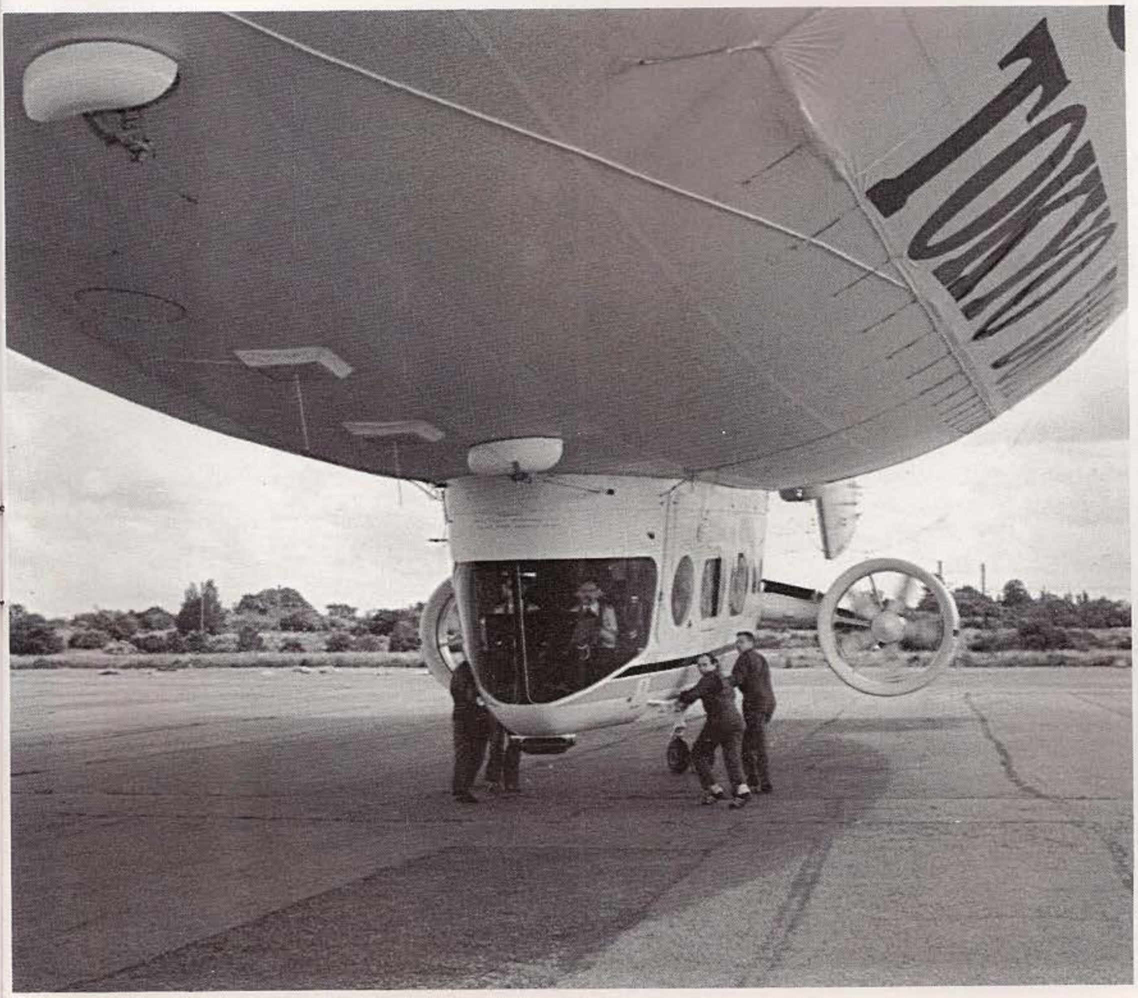
was appointed as chairman and in December 1983 Airship Industries signed its first ever charter in the USA for *Fuji* sponsorship leading up to the Los Angeles Olympics. The ship was delivered in March 1984 and in July the company made its first outright sale to Japan Airship Services, a division of Japan Air Lines. As this book goes to press, a further three sales have been delivered or contracted — another to JAS, one to the Korean government, and one to the Tokyo Metropolitan Police for internal security.

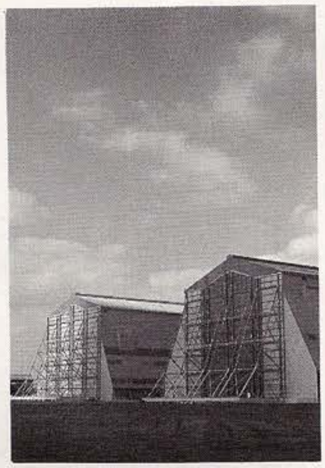
Enter Alan Bond

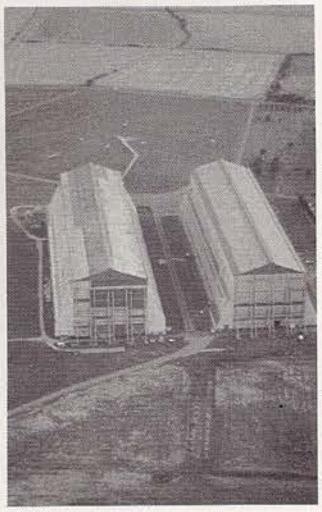
One of the world's leading businessmen, Alan Bond was born in 1938 at Ealing, West London and at 13 emigrated to Western Australia with his parents. Following apprenticeship as a signwriter he decided that there was real money to be made in the selling of property. He took to this with such dedication and flair that by the time of his 21st birthday he was a millionaire.

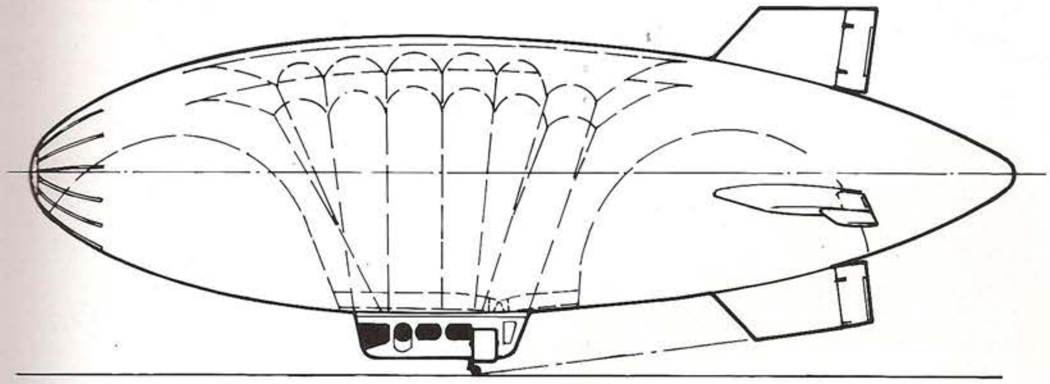
Today, the Bond Corporation, with its many diversified interests, ranks among Australia's top corporations with annual revenues approaching the 500 million dollar mark. One of Alan Bond's many interests is yachting and since 1974 he has been both chairman and team captain of the syndicate formed to mount challenges for the America's Cup. It was during this prestigious event in 1983 off Newport, Rhode Island — a memorable one for Alan Bond and all Australians as his yacht *Australia II* captured the coveted trophy — that 'Bondie' first became interested in airships

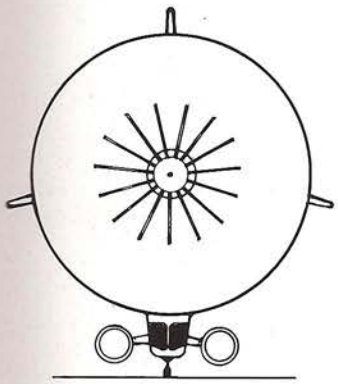
Far left, a mobile mooring mast is an enormous advantage. Below left, the Skyship's twin Porsche engines are run up, some of the ground crew steadying the gondola as G-SKSC prepares for take-off. Radlett, July 1987. Below, the historic sheds at Cardington.





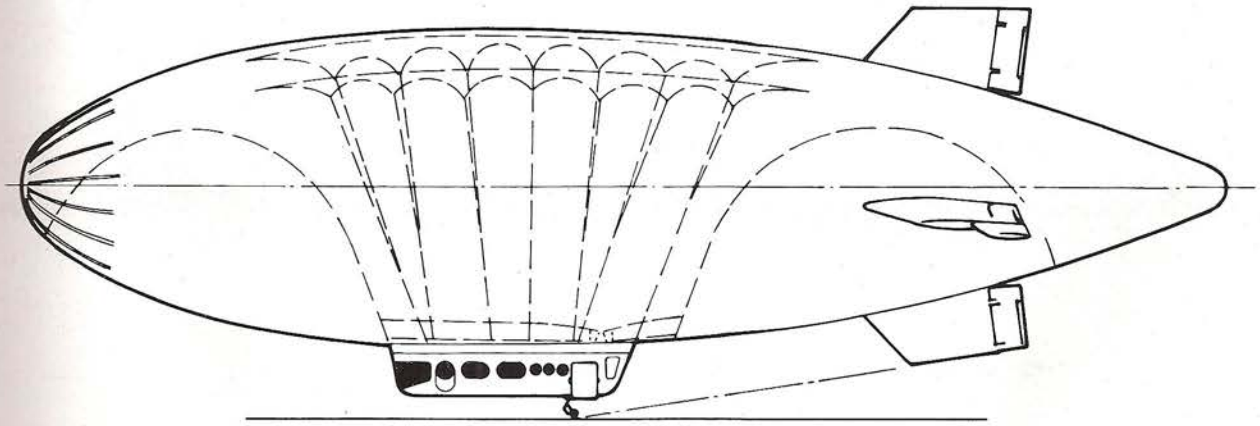


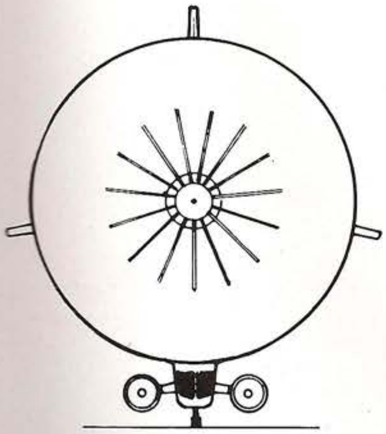




Skyship 500

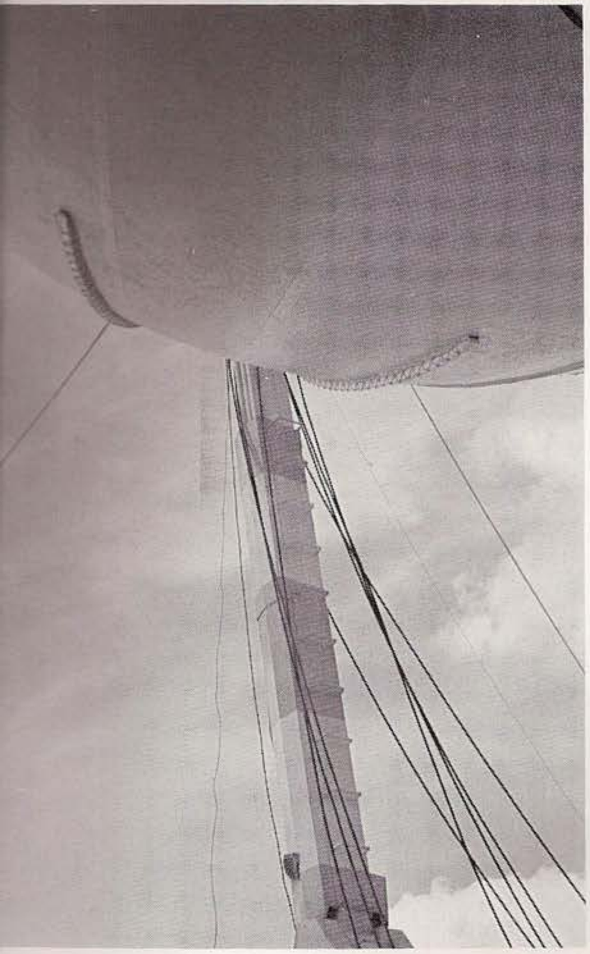
Principal Dimensions		
Gross envelope volume	5153m³	182,000ft³
Ballonet volume	26% of gross envelope volume	
Length (overall)	52.0m	170.6ft
Diameter	14.0m	45.9ft
Height (overall)	18.7m	61.2ft
Tailspan	17.0m	55.7ft
L/D ratio	3.71	—
Gondola Dimensions		
Length (overall)	9.24	30.3ft
Width (overall)	2.41m	7.9ft
Main cabin headroom	1.96m	6.4ft
Main cabin length	4.20m	13.8ft





Skyship 600

Principal Dimensions		
Gross envelope volume	6666m³	235,400ft³
Ballonet volume	26% of gross envelope volume	
Length (overall)	59.0m	193.6ft
Diameter	15.2m	49.9ft
Height (overall)	20.3m	66.6ft
Tailspan	19.2m	63.0ft
L/D ratio	3.88	—
Gondola Dimensions		
Length (overall)	11.67m	38.3ft
Width (overall)	2.56m	8.4ft
Main cabin headroom	1.92m	6.3ft
Main cabin length	6.89m	22.6ft



after watching a *Goodyear* blimp providing aerial coverage. For the 1987 Perth race, he vowed, he would have his own ship to record the event.

In March 1984 the Bond Corporation acquired 31% of Airship Industries' shares and subsequently increased their shareholding to 81%. As a result of dilution through subsequent share issues, the Bond Corporation currently controls 48% of the issued capital. This heavy involvement reversed the fortunes of Airship Industries which is now the world's largest organisation dedicated to the design, development, production, operation and marketing of modern airships. The ships produced by the company are unique. They are the most advanced in the world and the first generation of airships to attain full commercial certification.

