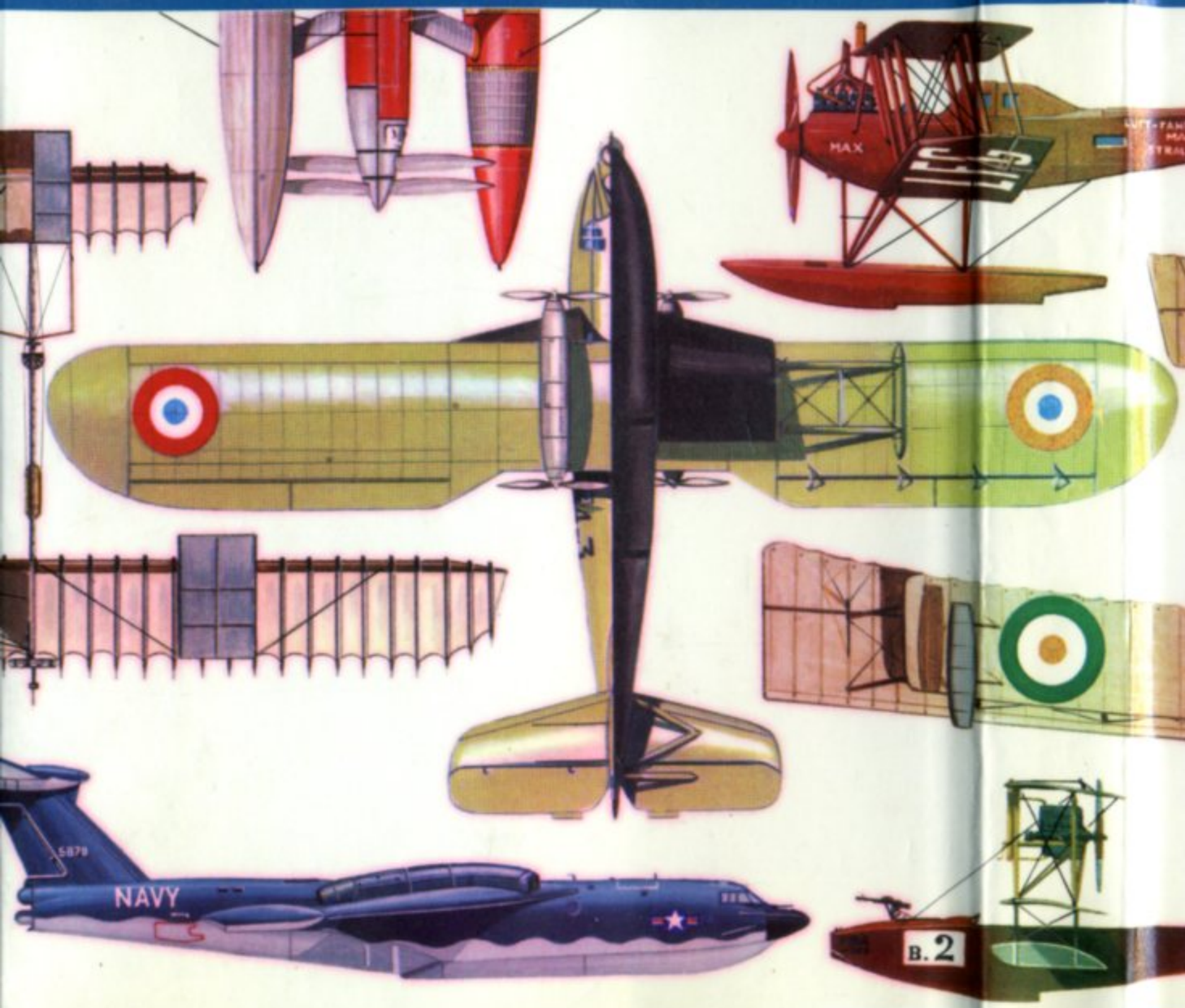
Blandford Colour Series

Flying Boats and Seaplanes

since 1910



Kenneth Munson

Blandford

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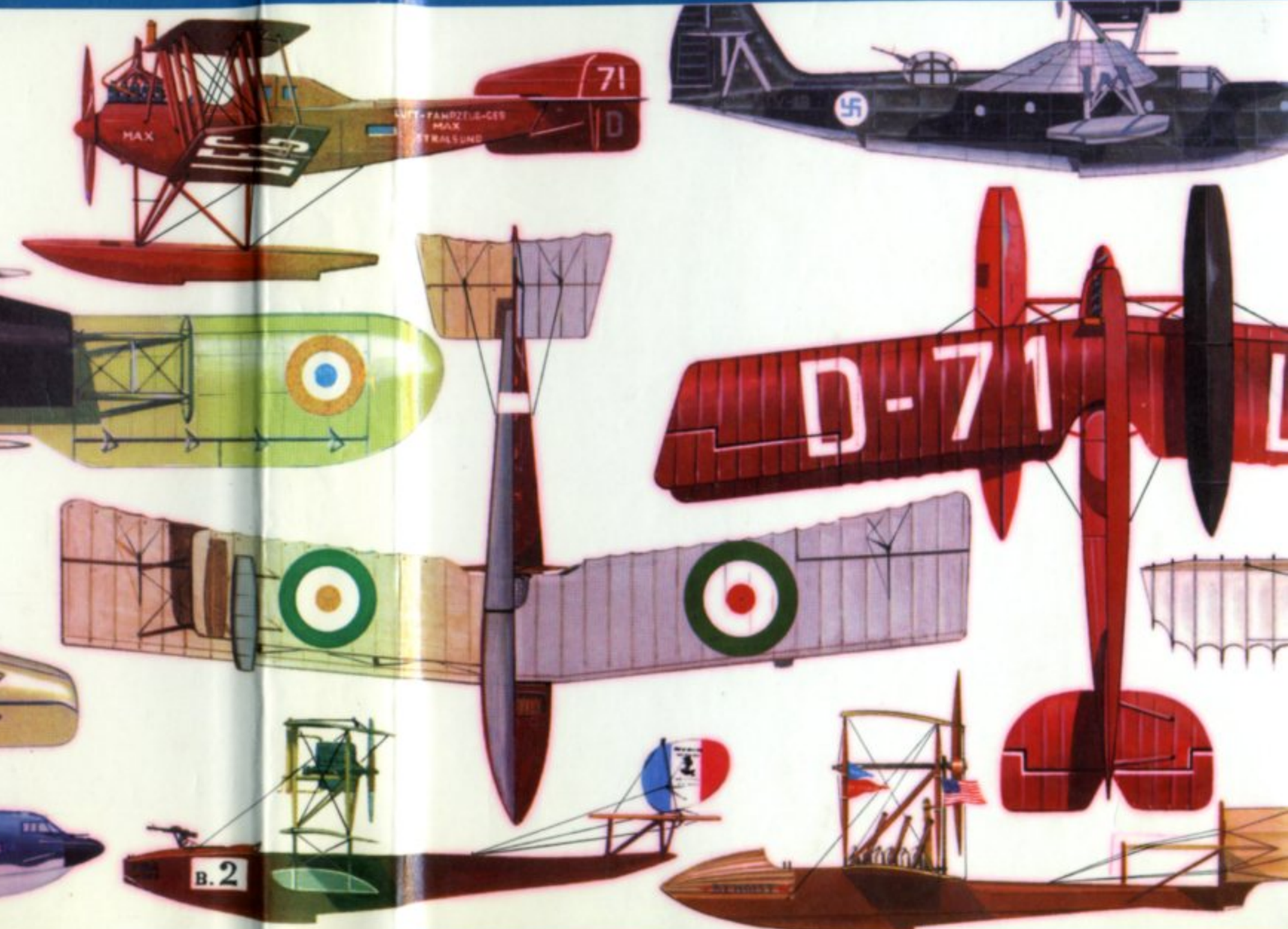

Kenneth Munson

Ever since the first seaplane flew in 1910, water-borne aeroplanes have exercised an appeal and fascination that are particularly their own. From the pioneering machines of Henri Fabre and Glenn Curtiss there grew up a tremendous variety of military and civil seagoing aircraft ranging from tiny floatplanes that could be carried inside a submarine to huge ocean-spanning giants like the Do X and the China Clipper, and even jet fighters like the SR/A.1.