Skyship applications

The roles that airships play in the modern world are many and varied. Aerial advertising, passenger carrying, and airborne (especially coastal) surveillance all come easily within their operating sphere. The Skyship has also proved to be a stable and reliable broadcasting platform for major sports events. In 1986 the *Swan*-liveried 600-02 (VH-HAA) was as common a sight to Australians in Perth for the America's Cup yacht race as was the *Pepsi*-sponsored 600-05 (G-SKSJ) to Californians flocking to the Super Bowl final. Some of the most dramatic coverage of these events was filmed from the Skyships and the 1984 Los Angeles Olympics was equally well covered by

Far left, G-SKSC on the mast at Radlett and below, rear aspect of the 500HL gondola in No. 1 shed, Cardington. The 'Heavy Lift' 500 combines the lighter gondola of the 500 with the large capacity envelope of the 600 resulting in greatly improved lift, thereby increasing payload capacity.

the *Fuji*-sponsored 500-04 (G-SKSB). In 1988 the latest Skyship (600-08) played a substantial part over the Seoul Olympics in Korea.

Other uses to which the modern airship may be put include the civil function of scientific testing; the surveillance functions of internal security, border control, anti-drug trafficking and pollution control; the military functions of Airborne Early Warning, Mine Countermeasures and Electronic Intelligence; and the equally important training function for pilots of both current and future generations of ships.

The way forward

On June 5 1987 Airship Industries achieved another major triumph thanks to a multi-million dollar order from the US Navy for the development, construction and operational evaluation of a very large airship, the Sentinel 5000, as a preliminary requirement ahead of a fleet procurement mooted in some quarters as being for up to 50 Oceanic Patrol airships. The contract was won by Airship Industries and its American partner, Westinghouse Electric Co., despite stiff opposition from home-based *Goodyear* whose historic experience in the LTA field and virtual monopoly in supplying maritime airships for the USN convinced many observers that the latter's proposals would be automatically selected.

The development of Sentinel 5000 marks a significant milestone in the short, yet eventful history of Airship Industries and may yet lead to military dirigibles of even greater size in decades to come. Resultant 'spin-off' technology could also pave the way for a civil variant of the 5000, capable of carrying over 140 passengers in all the style and luxury associated with the 'Sky Queens' of yesteryear — but in far greater safety and comfort.

Far right, G-SKSC passes over Cardington's sheds during a crew-training flight, September 1987. Below, a view of a Skyship gondola emphasising the generous proportions of the flight deck transparency.

A Skyship Profile

'... The main difference between the old airships and the ships that we're building is that we've been the first company to apply modern technology. So we've taken an old concept, brought it bang up to date using advanced composites, reliable and fuel-efficient engines, modern bonding techniques and vectored thrust. Not surprisingly, therefore, we have totally transformed the capability of the airship ...'
Roger Munk, Executive Director, Airship Industries, 1986

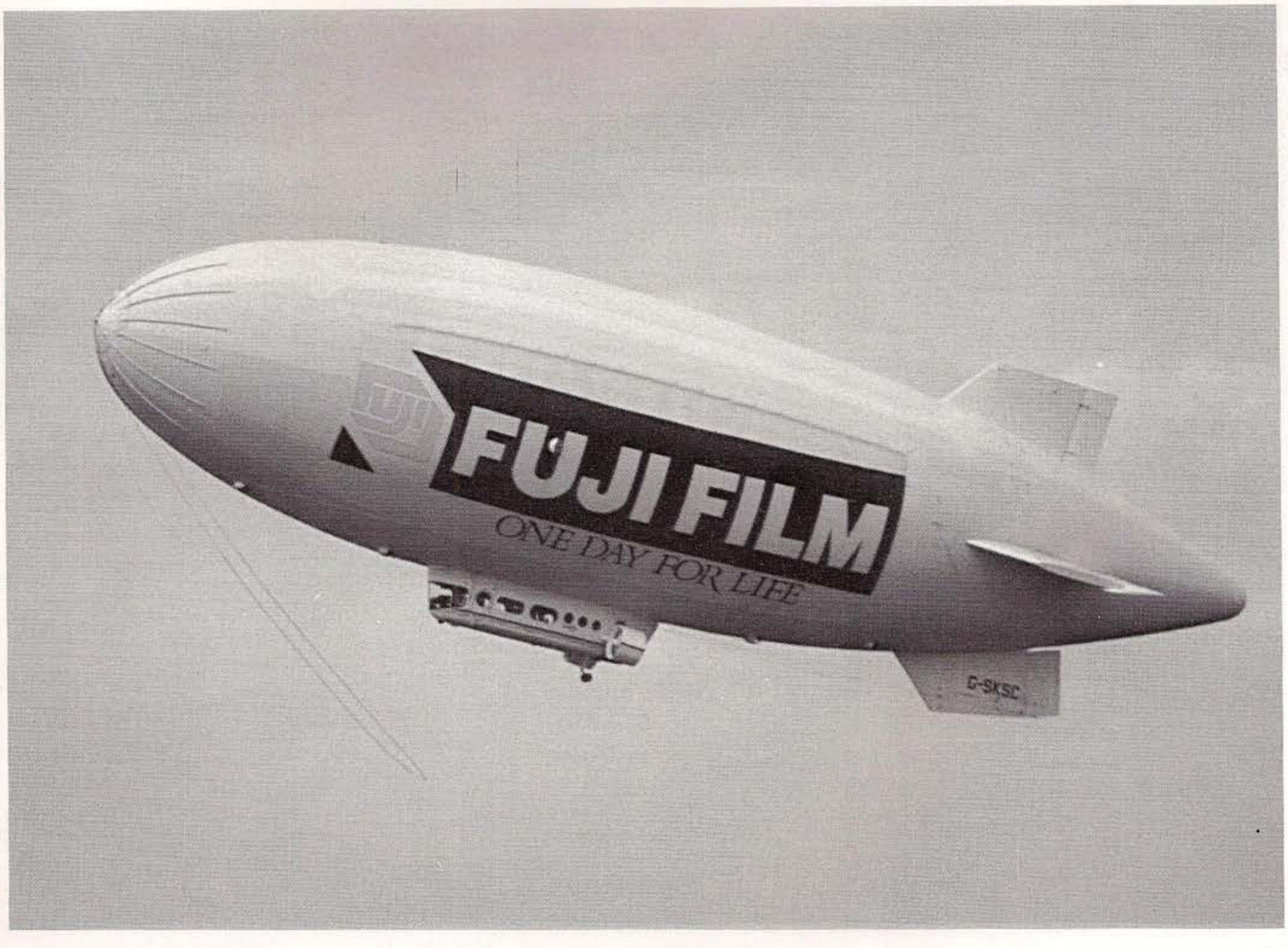
The modern Skyships were designed from the outset to take advantage of high tensile yet lightweight materials such as Kevlar, glass-reinforced plastic and honeycomb sandwich composites; while the envelope material, a strong, low gas-permeable polyester laminate has been developed specifically for the new airships. Heavy reliance on such state-of-the-art materials greatly reduces the overall structural weight of the Skyship and this, in turn, increases its disposable load. The materials also extend the life of the structure, easing maintenance and improving performance. In addition, the use of totally inert helium as the lift gas, has completely eliminated the dangers associated with the highly flammable hydrogen used in most pre-war dirigibles.

While most Skyship construction detail is common to both the 500 and 600 series, the specifications and dimensions quoted throughout this chapter refer to the 600 which is now the principal production model ...

Envelope

The Skyship 600 is of conventional non-rigid configuration. The envelope (or hull) is a laminated material with a polyester load carrier lined internally with a Saran gas-retention film and spray-coated externally with a white titanium dioxide-loaded polyurethane to provide a tough, durable skin. Leakage is extremely minimal, averaging only one per cent per month due to the relatively low pressures used. The envelope incorporates two large ballonets (pronounced ballon*ase*) one forward, one aft. Their primary functions are to maintain pressure and retain the shape of the envelope by compensating for expansion and contraction of the helium occupying the remaining space. Both ballonets are inflated with ram air collected from angular scoops mounted directly in the slipstream behind each propeller. Internal electric axial fans for low airspeeds or large vector angle operations are also fitted. Each of these can be operated independently and may also be switched to

Below, G-SKSC over Radlett in August 1987 during the second London Skycruise *season.*



Skyship under scrutiny. Far right, the emergency rip toggle is well safeguarded against accidental operation. In clockwise direction from below left: G-SKSC's crew welcomes passengers aboard; one of the four automatic ballonet valves beneath the airship; one of the pre-set envelope pressure valves; and finally, envelope radio aerial mounting just forward of the gondola.

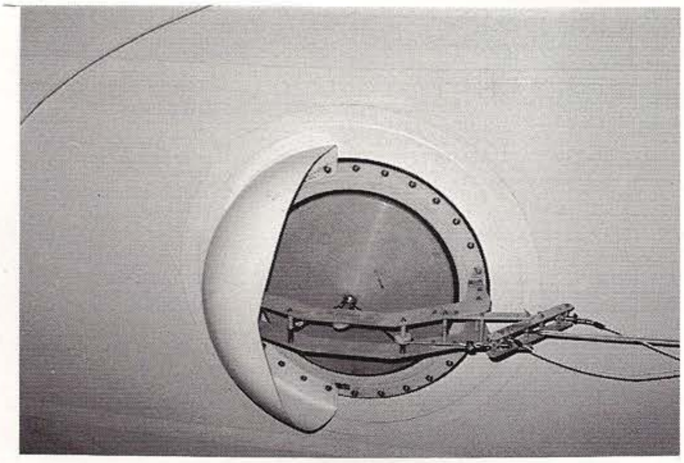
automatic mode so that the ship's pressure can be controlled by an adjustable pressure switch. Automatic flap valves ensure correct functioning of the ballonet air supply system with any combination of available air sources.

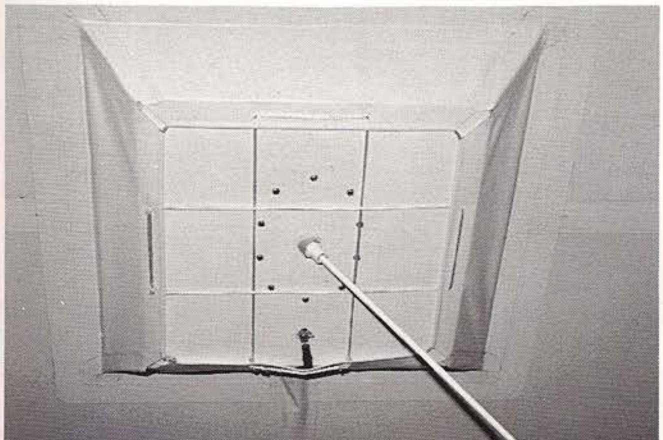
Should the ballonets become full in flight and envelope pressure drop below the safety level, a toggle is provided which, when pulled, opens a pair of fabric panels that quickly permit air to be discharged directly into the helium space.

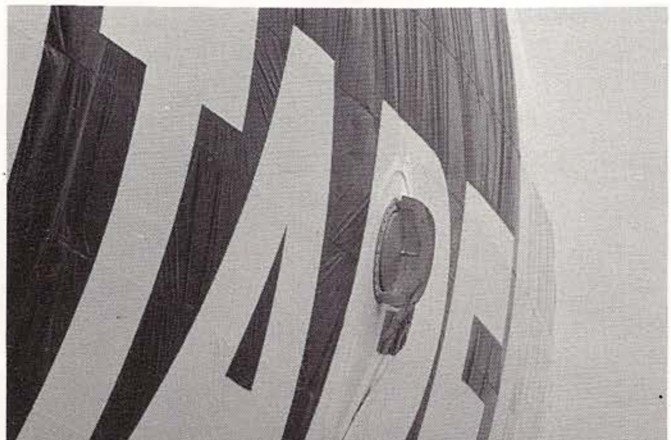
Excessive envelope pressure is prevented by releasing air from the ballonets via four fully automatic valves situated along the underside of the envelope. The 20 inch diameter valves are largely made from glassfibre and individually adjustable for pressure setting. Manual opening and closing facility for the valves is available to the flight deck crew, the system also making trim balance possible through differential inflation. A further two emergency valves are situated on either side of the envelope on the equator line and can be used to vent helium if the pressure height is exceeded and the ballonets are already exhausted.

Three polycarbonate inspection covers provide access to the envelope whilst inflated — one per ballonet, one into the hull — and each aperture is strengthened with a neoprene/aluminium alloy reinforcement ring. A special rip system, suitably safeguarded, is provided for rapid deflation of the envelope in dire emergency.

Strong points are provided around the envelope for emergency tie-down and inflation

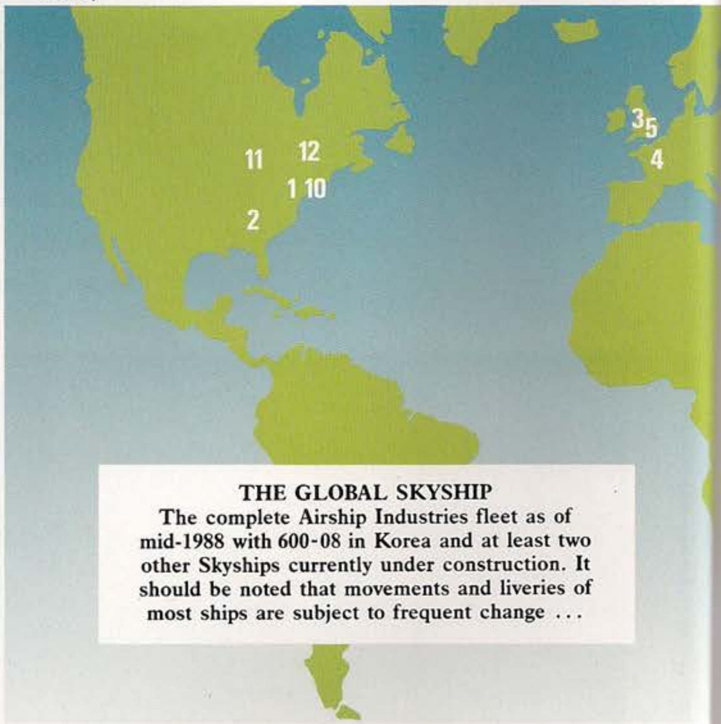






Left, take-off is smooth and surprisingly rapid. G-SKSC at Radlett, July 1987. Below, one of the 500HL's propeller ducts awaits installation.