To depict them all would require a much more extensive volume, but here in this book is a representative selection of flying boats and floatplanes of the past sixty years. Among them are the original Fabre *Hydravion*, some of the famous Schneider Trophy competitors, great names like Catalina, Walrus and Sunderland, and others which, if less universally known, all contributed their part to the evolution of what is now regrettably a dying class of aeroplane.

£ 1.15 net

The Pocket Encyclopaedia of World Aircraft in Colour

FLYING-BOATS and SEAPLANES

SINCE 1910

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of World Aircraft in Colour

FLYING-BOATS AND SEAPLANES

SINCE 1910

by

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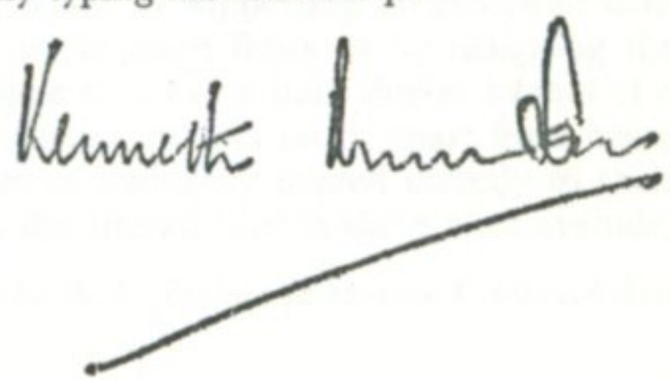
PREFACE

Following the publication of *Helicopters and Other Rotorcraft since 1907*, this is the second volume in the 'World Aircraft in Colour' series to be devoted to a specific class of aeroplane as distinct from the chronological division into military and civil functional categories which characterises the remainder of the series.

In marked contrast to rotating-wing aircraft, however, flying-boats belong to a class that is fast dying out. Despite this (or perhaps because of it) they evoke a nostalgia and affection among aerophiles that is possibly unrivalled by any other form of aeroplane: which may partly explain why this is the first title in the series to be produced at the instigation of the publisher rather than the author!

Within the limits of 80 illustration pages the selection of types for inclusion was necessarily an arbitrary one, and inevitably some deserving cases or personal favourites will have been omitted. It was felt undesirable, with but a few exceptions, to duplicate in this volume those flying-boats or floatplanes which have already appeared elsewhere in the series, but a complete list of these is included as a supplement to the index.

In preparing the colour plates we owe, once again, an extensive debt to Ian D. Huntley, whose comprehensive knowledge of aircraft colours and markings continues to provide the basis for the entire series. Among other friends who kindly offered individual assistance were J. M. Bruce, Philip Jarrett, Lt-Col N. Kindberg (Royal Swedish Air Force), David Mondey and the Research Information Bureau of Qantas Airways Ltd. Grateful acknowledgment is also made of miscellaneous items published by the *AAHS Journal*, *Aeromodeller*, *AiReview*, *Flying Review International*, IPMS (France) and Profile Publications Ltd. Last, but certainly not least, my thanks are due to Mrs. Janet Howell for so kindly and patiently typing the manuscript.



February 1971

INTRODUCTION

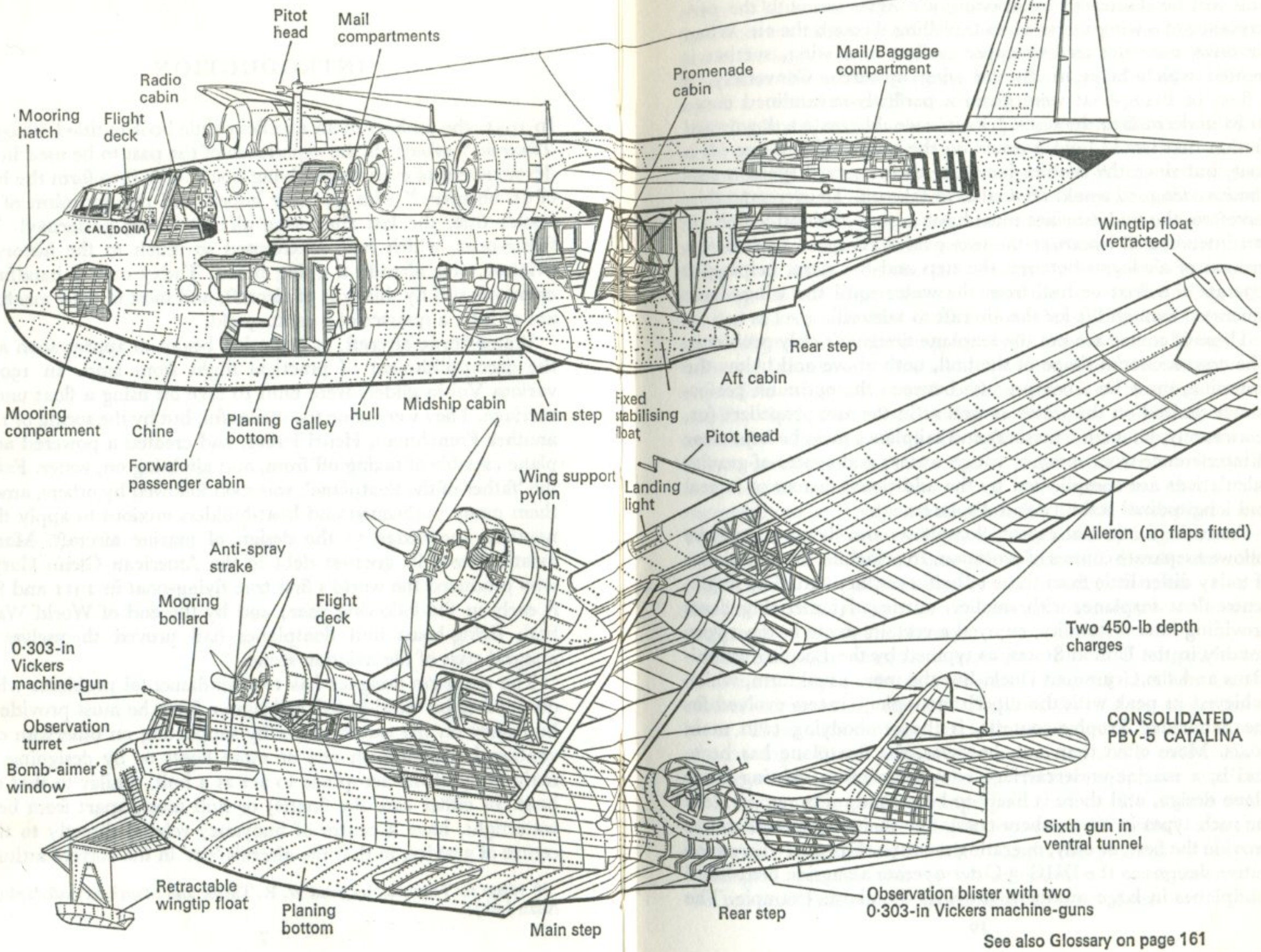
In 1951, the authors of an excellent little book entitled *Wings for Tomorrow** asked: 'Is the experience of the past to be used in the development of even better flying-boats, or is it to form the basis of an obituary?' Alas for their hopes, and the optimism of the book's title, the last rites were already being performed. The flying-boat, which had contributed so much to the history of aviation, was already a dying breed. Today only a handful of operators still fly this type of aircraft, and most of their machines are at least a quarter of a century old.

Water-borne aircraft, as a species, began to appear soon after the accomplishment of practical flight from land. In 1905–6 various Voisin gliders were built to take off using a float undercarriage. They were none too successful, but by the spring of 1910 another Frenchman, Henri Fabre, had created a powered aeroplane capable of taking off from, and alighting on, water. Fabre, the 'father of the floatplane', was soon followed by others, among them many yachtsmen and boat-builders anxious to apply their nautical knowledge to the design of marine aircraft. Marine aviation owes its greatest debt to the American Glenn Curtiss, who produced the world's first true flying-boat in 1911 and flew it early in the following year; and by the end of World War I both flying-boats and floatplanes had proved themselves an integral part of the aviation scene.

The seaplane designer has two fundamental problems which do not face his 'land-based' colleagues. First, he must provide for buoyancy on the water, either by supporting an otherwise conventional structure on one or more floats or by designing the main body of the aeroplane to act as a hull, similar to that of a boat. In either case the float(s) or hull must, apart from being watertight, have a centre of buoyancy related directly to their centre of gravity, so that the aircraft 'sits' in the correct attitude,

* *Wings for Tomorrow*, by John W. R. Taylor and Maurice F. Allward (Ian Allan Ltd.).

SHORT S.23 'C' CLASS



See also Glossary on page 161

and is in equilibrium, when at rest. Second, a float or hull shape that is ideal aerodynamically is not ideal hydrodynamically. This can be illustrated by drawing a comparison with the performance of a wing shape when travelling through the air. When air flows over the convex upper surface of a wing, suction is created which helps to lift the wing upwards. Conversely, if a float or flying-boat were given a perfectly-streamlined curve on its undersurface the same principle would create a downward suction that would hold it down on the water. This is fine for a boat, but since the suction increases with forward speed a seaplane so designed would be unable to take off. To overcome this, therefore, the undersurface must have a 'step', behind which air can intervene to interrupt the water flow. As speed increases, a cushion of air forms between the step and the stern, helping to separate the float or hull from the water until the wings have generated enough lift for the aircraft to take off.

These of course are not the seaplane designer's only problems. The cross-sectional shape of the hull, both above and below the waterline, must be a compromise between the optimum performance desired on the water as well as in the air; propellers (or, more rarely, jet engine intakes) and tailplanes must be kept clear of interference from spray or rough water; and centre-of-gravity calculations are complicated by the additional factors of lateral and longitudinal stability and displacement.

From the functional aspect, floatplanes and flying-boats have followed separate courses of evolution. In principle, the floatplanes of today differ little from those of half a century ago. The single-centre-float seaplane, with smaller, outrigged underwing floats providing lateral stability, enjoyed a certain vogue in the 1930s, notably in the United States, as typified by the Loening amphibians and the Grumman Duck. But the more usual form, which achieved its peak with the superb monoplane racers evolved for the Schneider Trophy contests, is that embodying twin main floats. More often than not, however, the floatplane has been, and is, a marine-undercarriage conversion of an existing landplane design, and there is likely to be a continuing requirement for such types in areas where coastal or sheltered inland waters provide the best, or only, operating medium. Canada, where such native designs as the DHC–3 Otter operate alongside float-fitted landplanes in large numbers, provides the classic example. The

two world wars, and the years between, produced their quota of scout or protective fighter floatplanes carried on board warships, either to be launched by ship's catapult or lowered over the side for a conventional take-off. The catapult concept was even extended in the late 1930s to commercial operations across the Atlantic, to achieve the necessary range by reducing the amount of fuel which a normal take-off would consume.

Flying-boats, on the other hand, have been much more subject to the prevailing state of the art in the general pattern of aircraft evolution. Much was learned during World War 1 with regard to the basic ingredients of efficient hull design, but throughout the 1920s and early 1930s the multi-engined biplane represented the dominant form of long-range aeroplane. Translated into flying-boat terms, the necessity to equate a top-heavy, engine-bearing biplane superstructure with the low centre of gravity needed to keep a shallow-draft hull stable on the water presented no small problem to the designer. By its very nature, a flying-boat fully and inherently stable about its fore-and-aft axis is virtually impossible to achieve, and both methods of assisting lateral stability had their disadvantages. Wingtip stabilising floats, especially when travelling through rough water, can transmit fatigue-producing vibrations to the main wing structure; sponsons, which otherwise had much to recommend them, had necessarily to be large, and therefore heavy and drag-producing. Wooden hulls, however well protected, soaked up huge quantities of water, thus adding to take-off weight and thereby reducing performance. The advent of all-metal construction, once corrosion problems had been overcome, contributed significantly to the performance of marine aircraft.

The flying-boat scored because of its ability to fly long distances, or to carry large payloads over short distances, and because the cost of constructing terminal facilities for it was appreciably lower. These factors, together with its obviously better chances of surviving a forced alighting on water, enabled it to flourish at a time when, by and large, there were not landplanes available with comparable payload/range performance. No airline today could contemplate operating a four-engined aircraft non-stop across the Pacific Ocean with a maximum payload of only 20 passengers, yet this was one of the most successful services of the pre-war Pan American Airways System. Even earlier, the

tremendous growth of Imperial Airways, which culminated in the famous 'Empire' flying-boats of the late 1930s, had been aided in no small measure by successive types of flying-boat, from the little 6-passenger Sea Eagle up through the multi-engined Calcuttas and Kents built by Short Brothers.

It is probably fair to claim that by 1939 trans-oceanic commercial flying-boat services were really into their stride, and it is interesting (albeit profitless) to speculate upon their subsequent history if war had not intervened. Not that there was any lack of employment for them during the war. Types like the Sunderland, the Catalina and the Kawanishi 'Emily' represented all that was best in flying-boat design and performance, and were used widely as maritime patrol aircraft. Several of their smaller brethren, including amphibians, were in demand for such other duties as air/sea rescue or as light transport or communications aircraft in areas where landplanes could not operate.

But if the war gave a temporary boost to the flying-boat, it was also instrumental in causing its demise, for two main reasons. First, it spurred the development, already begun, of landplanes able to equal or exceed the payload/range capabilities of contemporary flying-boats; second, it created hundreds of new airfields, with long concrete runways, in many parts of the world, providing the nucleus from which national and international airports could be developed once the war was over. Wartime military flying-boats, turned into stop-gap airliners, continued in service for a few years with some of the major airlines, but large overseas operators like Pan American and BOAC soon found the economics of land-based aircraft – which could also serve the major cities more directly – more to their liking. There were many who thought the trend away from the large flying-boat only temporary. No less a figure than Lord Brabazon of Tara, who had been chairman of the wartime committee set up to advise on post-war British civil aviation, wrote in his Foreword to *Wings for Tomorrow* that 'It will not be thus for long', and that the flying-boat would 'come into its own again, and remain predominant'.

It was not, however, to be. The long-range transport mantle was assumed by such types as the Constellation, DC-4 and Stratocruiser; and the development of these and comparable piston-engined types was followed by new generations of land-based airliners powered by turboprop, turbojet and turbofan

engines, not to mention large transport hovercraft, all of which have combined to prohibit the reappearance of the large commercial flying-boat. Military authorities, too, have virtually forsaken them, after Britain, the United States and the Soviet Union had each investigated briefly the possibilities of jet-driven types. The only current example of a large modern military flying-boat is Japan's PS-1, due to enter service in the early 1970s.

There remains a continuing, if modest, market for the allied, but generally smaller, breed of amphibians, although here again the majority of those still flying are re-engined or otherwise modified examples of 30-year-old designs. Recent exceptions are Russia's Be-12, in service with the Soviet Navy, and Canadair's CL-215 water bomber, currently doing valuable forest-fire patrol work in Canada and France; but the only other post-war amphibian serving in large numbers is the Grumman Albatross, first flown as long ago as 1947.

THE SCHNEIDER TROPHY RACES 1913–31

Donated in 1912 by M. Jacques Schneider for an international seaplane competition, the award consisting of a trophy valued at 25,000 frs. (approximately £1,000) and, for the first three years, a cash prize of 25,000 frs. to the winner.