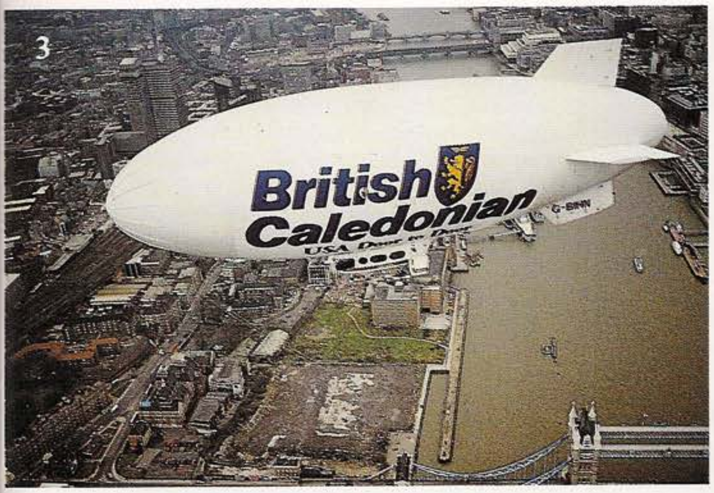
1. *600-04 (G-SKSF)* Weeksville. (Maiden flight, June 1986)
2. *600-05 (G-SKSJ)* Touring USA. (Maiden flight, November 1986)
3. *500-02 (G-BIHN)* Cardington. (Maiden flight, September 1981)



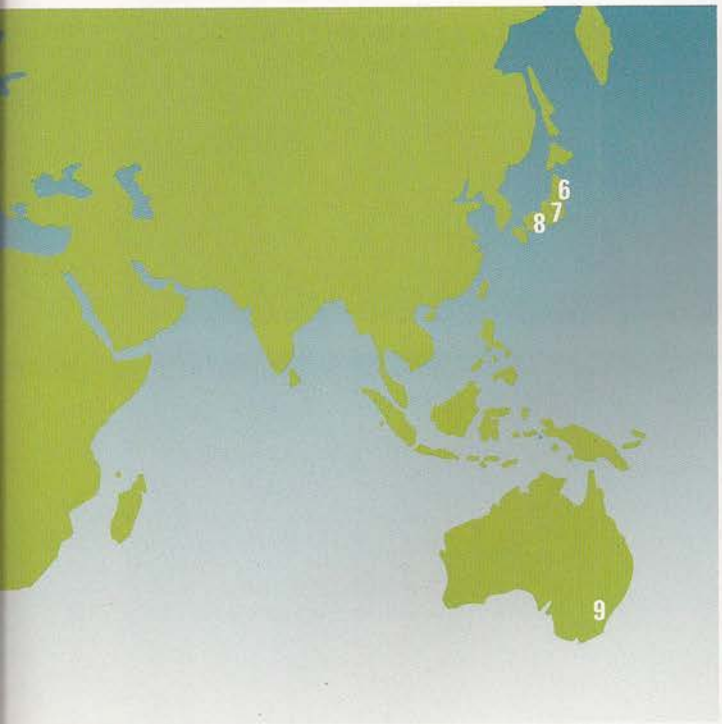
THE GLOBAL SKYSHIP

The complete Airship Industries fleet as of mid-1988 with 600-08 in Korea and at least two other Skyships currently under construction. It should be noted that movements and liveries of most ships are subject to frequent change ...

7. *600-07 (G-SKSL)* Tokyo. (Maiden flight, August 1987)
8. *600-06 (VH-HAN)* Touring Japan. (Maiden flight, February 1987)
9. *600-02 (VH-HAA)* ex G-SKSD Sydney. (Maiden flight, September 1985)

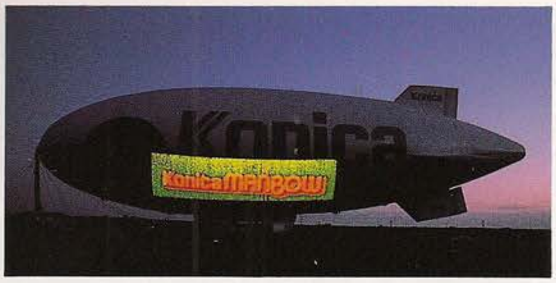


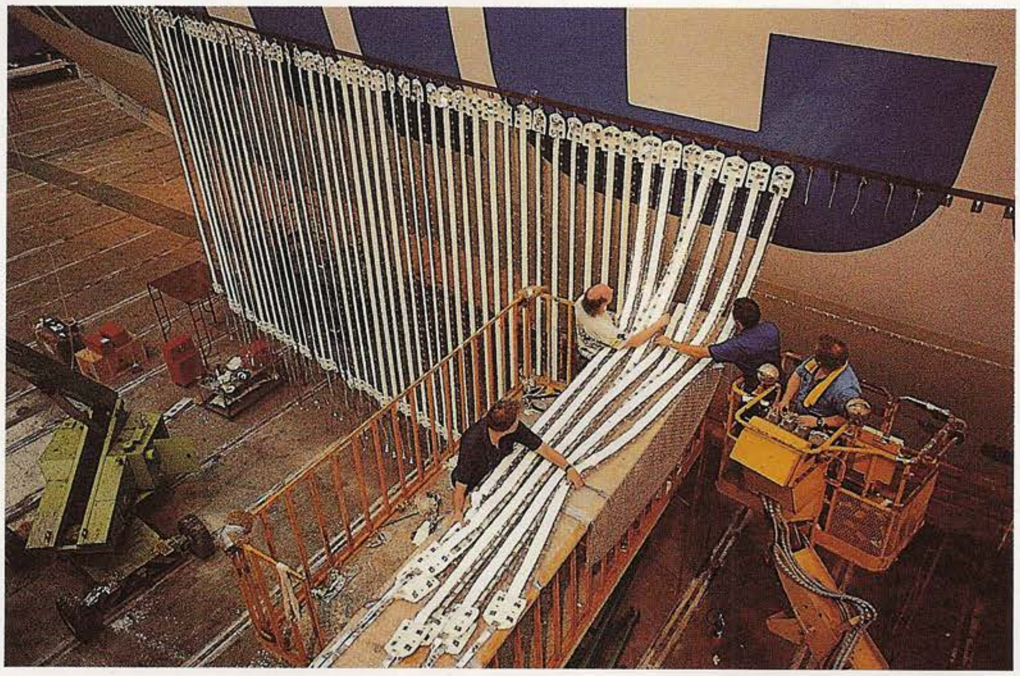
4. *600-01 (G-SKSC)* **Paris. (Maiden flight, March 1984)**
5. *500-04 (HL) (G-SKSB)* **Cardington. (Maiden flight, October 1987)**
6. *500-05 (JA-1003)* **Tokyo. (Maiden flight, May 1984)**



10. *500-03 (G-SKSA)* **Weeksville. (Maiden flight, April 198**
11. *500-06 (G-SKSH)* **Touring USA. (Maiden flight, August 1985)**
12. *600-03 (G-SKSG)* **Touring Canada. (Maiden flight, July 1985)**

Skyship!





Top right, currently operating in Japan, G-SKSL displays its impressive Skysign *facility. Right, mounting the strips of* Skysign *LEDs to the envelope of 600-07 in Japan. Below, long-term contract for the* Skysign *ship enables* Konica's *eyecatching livery to be painted directly to the envelope.*

purposes; two at the bow, two forward of the tail fins and one aft — all with a nominal breaking strain of 1000 kg. Six rigging points are positioned around the envelope's equator and a distinctive rain curtain circumscribes the lower part of the ship just above the gondola. Handling ropes include two bow yaw lines, a nose pendant of stainless steel, and two stern quarter lines.

The nose of the envelope is strengthened with a nose cone, a two-piece glassfibre moulding which provides a single mooring point housing designed to resist substantial loads. Fifteen glassfibre battens radiate from the nose, allowing the ship to withstand aerodynamic pressure at high speed.

The four large tail fins are of all-composite construction. Ribs and spars are profiled from glassfibre-faced Nomex honeycomb core material, the fins being clad with two-ply glassfibre on their leading edges, the remainder covered in Ceconite. Spring tabs are fitted to rudders and elevators.

Gondola

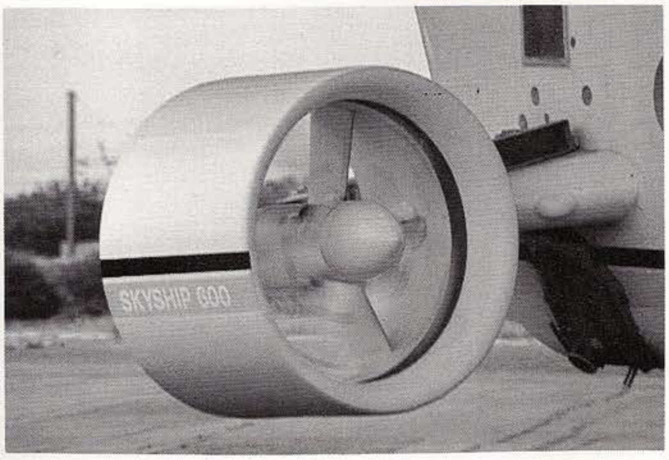
The gondola is essentially a large Kevlar moulding 11.8 metres long with the main cabin frame mouldings being formed from the same material. It is suspended from the envelope via a fail-safe system of 14 Kevlar suspension cables and a biased sheer collar for horizontal restraint, the load being spread by four parabolic arch fabric load curtains bonded to the top of the envelope. Interior of the 600 series gondola can be adapted either to provide comfortable seating for up to 13 passengers or to fit an extensive variety of equipment for military purposes.

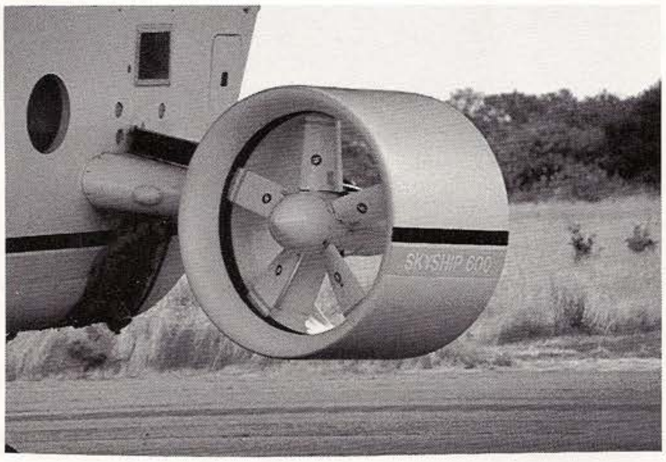
Although the Skyships are designed for one-man operation, two pilot's stations are catered for. Conventional twin control yokes are provided which operate all control surfaces — there are no rudder pedals as in a conventional aircraft — and single-lever engine controls are mounted in a central console.

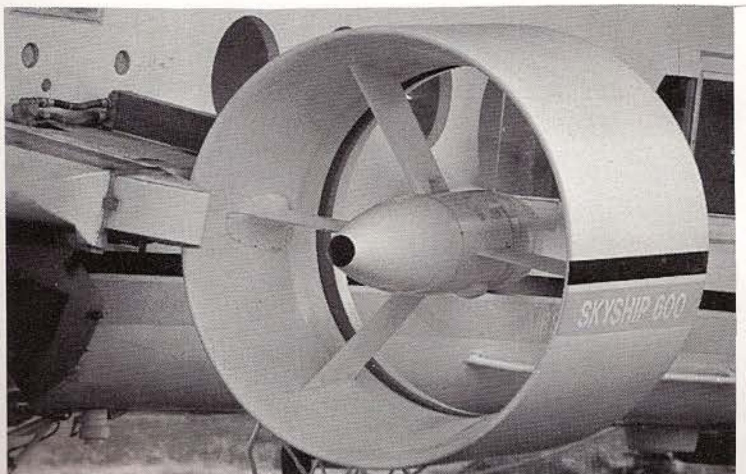
The main cabin, or payload compartment, is located in the centre of the gondola and is fitted with a double-skinned floor comprising Fibrelam panelling and floor supporting structure, the latter being bonded to the external Kevlar shell.

At the forward end of the cabin, the main access door is situated on the port side immediately behind the flight deck. Windows of generous proportions are installed either side of the gondola and the central panels can

Far left, the vectored thrust capability is shown to advantage as Skyship 500-03 takes off during the 1983 PACE trials. Below, two frontal aspects of the propeller ducts on G-SKSC at Radlett. At foot, angular scoop in the propeller slipstream collects air for the ballonets and, at right, the sturdy, single strut undercarriage unit.







be slid open, at the crew's discretion, to facilitate photography by passengers. These windows also double as emergency exits. At the rear of the cabin is a WC compartment incorporating an electrically-flushing toilet and handbasin.

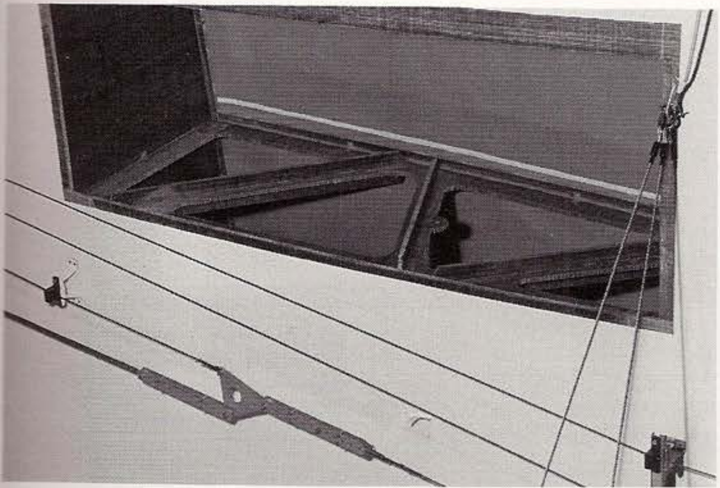
Running the length of the rear bulkhead is a box structure containing the battery and two water ballast tanks, a third tank being located beneath the engine compartment.