1913: held 16 April at Monaco, 28 laps of a 10 km course

1	Deperdussin (France)	Maurice Prévost	45·75 mph (73·63 km/hr)

1914: held 20 April at Monaco, 28 laps of a 10 km course

1	Sopwith Schneider (UK)	C. Howard Pixton	86·78 mph (139·66 km/hr)
2	FBA flying-boat (Switzerland)	E. Burri	51·00 mph (82·08 km/hr)

1919: held 10 September at Bournemouth, 10 laps of a 20 nm course (= 370·6 km)

1*	SIAI (Savoia) S.13 (Italy)	Janello	109·77 mph (176·66 km/hr)

(* contest declared null and void)

1920: held 21 September at Venice, 10 laps of a 37·5 km course

1	SIAI (Savoia) S.19 (Italy)	Lt Luigi Bologna	107·22 mph (172·55 km/hr)

1921: held 7 August at Venice, 10 laps of a 37·06 km course

1	Macchi M.7*bis* (Italy)	Lt Giovanni de Briganti	110·99 mph (178·63 km/hr)

1922: held 12 August at Naples, 13 laps of a 28·5 km course (= 370·5 km)

1	Supermarine Sea Lion II (UK)	Capt H. C. Biard	145·62 mph (234·37 km/hr)
2	Macchi M.7 (Italy)	A. Passaleva	143·20 mph (230·46 km/hr)
3	SIAI (Savoia) S.19 (Italy)	Arturo Zanetti	139·75 mph (224·90 km/hr)

1923: held 28 September at Cowes, 5 laps of a 37·2 nm course (= 344·69 km)

1	Curtiss CR–3 (USA)	Lt David Rittenhouse, USN	177·38 mph (285·46 km/hr)
2	Curtiss CR–3 (USA)	Lt Rutledge Irving, USN	173·46 mph (279·16 km/hr)
3	Supermarine Sea Lion III (UK)	Capt H. C. Biard	151·56 mph (243·91 km/hr)

1924: due to be held 25 October at Baltimore, 7 laps of a 27 nm course (= 350·37 km)

Contest postponed by US after withdrawal of all foreign entries

1925: held 26 October at Baltimore, 7 laps of a 27 nm course

1	Curtiss R3C–2 (USA)	Lt James H. Doolittle, USAAS	232·57 mph (374·29 km/hr)
2	Gloster-Napier III (UK)	Capt Hubert S. Broad	199·17 mph (320·53 km/hr)
3	Macchi M.33 (Italy)	Lt Giovanni de Briganti	168·44 mph (271·08 km/hr)

1926: held 13 November at Hampton Roads, 7 laps of a 27 nm course

1	Macchi M.39 (Italy)	Major Mario de Bernardi	246·50 mph (396·70 km/hr)
2	Curtiss R3C–2 (USA)	Lt Christian F. Schilt, USN	231·36 mph (372·34 km/hr)
3	Macchi M.39 (Italy)	Lt Adriano Bacula	218·01 mph (350·85 km/hr)

1927: held 26 September at Venice Lido, 7 laps of a 50 km course

1	Supermarine-Napier S.5/25 (UK)	Flt Lt S. N. Webster	281·66 mph (453·28 km/hr)
2	Supermarine-Napier S.5/21 (UK)	Flt Lt O. E. Worsley	272·91 mph (439·20 km/hr)

1929: held 7 September at Spithead, 7 laps of a 50 km course

1	Supermarine S.6 (UK)	Fg Off H. R. D. Waghorn	328·63 mph (528·88 km/hr)
2	Macchi M.52*bis* (Italy)	Warrant Officer Tomaso Dal Molin	284·49 mph (457·85 km/hr)
3	Supermarine-Napier S.5 (UK)	Flt Lt D. D'Arcy A. Greig	282·11 mph (454·01 km/hr)

1931: held 13 September at Spithead, 7 laps of a 50 km course

1*	Supermarine S.6B (UK)	Flt Lt J. N. Boothman	340·08 mph (547·31 km/hr)

(* unopposed)

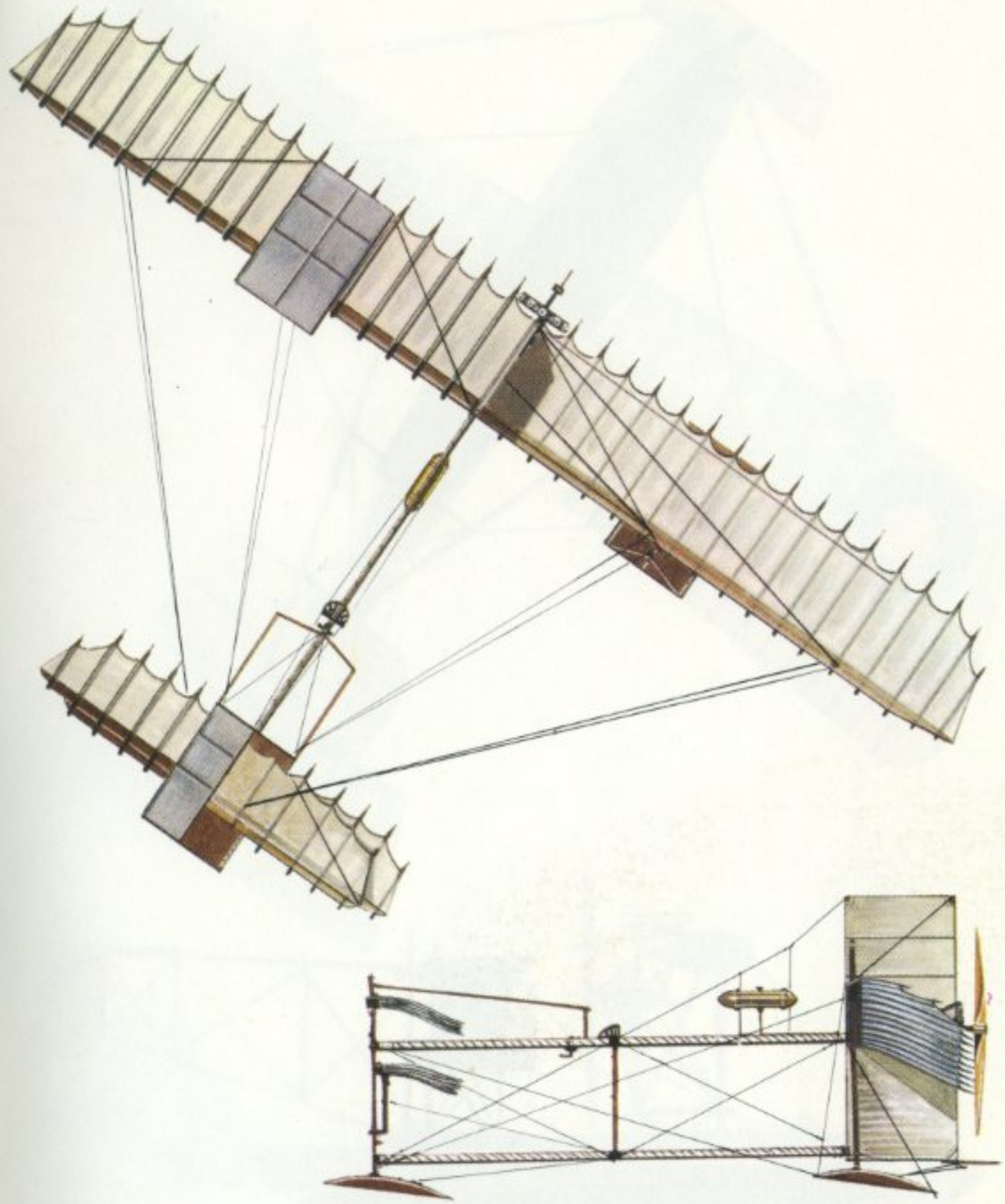
THE COLOUR PLATES

The colour plates which follow have been arranged in approximately chronological order from 1910 to the present day. The reference number of each type illustrated corresponds to the appropriate text matter, and an index to all types illustrated appears on pp. 161–162.

To enable reference to be made to illustrations and/or descriptions of marine aircraft appearing in other volumes in this series, a list of such types is included as a supplement to the index.

The 'split' plan view, adopted to give both upper and lower surface markings within a single plan outline, depicts the colour scheme appearing above and below either the port or starboard half of the aircraft, according to whichever aspect is shown in the side elevation.

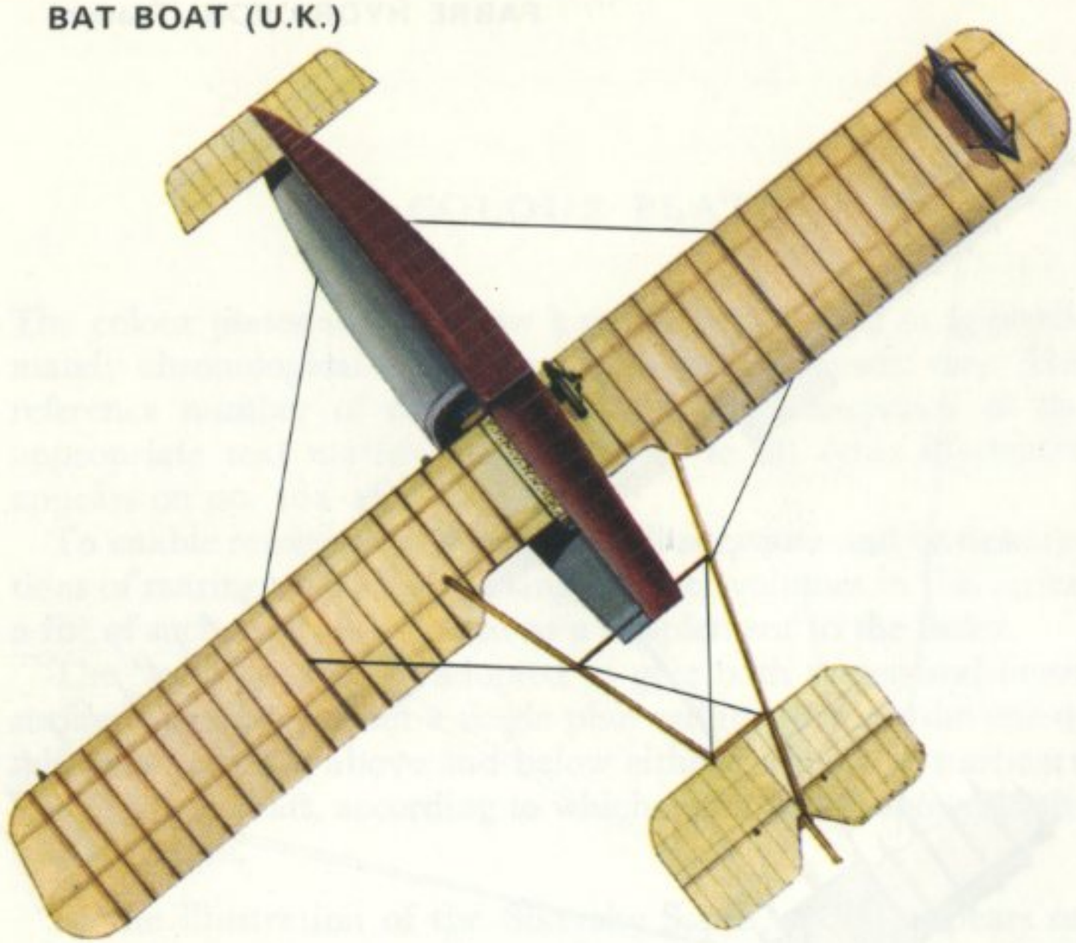
In the illustration of the Sikorsky S.42B, which appears on pages 56–57, the civil registration of the aircraft depicted has been rendered incorrectly. The correct registration of this aircraft, which bore originally the fleet name *Pan American Clipper III*, should read NC.16736.



1

Henri Fabre *Hydravion,* as exhibited at the *Salon de l'Aéronautique* in Paris, October 1910. *Engine:* One 50 h.p. Gnome seven-cylinder rotary. *Span:* 45 ft. 11¼ in. (14 m.). *Length:* 27 ft. 10¾ in. (8·50 m.). *Height:* approx 12 ft. 1¾ in. (3·70 m.). *Wing area:* 183 sq. ft. (17 sq. m.). *Take-off weight:* 1,047 lb. (475 kg.). *Speed:* 55 m.p.h. (89 km/hr.) at sea level.

BAT BOAT (U.K.)



2

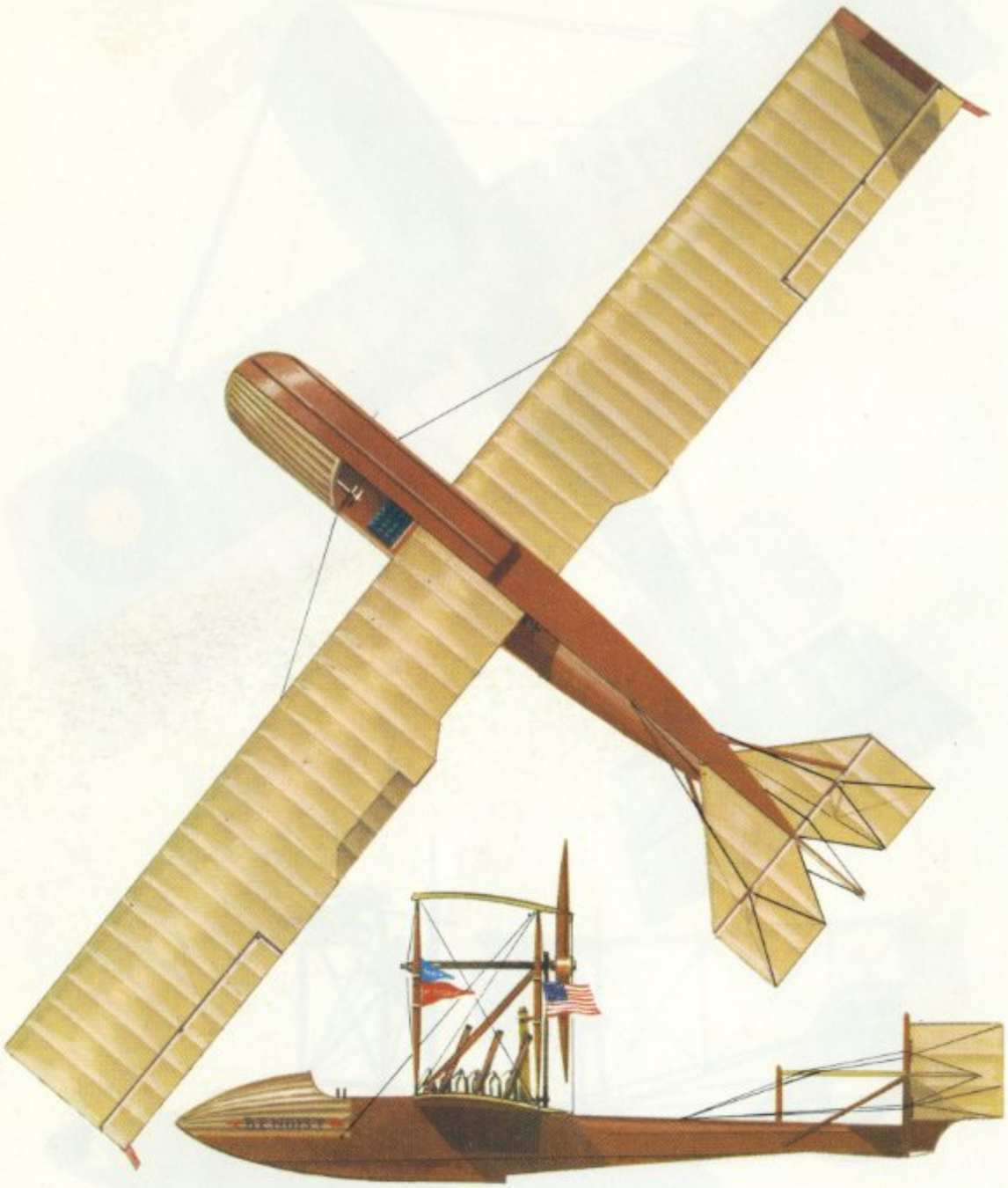
Sopwith Bat Boat, early summer 1913. *Engine:* One 90 h.p. Austro-Daimler four-cylinder in-line. *Span:* 41 ft. 0 in. (12·50 m.). *Length:* 30 ft. 4 in. (9·24 m.). *Wing area:* 428 sq. ft. (39·76 sq. m.). *Take-off weight:* 1,700 lb. (771 kg.). *Speed:* 65 m.p.h. (105 km/hr.).