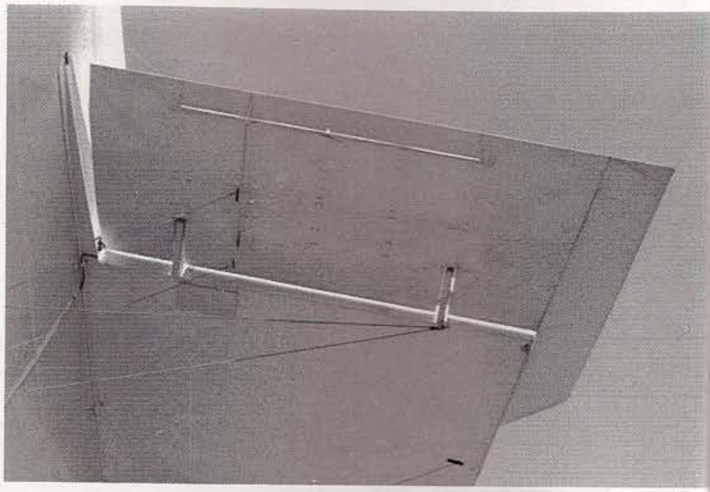
Propulsion system

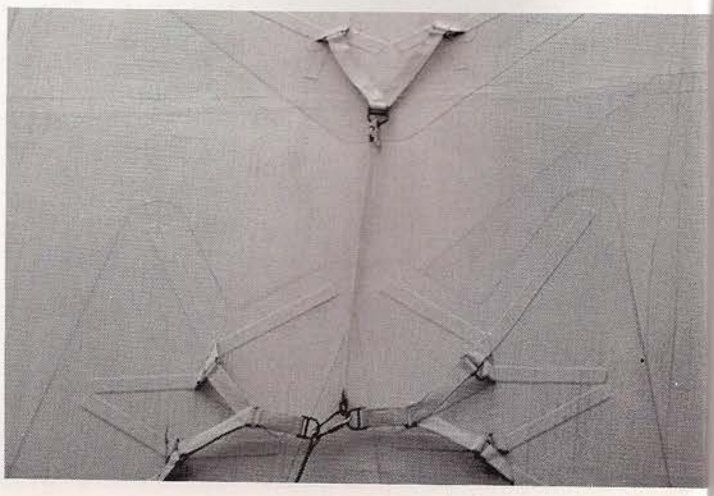
One of the Skyship's most important design features is its vectored thrust capability. By rotating the ducted propellers through a maximum 200 degrees arc, the Skyship can take off and land vertically as well as being able to manoeuvre and remain in a steady hover position with impressive accuracy. The ducts themselves not only reduce propeller noise but increase efficiency and offer improved safety to boarding and disembarking passengers, as well as the ground crew working around the ship.

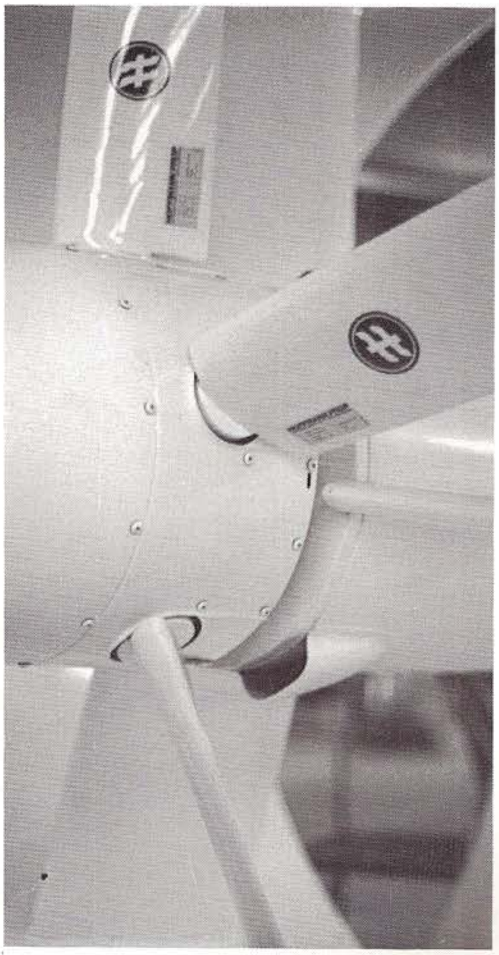
The engine compartment is located at the rear of the gondola and houses a pair of transversely-mounted Porsche 930/67 piston engines, each contained in separate fire-resistant housings. Titanium-faced panels provide access from inside the gondola to the top of the powerplants for routine maintenance and fine tuning while access to the underside of the engines is via hatches fitted beneath the gondola. An engine lifting beam, incorporating a pair of strong points for lifting tackle, is fitted to the ceiling of the gondola. The rear of

Far right, undercarriage detail of the 'Heavy Lift' Skyship at Cardington, September 1987. Below, in clockwise direction from left: composite structure of a Skyship fin is revealed; looking up at the starboard elevator of 600-01; close-up on reinforcing webs supporting the tail bracing and, finally, lower fin and rudder with control cables well in evidence.









the engine compartment also contains the main fuel tank which holds 150 imperial gallons of either Mogas 4 Star or Avgas 100LL.

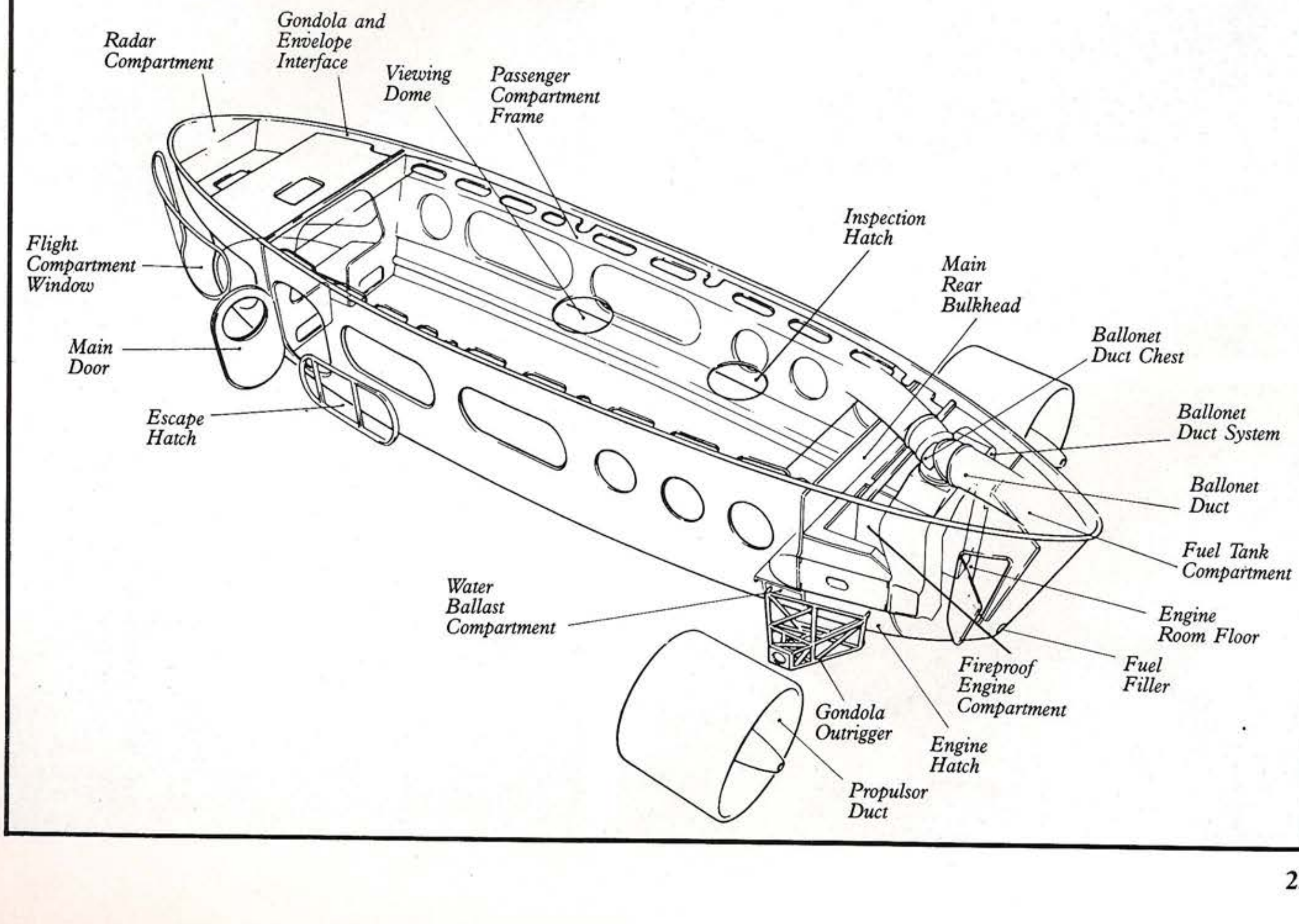
Individually rated at 255 hp, each Porsche engine drives a variable pitch ducted propeller unit via a Westland-built transmission shaft and a right angle bevel drive reduction gearbox, a unit which usually serves the rear rotor of the WG13 Lynx helicopter.

The propellers themselves are 54 inch diameter Hoffman units with five variable pitch blades, these being of glass epoxy-sheathed wood with aluminium alloy leading edges. Each propeller has four pitch settings: forward coarse; forward maximum power; forward fine and reverse, these changed from the flight deck by an electric actuator driving through the pitch change mechanism of the gearbox. There is provision for declutching of the actuators in the event of an emergency, allowing the propeller to return to the forward coarse position by virtue of a strong spring within the propeller hub.

Each of the ducted fan units is rotated by an electric vector motor via a self-locking spiroid bevel gear. These motors are coupled by a cross shaft system allowing accurate synchronisation of both duct units, while also allowing one vector motor to drive both units should a single motor failure occur. In the event of total breakdown, an emergency hand-cranked system is provided at the rear of the main cabin. In the further event of either duct becoming jammed, the faulty unit may be disengaged and the other independently operated, all normal vectoring being controlled

Far left, five-blade variable pitch propellers are manufactured by Hoffman in Germany. Below, gondola structural details

Skyship 600 Gondola



by thumb switches on the pilots' control yokes.

Ballast

Some 450 kg of water ballast can be carried in three interconnected tanks mounted towards the rear of the gondola and valves can be operated from the flight deck to discharge water at a rate of 8 kg per second. In addition there are four compartments for solid ballast, all being accessible from both inside and outside the gondola. Two are situated underneath the pilots' seats and a further pair in the gondola mid section.

Undercarriage

A long-stroke fully castoring twin wheel unit is fitted beneath the gondola directly under the Skyship's centre of gravity. The undercarriage incorporates a Dowty liquid spring unit with damping facility. Maximum deflection is 18 inches.

Right, pilot David Griffiths awaits final clearance for take-off from Radlett aerodrome during London Skycruise, *July 1987. Below, 500-02 shows its single-wheel undercarriage strut to advantage as the ship 'kites' at the mast on a blustery day.*

Skycruise International

'... Next, you'll notice the remarkable smoothness of your flight. Skyships offer just about the most serene, stable flying environment of any aircraft in the sky.