DONNET-LÉVÊQUE TYPE A (France)

3

Donnet-Lévêque Type A of the Royal Swedish Naval Aviation, early 1915. *Engine:* One 50 h.p. Gnome seven-cylinder rotary. *Span:* 31 ft. 2 in. (9·50 m.). *Length:* 27 ft. 10¾ in. (8·50 m.). *Wing area:* 183 sq. ft. (17 sq. m.). *Take-off weight:* approx. 1,323 lb. (600 kg.). *Speed:* 68 m.p.h. (110 km/hr.).

BENOIST 1913 (U.S.A.)



4

Benoist flying boat used for Tampa-St Petersburg service, early 1914. *Engine:* One 75 h.p. Roberts six-cylinder in-line. *Span:* 45 ft. 0 in. (13·72 m.). *Length:* 26 ft. 0 in. (7·92 m.). *Wing area:* approx 416 sq. ft. (38·65 sq. m.). *Empty weight:* 1,190 lb. (540 kg.). *Speed:* 64 m.p.h. (103 km/hr.).

BURGESS-DUNNE (U.S.A.)

5

Burgess-Dunne No. 3, delivered to the US Army Signal Corps in December 1914. *Engine:* One 135 h.p. Salmson M9 nine-cylinder radial. *Span:* 45 ft. 0 in. (13·72 m.). *Length:* 26 ft. 0 in. (7·92 m.). *Height:* 10 ft. 11 in. (3·33 m.). *Take-off weight:* 2,140 lb. (971 kg.). *Maximum speed:* 75 m.p.h. (121 km/hr.).

PEMBERTON-BILLING P.B.1 (U.K.)

6

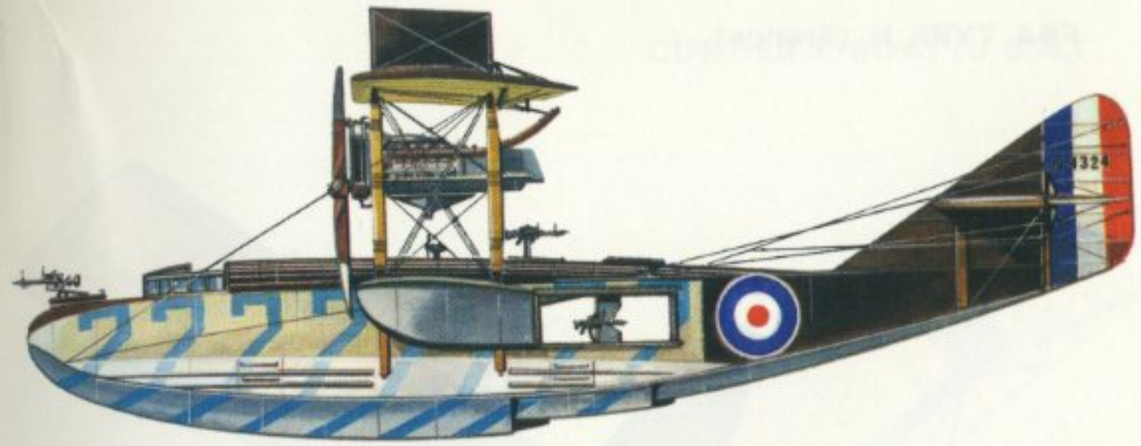
Pemberton-Billing (Supermarine) P.B.1, as exhibited at the Olympia Aero Show, London, in March 1914. *Engine:* One 50 h.p. Gnome seven-cylinder rotary. *Span:* 30 ft. 0 in. (9·14 m.). *Length:* approx 27 ft. 0 in. (8·23 m.). *Wing area:* 293 sq. ft. (27·22 sq. m.). *Weight empty:* 750 lb. (340 kg.). *Take-off weight:* 970 lb. (440 kg.). *Maximum speed:* 50 m.p.h. (80·5 km/hr.) at sea level.

CAMPANIA (U.K.)

7

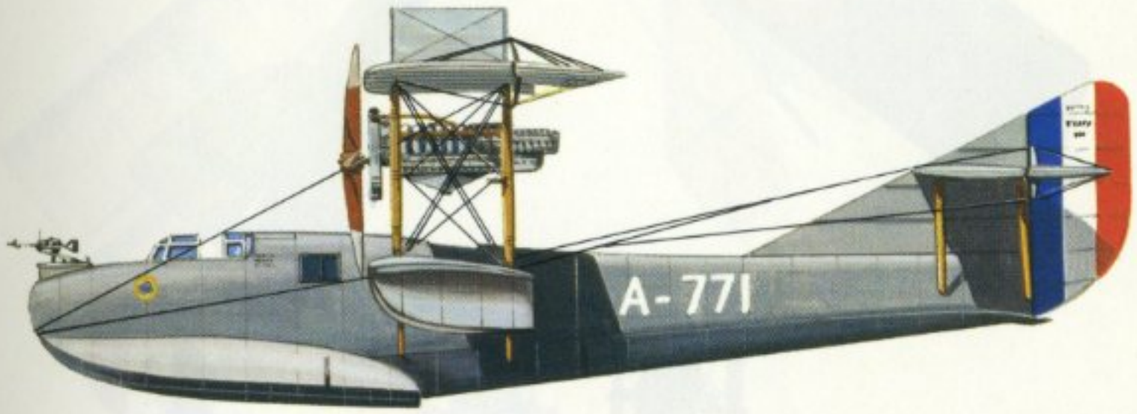
Fairey-built F.17 Campania assigned for trials aboard HMS *Campania, ca* December 1917. *Engine:* One 345 h.p. Rolls-Royce Eagle VIII twelve-cylinder Vee-type. *Span:* 61 ft. 7½ in. (18·78 m.). *Length:* 43 ft. 0⅝ in. (13·12 m.). *Wing area:* 627 sq. ft. (58·25 sq. m.). *Take-off weight:* 5,657 lb. (2,566 kg.). *Maximum speed:* 80·5 m.p.h. (129·6 km/hr.) at 2,000 ft. (610 m.). *Operational ceiling:* 5,500 ft. (1,676 m.). *Endurance:* 3 hr. 0 min.

FELIXSTOWE F.2A (U.K.) and CURTISS H-12 (U.S.A.)