'Get up from your comfortable lounge chair. Stroll around the spacious passenger compartment. Enjoy unobstructed panoramas in all directions. You can even open the windows for an invigorating breath of fresh, cool air ...'
San Francisco Skycruise brochure, 1987

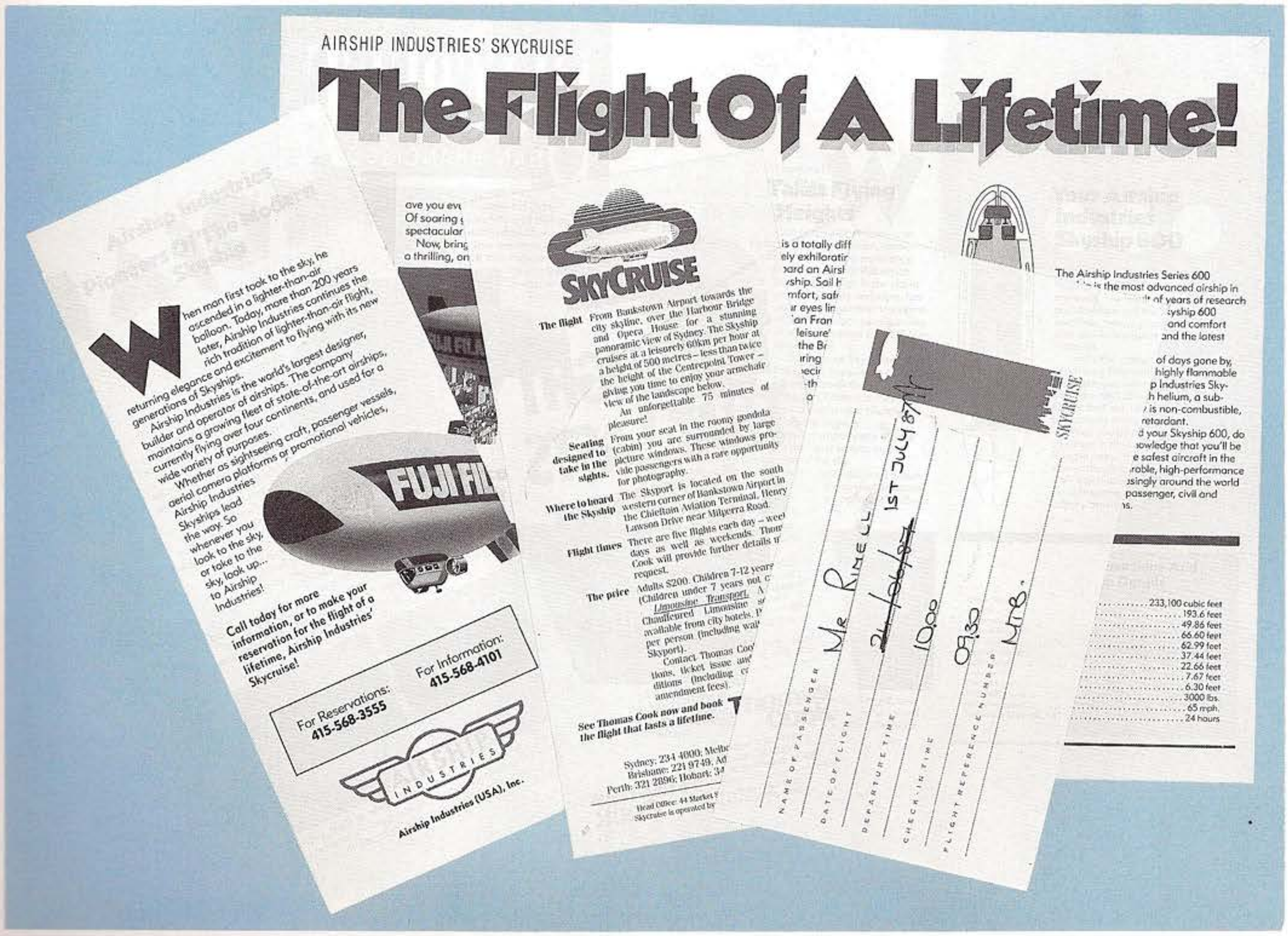
On April 23 1986, Airship Industries, operating Skyship 500-02 G-BIHN from Leavesden aerodrome near Watford, Hertfordshire inaugurated its first *Skycruise* service, a series of sightseeing flights over London. This trial operation was immediately popular being completely sold out within 48 hours and leaving several thousand would-be passengers on the waiting list. The following year, *Skycruise* shifted the base of its operations to Radlett aerodrome near St Albans, where an impressive, well-appointed terminal complete with adjoining restaurant was installed. London flights were resumed in May, this time using the larger Skyship 600 with its increased passenger accommodation. 1987 also saw the start of passenger services over San Francisco, Sydney, Melbourne, and Munich; all were enormously successful and offered unrivalled views of some of the world's most exciting cities. With a fine sense of history, the San Francisco *Skycruise* was launched on May 5 1987 exactly 50 years to the day when the *Hindenburg* exploded over Lakehurst.

So what is it like to fly in an airship? As long ago as 1911 the German Zeppelin service DELAG, was extolling the virtues of lighter-than-air travel to prospective passengers.

'... When he first enters the gondola he will quickly realise that all that air travel really requires of him is an open heart and open eyes. Like streaks of mist, anxiety and doubt will blow away. For the ascent of an airship takes place in such unexpected and complete tranquility that the passenger will literally not be aware of the motion if he shuts his eyes. Or, instead of looking down at the spectators growing smaller and smaller, he lets his eyes stray towards the horizon ...'

As it was over 75 years ago so it is today. Although much smaller than the Zeppelins of yesteryear, the Skyships are no less impressive and, as far as passengers are concerned, are equally as comfortable as their predecessors, besides offering a superb bird's-eye view of the world below.

Below, a montage of international Skycruise *brochures.*



Skyship!

Skycruise *snapshots. Below left, the 1987 terminus at Radlett and, right, London's St. Paul's Cathedral and the Thames. Large picture windows of the Skyship 600 (lower left) offer unparalleled views.*

Skycruising

A typical flight begins with arrival at the terminal check-in desk where passengers are each carefully weighed before receiving their individual seat allocations. A comfortable lounge is normally complemented by a bar, souvenir shop and washroom facilities; an ideal atmosphere in which to relax and study the mandatory safety regulations. Before long the ground crew chief arrives to usher the camera-laden passengers to a waiting minibus for the short trip to the landing area where the airship rides gently at its mast.

The two-man flight crew are involved in pre-flight checks as passengers are embarked — usually in pairs. Boarding the gently bobbing gondola is not as difficult as it first appears and there are plenty of willing hands around to help. Several members of the ground crew are stationed around the gondola whilst others wait to take hold of the bow lines to steady the yaw of the ship after release from the mast. The ship is carefully 'weighed off' with bags of lead shot as passengers find their seats and strap in.

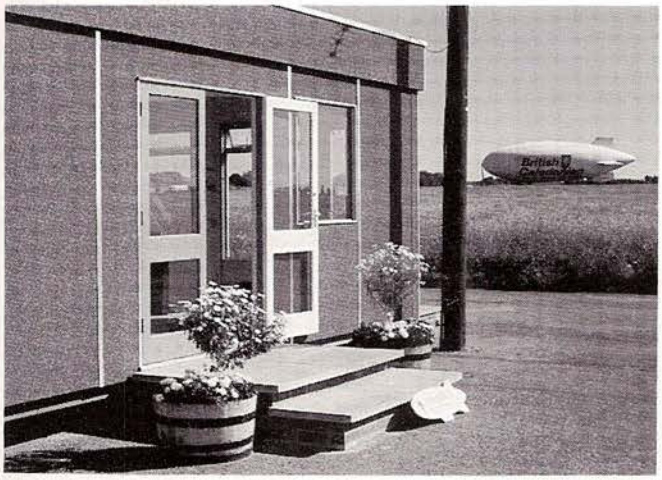
Once the ground crew chief and pilot have exchanged final signals the ship's nose is detached manually from the mooring mast, the ground crew releasing the bow lines as the propeller ducts are rotated to power the ship smoothly but firmly into the air. Take-off is surprisingly rapid. The ship soon clears the airfield perimeter and, having reached its usual cruising altitude of around 1000 feet, passengers are free to release their seat belts, wander around the airy cabin, and choose the best window to more fully appreciate the panorama unfolding below them at a steady 30 knots.

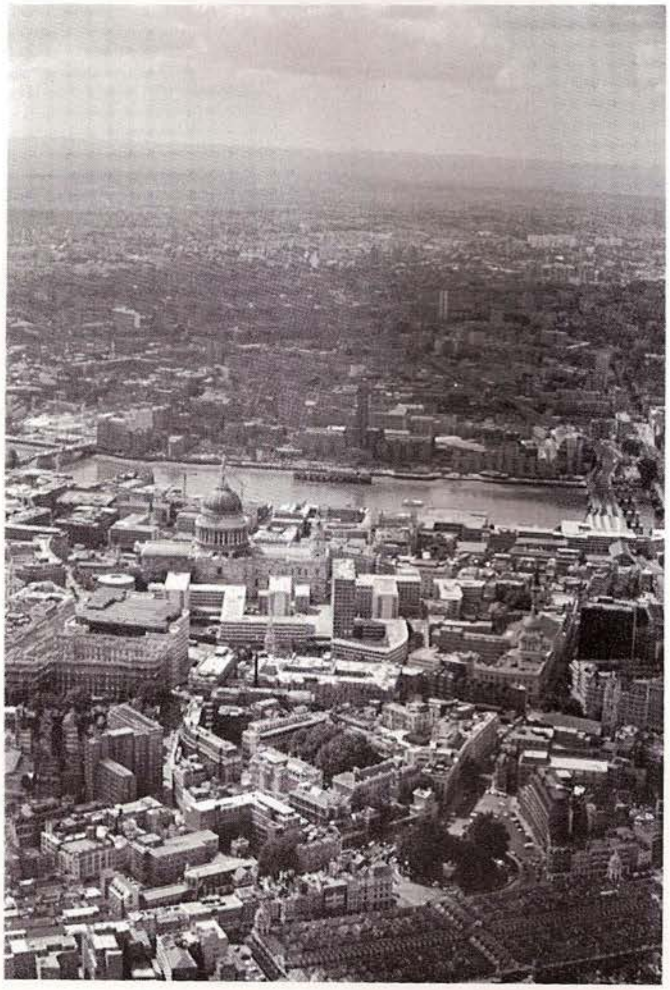
Passengers in helicopters may enjoy comparable views but they will experience none of the gentle pace of the airship, nor its spaciousness. Flight characteristics are smooth and unlikely to upset even the most delicate of stomachs. Another surprise is the sound, or rather the lack of it. Noise levels in the gondola are low and even with the main windows slid open a normal conversation can be carried on with ease.

Cruising low over a major metropolis is a sensation rarely equalled by any other form of air travel and certainly more intimate. Well above the noise and pollution of city traffic, camera-toting passengers have the time to select those landmarks they can recognise before coming within range of their lenses. A brief camaraderie is quickly formed with fellow passengers, all thrilling to the same unique experience of 'pleasure boating' in mid-air.

All too quickly, the flight draws to a close. Slowing down over the aerodrome the pilot positions the ship above the waiting hands of the ground crew who grab hold of the trailing bow lines and guide the vessel back to the masthead. By this time another bus-load of passengers will have arrived and as two members of the first complement disembark, two new passengers take their place and this process is repeated until the transfer is complete.

London *Skycruises* offer a rare opportunity to appreciate the city's finer points from a whole





new perspective: the Tower of London; St. Paul's Cathedral; the Houses of Parliament; Buckingham Palace and the snaking ribbon of the Thames are firm favourites with passengers.

Skycruises in other continents are no less impressive. The 1987 San Francisco flights, operating from Oakland International Airport, took in the Golden Gate Bridge, the infamous island prison of Alcatraz, Coit Tower on Telegraph Hill and the distinctive Transamerican Pyramid. On the other side of the world, Australian sightseers flying from Bankstown Airport in Sydney enjoy stunning views of the Harbour Bridge and Opera House, the undoubted highlights of a memorable 75 minute excursion.

Mainland Europe is also no stranger to the Skyship, with both Munich and Paris hosting *Skycruise* operations over the past year. But *Skycruise* offers more than just a pleasant city fly-over, it also provides the perfect platform for consumer product and corporate promotion.

The Flying Billboard

Several of the world's leading companies have already taken advantage of aerial advertising with Airship Industries, among them *British Caledonian, Citibank, Fuji, Kodak, Konica, Pan-Am, Pepsi Cola, Rowntree/MacIntosh* and *Swan Lager* to name but a few. The key to any successful advertising campaign is memorable simplicity. Complex messages or confusing designs create less impact than bold logos and the large surface area of the Skyship's hull

Far left, members of the hard-working ground crew take the strain as they pull the nose of 600-01 towards the mobile mast. Radlett aerodrome, July 1987. Below, Skyship 600-01 (G-SKSC) with ducts fully vectored hovers over some familiar London landmarks.

Skyship!

makes it ideal for profiling leading brand names. At the same time the advertiser gains the major promotional advantage of offering highly-prized airship rides for consumers, corporate clients and, of course, the media.

The degree of hull decoration available to prospective clients varies according to the length of the contract. For short charters the livery is confined to giant banners measuring 28 metres by 10.5 metres and fixed to the envelope by a series of elasticated attachments around their periphery. Additional decoration may also be applied to the gondola and upper tail fin, although this facility is only available for contracts in excess of six months. In those cases where a contractual commitment lasts for a year or longer, more extensive liveries are offered and these are painted directly on the envelope rather than on detachable panels.

Skysign

The impact of daytime banner promotion has recently been extended by the introduction of night-time advertising using specially developed electronic signs mounted to each side of the Skyship envelope.

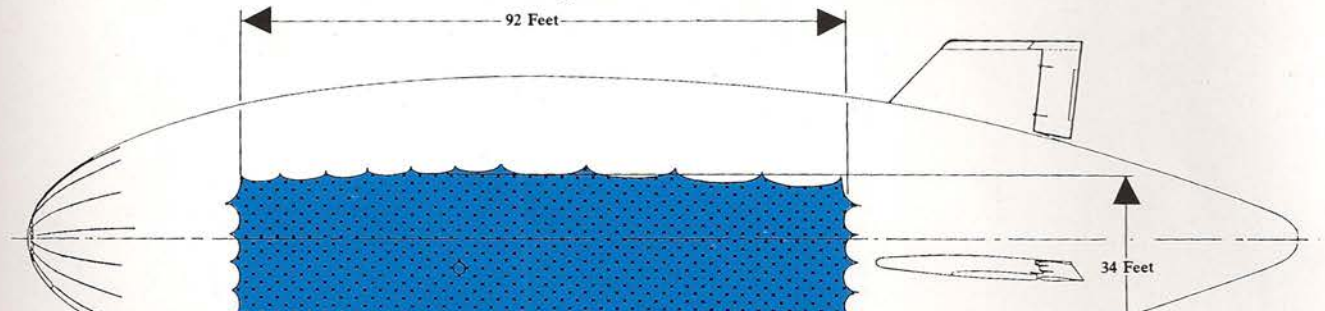
Skysign is simply a giant video screen. Each panel measures 19.2 metres by 4.8 metres and is capable not only of displaying VHS video tapes and live TV-camera pictures but also messages generated on board the airship. Essentially *Skysign* consists of a matrix of light-emitting diodes under full computer control which translate recorded or digitally-developed images into a light pattern that can be seen over considerable distances. The maxtrix contains 9216 pixels (48 x 192) each with an area of 10 cm^2 and containing nine red and seven green LEDs, making over 1500 shades possible. Through a strange optical phenomenon, by illuminating all 16 LEDs in a pixel, the green and red appear as gold.

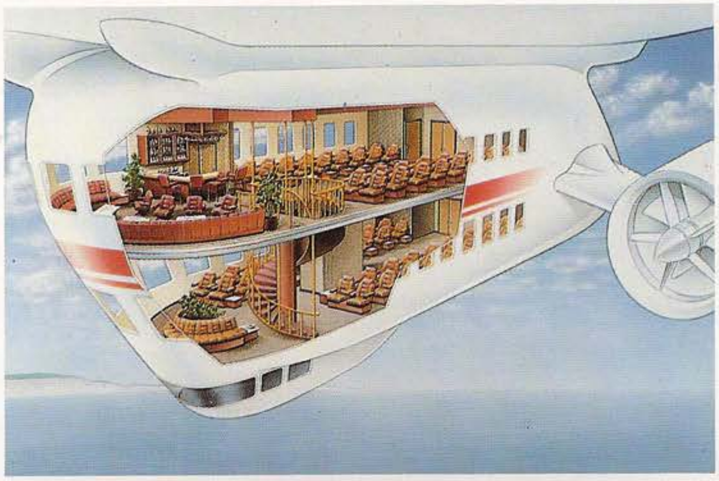
The unit is entirely self-contained aboard the airship and powered from a petrol-driven auxiliary generator. *Skysign*'s on-board computer system enables specific presentations to be selected from pre-recorded cassettes and allows on-board generated text to be inserted into the display programme. A complete display of what will appear on the sign is first shown to the operator on a display screen.

At the time of publication Skyship 600-07 (G-SKSL) is currently touring Japan with *Skysign* following a multi-million pound contract with *Konica*.

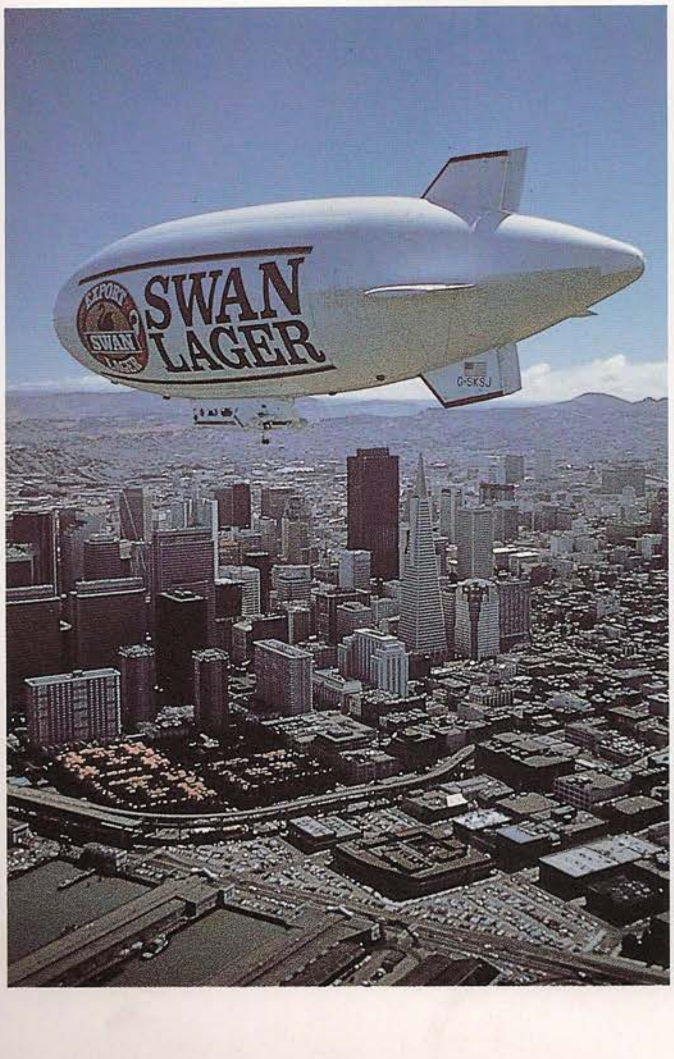
Far right, a member of the ground crew awaits the signal to de-mast G-SKSC. Radlett, July 1987.
Below, UK sponsors for Skyship 600-01 G-SKSC included Charles Wells of Bedford during early 1988 at Cardington (left) and British Caledonian during the first half of the 1987 London Skycruise. *At foot, advertising panel dimensions for the Skyship 600.*

Advertising Panel Dimensions





Above left, artist's impression of a 'Skyship 5000' gondola and passenger accommodation; centre, G-SKSJ over San Francisco; below left, same ship, same city, different sponsor. Below, the Konica *ship (600-07) cruises above Tokyo.*



Skyship!

Top, 'Knock-out' panels in pilots' transparencies afford extra vision in poor weather. Right, the typical Skyship 600 cabin is roomy. Seats are rarely occupied for long during Skycruise, *passengers preferring to wander from one side of the gondola to the other to take full advantage of the large picture windows. Below, the pilots' view forward from the flight deck is impressive.*

From The Cockpit

'... There's more to this airship-flying business than meets the eye. Having started to get the hang of the basic flying controls, heavy emphasis is placed on the complete familiarisation of the pressure system and how to look after it. Mistakes, though unlikely to be disastrous, are nevertheless embarrassing at least, and could be expensive...'
Robert Mawson, Pilot, Airship Industries, 1987

The flight deck of a Skyship may look deceptively familiar to a fixed-wing pilot, the absence of any rudder pedals appearing at first to be the only major omission. All-round visibility is excellent except upwards where the envelope stretches away towards the horizon. A standard IFR panel sits in front of the pilot; the engine instrument cluster is in front of the co-pilot with throttle quadrant, full IFR radio fit and weather radar mounted centrally. Overhead, eyebrow panels contain controls and gauges for managing the ballonets and helium within the envelope.

Once aboard, the pilot's first task is to complete a trim sheet, which takes fuel consumption, atmospheric conditions, disposable ballast requirements and other considerations into account. When correctly filled out and ballast adjusted, the airship will slip the mast in level trim.

Using the approved checklist the pilot will secure his safety harness and start up the twin engines. This is followed by the usual warm-up, engine performance and radio checks. He must also carefully check the various pressure system valves for proper gas management is essential.

Due to their size and susceptibility to wind, the Skyships are unable to move around on the ground in the conventional manner. With a single undercarriage unit, no differential brakes and no flying control at zero airspeed, some other method of manoeuvring is needed: a well-drilled ground crew. There are usually 13 members on station at any one time, four on each of the two bow lines, two on each grabrail either side of the gondola while the thirteenth shins up the mast for undocking the nose probe. All members of the ground crew are under the control of a crew chief who directs everyone with pre-arranged hand signals. During take-off he stands directly beneath the ship's nose where he is readily visible to everyone including the flight crew.

Once the pilot signals the crew chief to de-mast, the ground crew walk the ship to its take-off position, ballasting with lead shot bags

Below, the measure of comfort enjoyed by the Skyship crew can be gauged by this unusual aspect of the flight deck area.

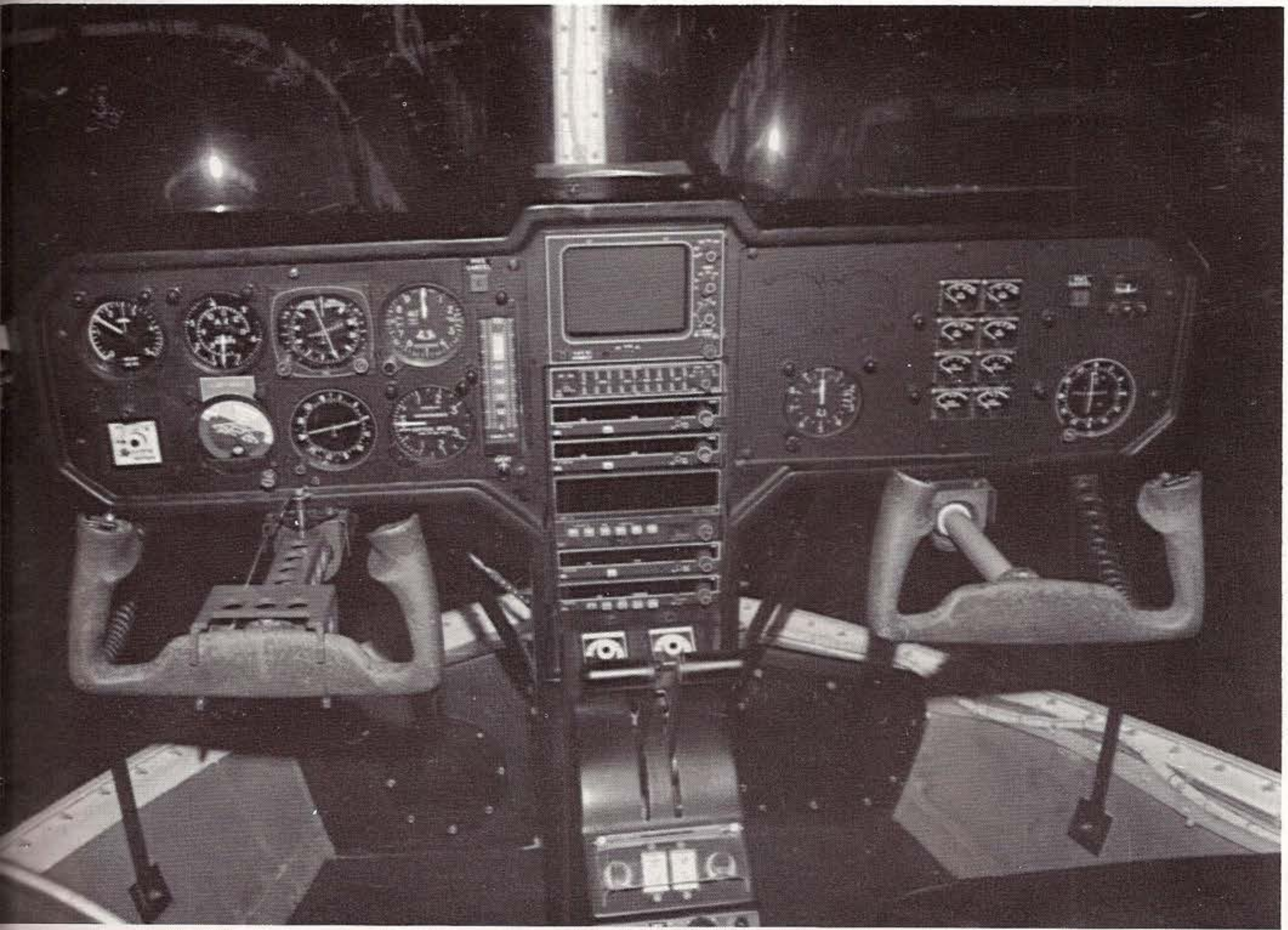
Far right, in flight, bound for Cardington, September 1987. Below, main control panel in the 500HL. There are no rudder pedals on the Skyships, the twin yoke control columns do all the hard work.

as required. Pre-take off checks are run and the ship is ready for lift off. As standard practice the Skyship pilots select 40 degrees of up vector and once the crew chief has been signalled, the throttles are fully opened and after a couple of yards the ship is away. Angling the propeller ducts in this way provides both lift and forward speed. Ascending through safety height the ducts are rolled forwards to the level flight position. Once airborne, controlling the Skyship seems relatively straightforward but although the theory of climbing, descending and turning seems simple enough, the physical side of things is somewhat more demanding as David Esler, writing in the November 1987 issue of *Aviation International News*, discovered:

'*... I tested the yoke, which was connected by about a hundred miles of braided wire cable to the rudders, each as large as the wing of the airplane I normally fly, and was rewarded by rock-hard resistance. Cranking in what seemed like an appropriate amount of left rudder, I waited. Nothing changed; the blimp continued its excursion toward downtown Oakland. I turned the yoke further to the left. The control pressures were unbelievably heavy. Still nothing. When the yoke finally bumped against the stop, the nose slowly began to swing to the left ...*'

Half an hour or so at the controls, even in light winds, will certainly tone up a pilot's arm muscles. Since the airship has no ailerons, turns are effected with rudder only by turning the control column yoke. The airship virtually 'skids' through the turn and since it enjoys a low centre of gravity a pendulum effect results causing the ship to swing towards the outside of the turn, generating an artificial bank.

The pilot's exertions will soon be a thing of the past with the introduction of powered controls. Currently under development is a move not to the fly-by-wire systems now entering service in commercial aviation but a step beyond, leading the aeronautical industry to the next generation of fly-by-*light* fibre optic control.



Gas management

Then there are gas and air controls to contend with. When climbing, the helium in the envelope begins to expand due to the decrease in atmospheric pressure outside. To compensate the pilot must open one or more of the ballonet valves and release air from the ship at a rate which keeps the envelope pressure constant. Similarly, as the ship descends so the helium contracts necessitating closure of the valves. The pilot is then required to operate the ram air scoops fixed open behind the propeller ducts in order to push air back into the ballonets and so maintain the envelope pressure. The same process applies to changes in temperature as well as altitude. By adjusting damper valves, the flow of air in and out of the ballonets can be controlled by the pilots to counter both expansion and contraction of the helium.