8

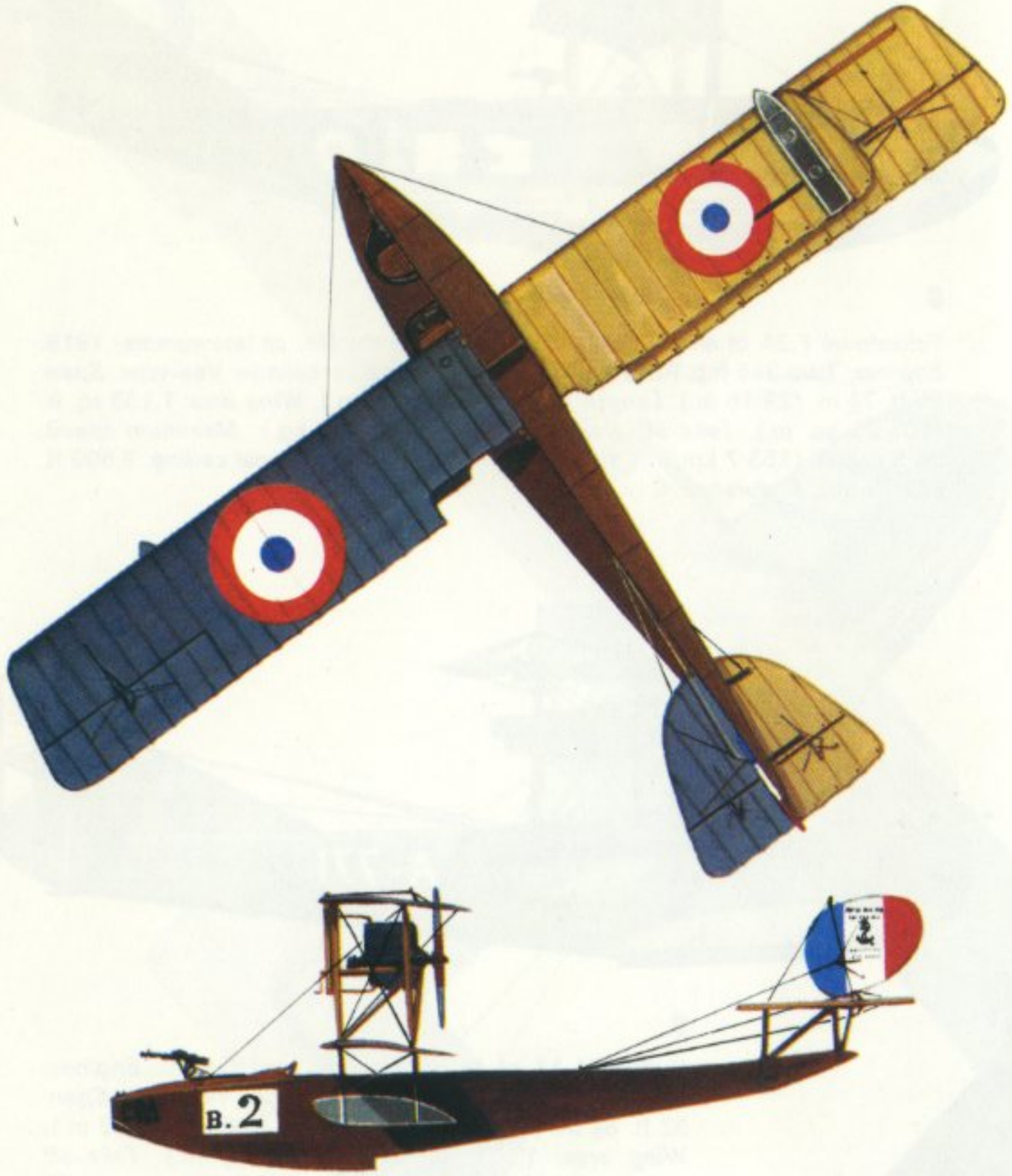
Felixstowe F.2A of an RAF coastal air station in the UK, *ca* late summer 1918. *Engines:* Two 345 h.p. Rolls-Royce Eagle VIII twelve-cylinder Vee-type. *Span:* 95 ft. 7½ in. (29·15 m.). *Length:* 46 ft. 3 in. (14·10 m.). *Wing area:* 1,133 sq. ft. (105·26 sq. m.). *Take-off weight:* 10,978 lb. (4,980 kg.) *Maximum speed:* 95·5 m.p.h. (153·7 km/hr.) at 2,000 ft. (610 m.). *Operational ceiling:* 9,600 ft. (2,926 m.). *Endurance:* 6 hr. 0 min.



9

Curtiss H-12 of the US Navy, *ca* 1919/20. *Engines:* Two 330 h.p. Liberty twelve-cylinder Vee-type. *Span:* 92 ft. 8½ in. (28·26 m.). *Length:* 46 ft. 0 in. (14·02 m.). *Wing area:* 1,121 sq. ft. (104·14 sq. m.). *Take-off weight:* 7,989 lb. (3,624 kg.). *Maximum speed:* 85 m.p.h. (136·8 km/hr.) at 2,000 ft. (610 m.). *Operational ceiling:* 10,800 ft. (3,292 m.). *Endurance:* 6 hr. 0 min.

FBA TYPE H (France)



10

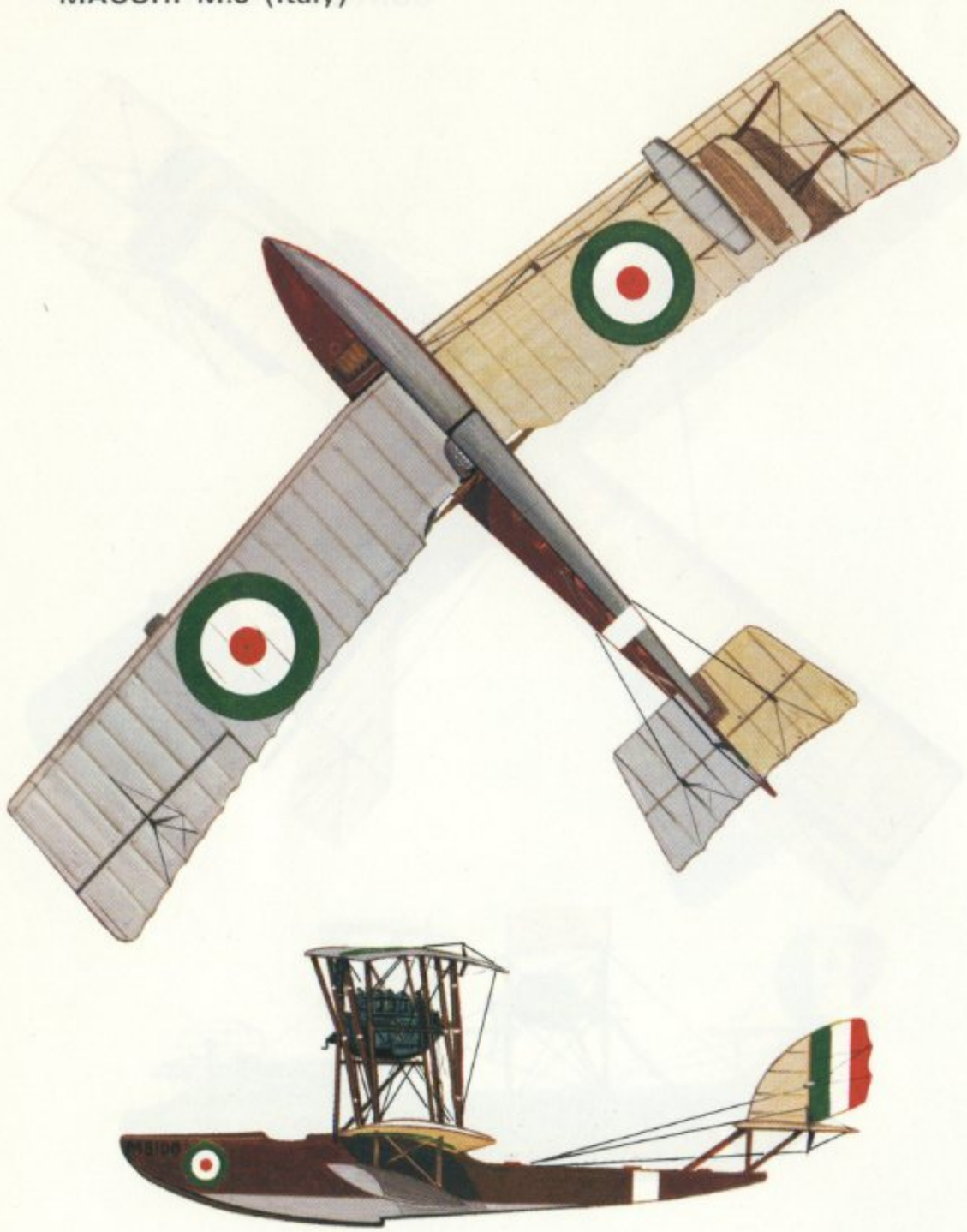
FBA Type H of the French Navy, *ca* 1919/20. *Engine:* One 170 h.p. Hispano-Suiza six-cylinder in-line. *Span:* 47 ft. 6¾ in. (14·50 m.). *Length:* 33 ft. 1¾ in. (10·10 m.). *Wing area:* 452·1 sq. ft. (42 sq. m.). *Take-off weight:* 3,219 lb. (1,460 kg.). *Maximum speed:* 90 m.p.h. (145 km/hr.). *Range:* 185 miles (300 km.).