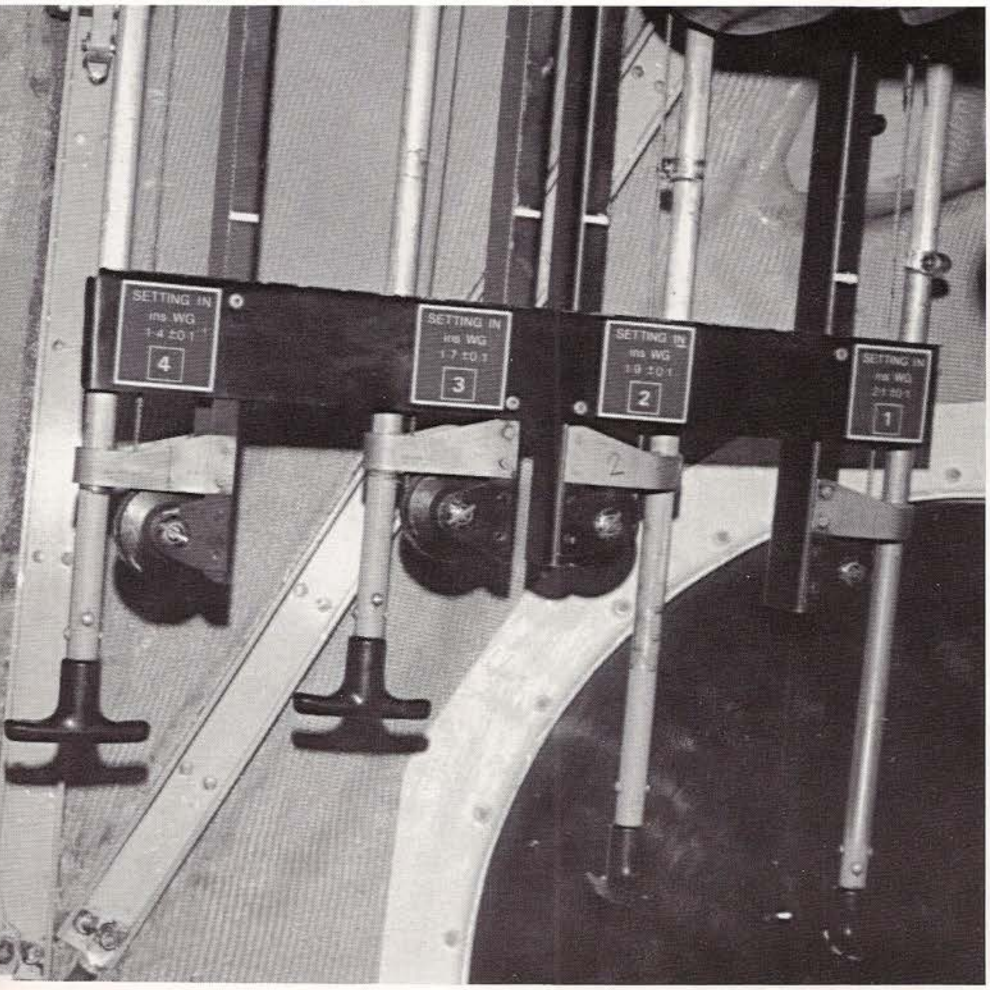
Ballonets are also used for trim. If the pilot pumps air into the forward chamber to inflate it, the aft ballonet deflates and the helium will be displaced backwards making the ship tail-light/nose-heavy and vice-versa. The complete gas management system demands careful handling for should a pilot allow the envelope pressure to get too high, the pre-set valves on the envelope equator will open automatically and release the vital helium until a lower pressure is reached. If he allows the pressure to drop (by forgetting to open the air scoops during descent for example) the envelope could lose its aerodynamic shape with potentially dire consequences. However Skyships are well protected with both visual and audible warning devices and mishaps of either kind hardly ever occur.

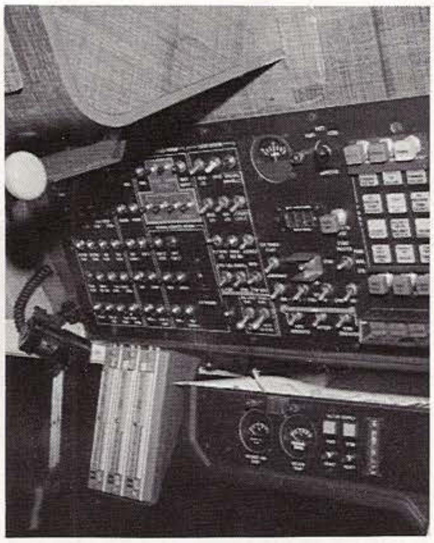
Landing

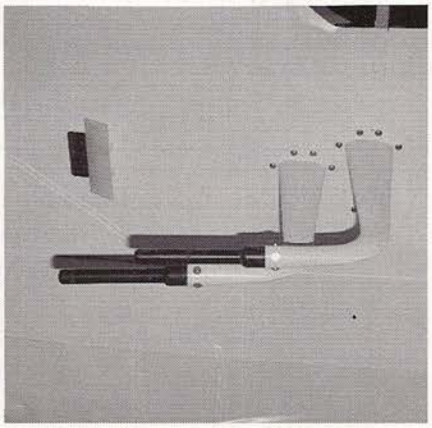
As the pilot completes landing checks he steers the ship towards the landing field. With no two landings ever being the same, this is a moment when the skill and experience of the pilot is most evident. The ground crew is already lined up in 'V' formation, the crew chief at its point; the ground crew placing themselves so that the airship approaches them into wind. As the ship's speed drops to around 20 knots it becomes more susceptible to gusts and thermals and if the ship is slightly heavy, then the pilot must control the rate of descent with careful use of vectored thrust. If he sinks too fast, more up vector will be necessary but if the ship's forward motion falls off, a touch more power will be called for. It requires practice to master such intricacies but a skilled pilot will be able to drop his ship literally into the hands of the ground crew, so smoothly that most passengers will be unaware that they have landed.

The ground crew finally walks the ship back to the mast and once secured, as the passengers and crew disembark, ballast is added to compensate for their weight. Pilots will tell you that flying a Skyship is not particularly difficult or complicated, just *different*. As one of them put it, *'How do you teach an experienced fixed-wing pilot that it is standard (airship) procedure to* close *both throttles after take-off in order to actuate the propeller pitch changing switches?'*

Below, overhead control panel includes air valve controls and ballonet pressure indicators. At foot, twin pitot heads on the gondola's starboard side and, at left, the distinctive roof-mounted handles which control the ballonet valves.







The Military Role

'. . . The award of the US$170 million contract represents the culmination of a three year study of the feasibility of using airships with fleet groups for surveillance, airborne early warning and communications. The Contract initially provides for the design, development and production of one ship, officially known as an Operational Development Model (ODM), which will be used to prove the basic operating concept of Airship/Fleet operations . . .'
Airship Industries Ltd., Directors' Report, 1987

In an historical context the airship played a significant part in two world conflicts, particularly the First World War where the Allies' success using comparatively small non-rigid ships for maritime patrol duties and submarine hunting is a matter of record. In stark contrast the use of Zeppelin and Schütte-Lanz rigids by Germany in the role of strategic bombers proved ultimately to be a costly failure.

With the reawakening of interest in airships, the military has been quick to reassess their capability in the surveillance field. The conduct of this task falls into four distinct phases: pure surveillance, interception, identification and interdiction — only an airship can offer the capability to meet all these requirements in a single vehicle. Operating at the height of most aircraft a Skyship 600 can provide an endurance comparable to a surface ship of equivalent size (such as a fast patrol boat) with considerably improved cruise and 'sprint' speeds. An airship's ability to hover is another of its important capabilities for military purposes enabling it to achieve autonomous interdiction similar to that of both surface ships and helicopters but with the added advantage of much lower operating costs and smaller crewing requirements.

During 1983 evaluations of Skyship 500s were conducted by the military establishments of France, UK and the USA. Of these the American *Patrol Airship Concept Evaluation* (PACE) was the most extensive. This was a 'multiphase evaluation' which included a fully instrumented 'Airship characteristic' performed by NASA; handling tests by NADC Patuxent River; an evaluation by the USCG involving patrol efficiency assessment, scientific marine experiments and demonstration of a rescue winch and boarding boat deployment; followed by general flight familiarization for senior officers and staff within USN, USCG and NASA.

For these evaluations the Skyship 500 was

Below, Skyship 600-01 (G-SKSC) completes boat deployment during maritime surveillance trials with the French Navy off the Cherbourg Peninsula, November, 1984.

fitted with marine surveillance radar, an infra-red imager, rescue winch, deployable boat and various USCG sensors for scientific purposes. The utility of the Skyship in its various roles was both conceptually and technologically proven and although military contracts for the existing 600 series have yet to materialize, nevertheless the US Naval Airship Program for the development of an oceanic fleet AEW vehicle had its origins in the PACE trial.

In 1984/85 a further maritime surveillance evaluation was conducted by the French Navy. The mission avionics were similar to those used by the PACE trial but with improved electro-optics and an uprated boarding boat enabling its deployment by day or night in winds of up to Force 7 — an invaluable asset for maritime patrol operations. With its unique combination of capabilities, the Skyship offers many advantages over the helicopter. Recent in-depth study clearly demonstrated the Skyship's ability to deploy sub-sea Remotely Operated Vehicles (ROV) equipped with detection and interdiction systems for Mine Countermeasures (MCM). In this way the airship, being invulnerable to the threat of mines, can easily locate, identify and, if necessary, destroy them.

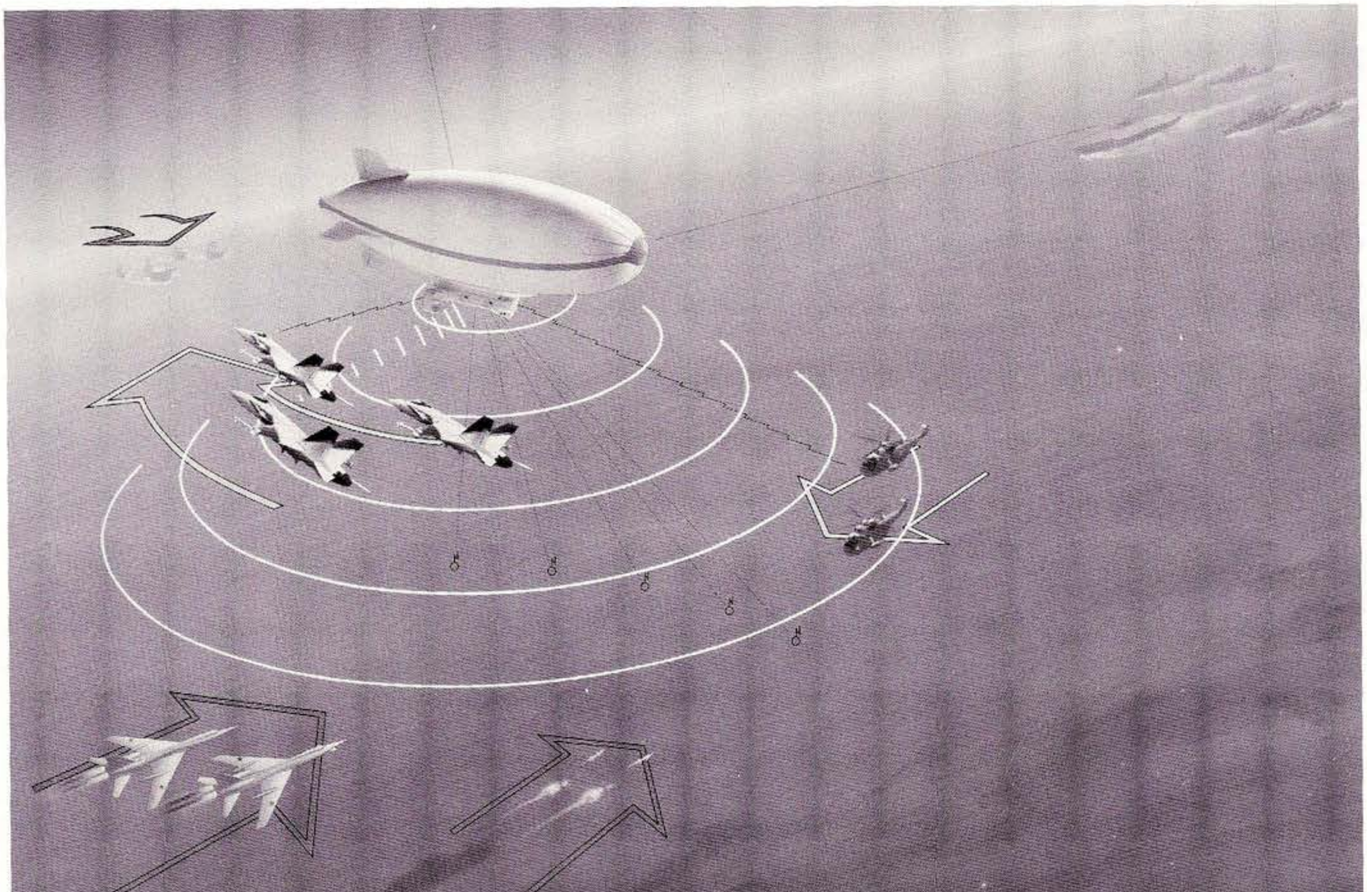
Another important airship role is that of Airborne Early Warning (AEW) where the Skyship offers extensive surveillance cover for prolonged periods. In the oceanic fleet protection role the radar antenna has, of necessity, to be very large in order to detect the latest generation of supersonic stealth missiles. The airship is the *only* platform that can cost-effectively accommodate such antennae and since the current series of Skyship 600 craft are too small both for the envisaged radar and intended oceanic deployments, a much enlarged version becomes an obvious requirement.

A new era

On June 5 1987 Westinghouse/Airship Industries were awarded a 170 million dollar contract to design an Operational Development Model (ODM) as part of the USN Airship Program, winning it from the US Loral Corporation (formerly *Goodyear* Aerospace).

Preliminary specifications will invariably change during the course of the design stage, but from published information Sentinel is an ambitious project. The 5000 (USN designation YEZ 2A) will be the largest non-rigid airship yet conceived: it will measure over 400 feet in length, compared with the 193 feet of the Skyship 600, and will have a gas volume of over two and a half million cubic feet. The gondola, over 80 feet long, comprises three decks: crew accommodation, operations centre and flight deck. As the design service ceiling is well in excess of 10,000 feet the gondola will be suitably pressurized. Ferranti will design and integrate the flignt deck avionics incorporating the GEC Avionics fly-by-light technology already being proven on the Skyship 600. Though 'fly-by-wire' controls have the advantage of already being in service, in the all-composite, radar transparent Skyship a fibre-optic control is far more attractive, being impervious to strong RF signal

Below, in this projected scenario, Sentinel 5000 on picket duty detects a flight of enemy bombers (lower left) preparing to attack a naval task force. The airship directs USN F18 Hornets to meet the threat. Meanwhile two submarine-launched cruise missiles break the surface (lower centre) in a secondary attack. The two Sikorsky Sea Kings with their limited radar capabilities fail to detect the in-coming missiles but Sentinel, with its much larger antenna, easily picks out the small, high speed targets and alerts the task force to their presence.



Below, crew accommodation and mess areas, which include double cabins and shower facilities, will be situated on the upper deck, with the operations centre on the middle deck and flight control situated in the nose at the lowest level. All clearly visualised by this three-dimensional scale model of the Sentinel 5000 gondola.

transmissions either from onboard radar equipment or other external sources.

Three day endurance at a 45 knot cruise speed will be provided by a pair of lightweight turbo-charged 1800 hp PPB diesel marine engines developed by CRM of Italy and assisted for 90 knot 'sprint' speeds by a single GE T700 1700 hp turbo-prop.

Initially, the intention is for Sentinel 5000 to incorporate a Grumman E2-C Hawkeye radar suite (complete with an enlarged 40 foot rotating antenna) although inclusion of a much larger phased array radar dish is anticipated during the later stages of devlopment. The size of the radar dish won't be apparent for it will be mounted inside Sentinel's generous envelope, which being radar transparent, effectively doubles as an aerodynamic radome.

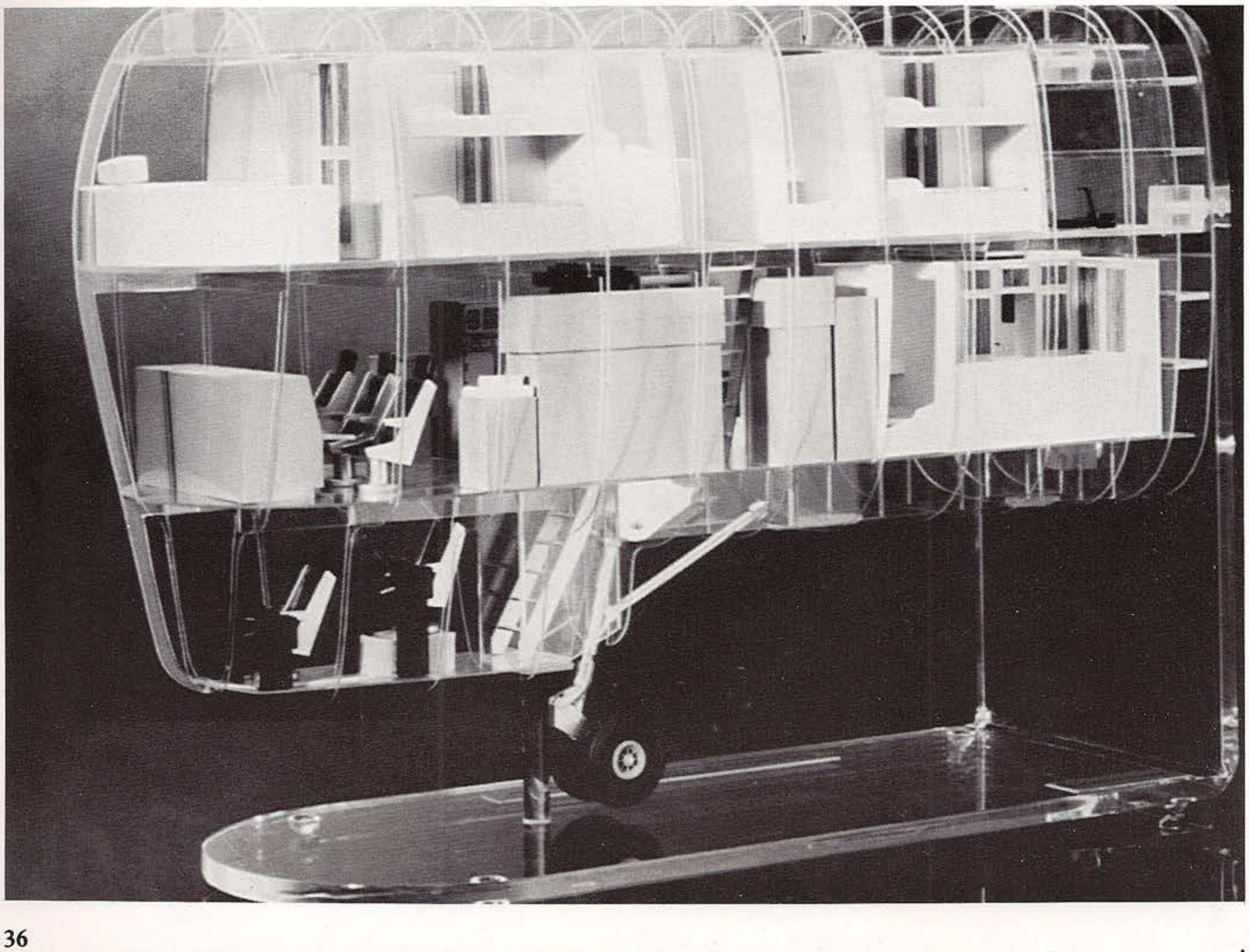
Sentinel 5000 has the potential to be virtually radar invisible — the enormous gondola is to be built of composite materials and the low infra-red signature from the diesel engines is easily shielded within the rear portion of the structure, itself shrouded with Radar Absorbent Material. Paradoxically, as with all AWACS aircraft, the only thing that will betray Sentinel to a potential enemy is the emission from its radar, making it potentially vulnerable to attack by aircraft armed with radar-homing missiles. For this reason Sentinel might carry the means to defend herself should supporting surface vessels and carrier air cover fail to prevent an attack. Such defences might include medium and short range air-to-air missiles, together with an ECM suite and decoys to misroute incoming missiles.

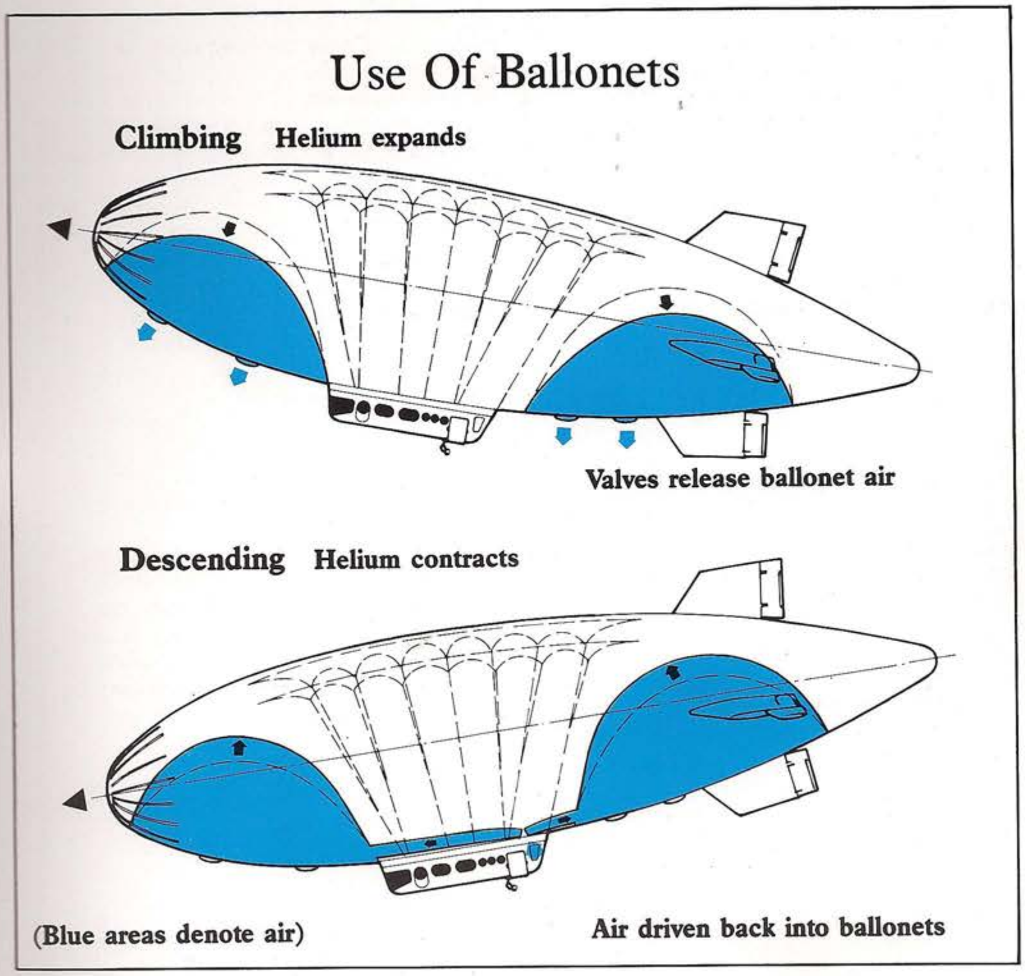
In any case, despite the large target the Sentinel represents, it will have a high survivability from attack. Cannon shells will have minimal effect. Even with multiple perforations of the envelope, the low internal pressure is such that helium egress would be so low that the airship would take some hours to sink towards the sea. Active damage control measures coupled with multiple gas compartments would make even this unlikely.

Severe weather conditions do not appear to present serious problems either. During the Second World War, off the wintry coast of North East America, the US Navy was able to operate its more modest-sized airships for 87% of the time. Even in gale force conditions it is claimed that large modern airships are better able to ride out storms — perhaps even more easily than any surface vessel.

The intention is that this type of airship will deploy with a Task Force to provide vital Airborne Early Warning (AEW) cover. Given a successful evaluation to prove the concept, a substantial procurement must surely follow.

The research and development necessary for Sentinel may well lead to other exciting possibilities. Already there are tentative suggestions for a civil version, a 'Skyship 5000' with a 140 seat twin-deck gondola. Not too many years ago such a proposition would have been the subject of cynicism and derision, but Airship Industries has since proved in no uncertain terms that the airship can indeed play a large part in the modern aviation world. It is a renaissance many will welcome . . . □





USE OF BALLONETS
Skyships are equipped with a pair of ballonets, one forward, one aft. They can be filled or partially filled with air. Emptying is via four valves under the envelope. The valves open automatically as the ship climbs, releasing air and allowing the ballonets to collapse as the helium expands. On descent, internal trunking allows air to be driven in from the propeller ducts, and/or electric fans, and thus avoid collapse of the envelope. The ballonets can be independently filled by using shut-off dampers in the air supply trunking. One important by-product of ballonet operation is that through differential inflation a measure of pitch trim can be obtained, in much the same way as a submarine uses its water ballast for buoyancy trim.

A Glossary Of Airship Terms

BALLAST: Dropping ballast enables an airship to ascend, or to compensate for gas loss or an increased payload.
BALLONETS are air-filled compartments within an airship which can be differentially inflated to control trim. They also compensate for the expansion and contraction of the helium, thereby maintaining a required envelope pressure.
DYNAMIC LIFT is the aerodynamic lift derived by flying an airship at negative or positive attitude to compensate for lightness or heaviness.
ELEVATORS are the moveable surfaces attached to an airship's horizontal tail fins used to control ascent or descent.
ENVELOPE is the gasbag of a non-rigid airship.
FINS are the fixed vertical and horizontal stabilising surfaces attached to an airship's tail, usually of cruciform configuration.
GROSS LIFT is the total lift of helium contained within the airship under standard barometric conditions; equal to the total weight of air displaced minus the weight of the gas.
HELIUM is the second lightest element known, odourless and non-flammable. Helium is calculated to weigh 63 lb per 1000 cubic feet and is a totally safe lifting gas with 93 per cent of the lifting force of hydrogen.
NON-RIGID AIRSHIP: An airship with an envelope made of gas-tight materials, the integrity of which is maintained by positive internal pressure of helium and expansion or contraction of the ballonets inside.
PRESSURE HEIGHT is the maximum height at which an airship can ascend before decreasing atmospheric pressure has caused the ballonets to become completely empty. Above this height the helium continues to expand and automatic safety valves start to open.
RIGID AIRSHIP: An airship constructed from a rigid framework of light metal (or wood) and covered with fabric. Inside the vessel, a number of gasbags provide buoyancy.
RIP PANEL is a detachable section which in an emergency can be torn from a non-rigid airship's envelope to rapidly deflate it.
RUDDERS are the moveable surfaces attached to an airship's vertical tail fins used for steering the vessel to port or starboard.
STATIC LIFT is provided by the buoyancy of the helium. As the airship climbs so the weight of air it displaces remains the same. The static lift remains the same at all altitudes if the temperatures are not changed.
SUPERCOOLING is caused by an airship flying through cold air layers which increases helium density reducing buoyancy as a result.
SUPERHEATING is caused from the sun's heat being trapped within the envelope as a result of a rise in temperature of the ambient atmosphere. The helium expands, increasing buoyancy as a result.
TRIM is the attitude of an airship in flight. When the vessel is in level flight, with no deflection of the elevators, it is 'in trim'; when inclined down by either the bow or stern, it is 'out of trim'.
USEFUL LIFT is calculated by deducting the fixed weight of an airship, and its permanently-fitted equipment, from the gross lift.
USEFUL LOAD is the disposable load equal to the useful lift such as cargo, crew, pasengers and ballast.
VECTORED THRUST is directional thrust from swivelling propeller ducts, permitting an airship to take-off with heavier than neutral buoyancy or land with lighter than neutral buoyancy.
'WEIGH OFF' is the term used for assessment of an airship's weight and trim. This can be altered by adjustment of ballast and/or ballonet air contents.
'WEIGHT EMPTY' is the combined, fixed weight of an airship and its permanently fitted equipment.