CURTISS F-BOAT (U.S.A.)

11

Curtiss F-Boat of the US Navy, *ca* late 1916. *Engine:* One 100 h.p. Curtiss OXX eight-cylinder Vee-type. *Span:* 45 ft. 1⅜ in. (13·75 m.). *Length:* 27 ft. 9¾ in. (8·48 m.). *Wing area:* 387 sq. ft. (35·95 sq. m.). *Take-off weight:* 2,460 lb. (1,116 kg.). *Maximum speed:* 69 m.p.h. (111 km/hr.) at sea level. *Operational ceiling:* 4,500 ft. (1,372 m.). *Endurance:* 5 hr. 30 min.

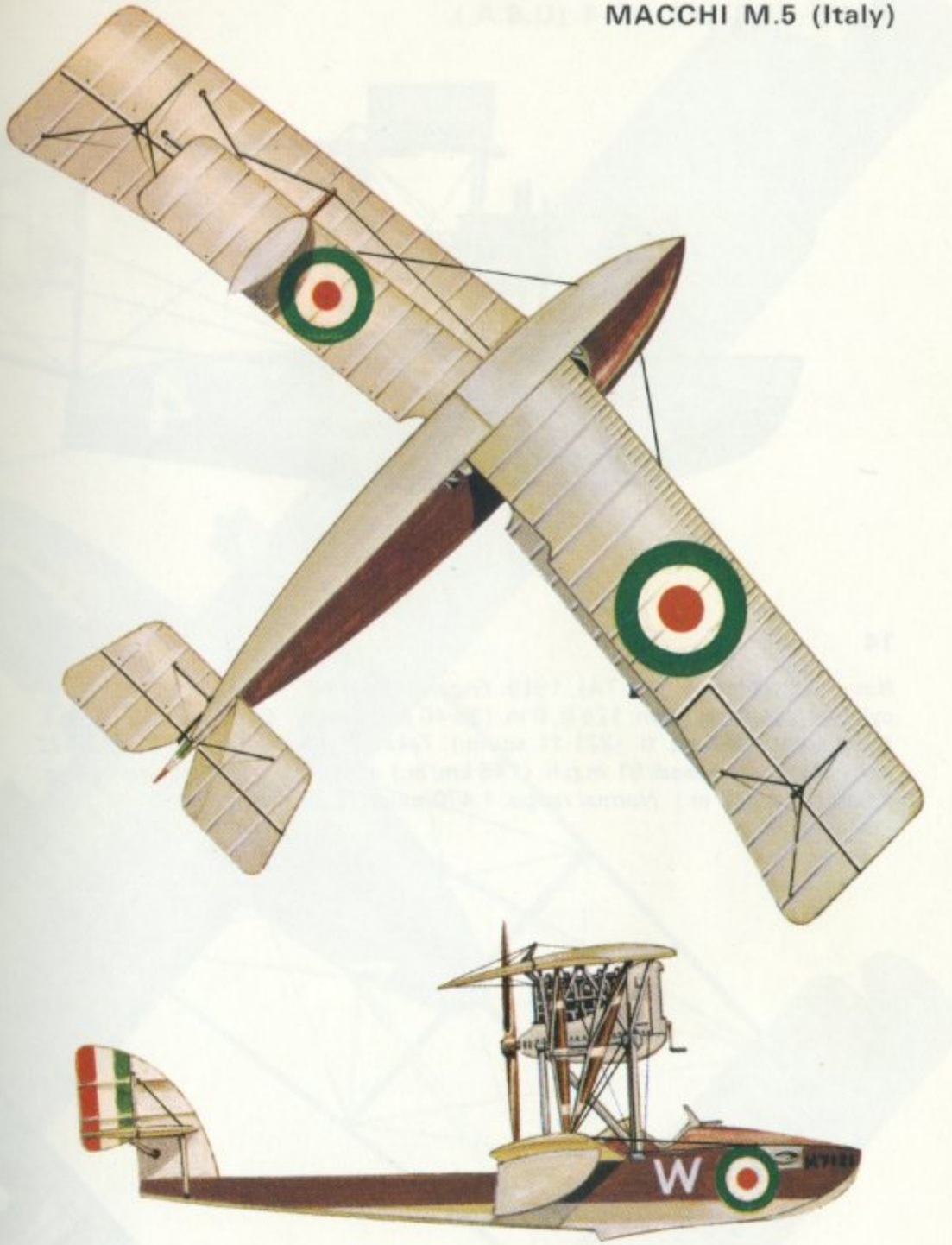
MACCHI M.3 (Italy)



12

Macchi M.3 of the *Regia Marina Italiana,* 1918/19. *Engine:* 160 h.p. Isotta-Fraschini V-4B twelve-cylinder Vee-type. *Span:* 52 ft. 4 in. (15·95 m.). *Length:* 33 ft. 7½ in. (10·25 m.). *Wing area:* 484·4 sq. ft. (45 sq. m.). *Take-off weight:* 2,976 lb. (1,350 kg.). *Maximum speed:* 90 m.p.h. (145 km/hr.). *Operational ceiling:* 19,685 ft. (6,000 m.). *Range:* 280 miles (450 km.).

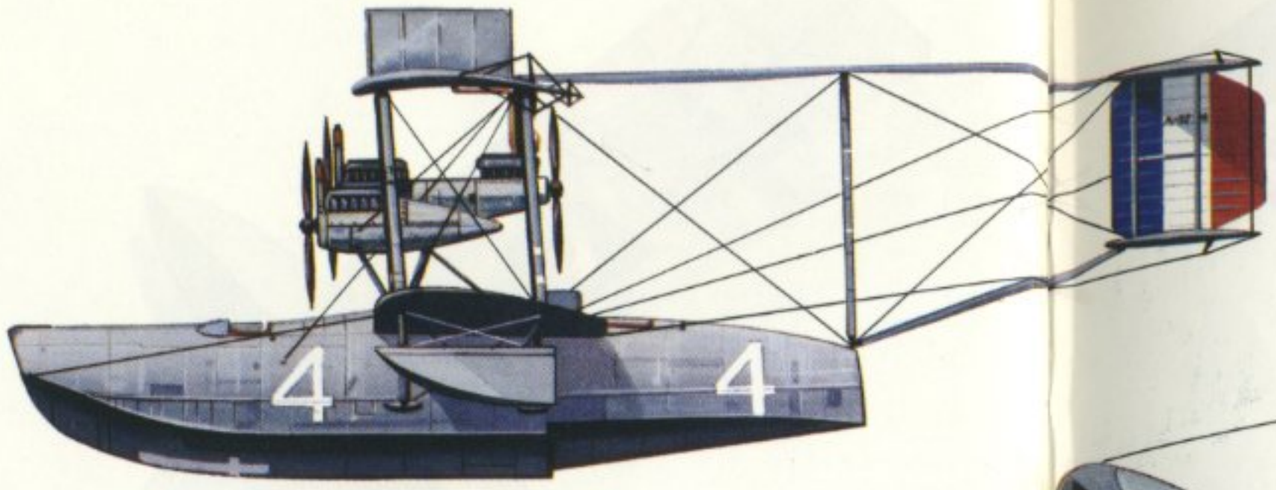
MACCHI M.5 (Italy)



13

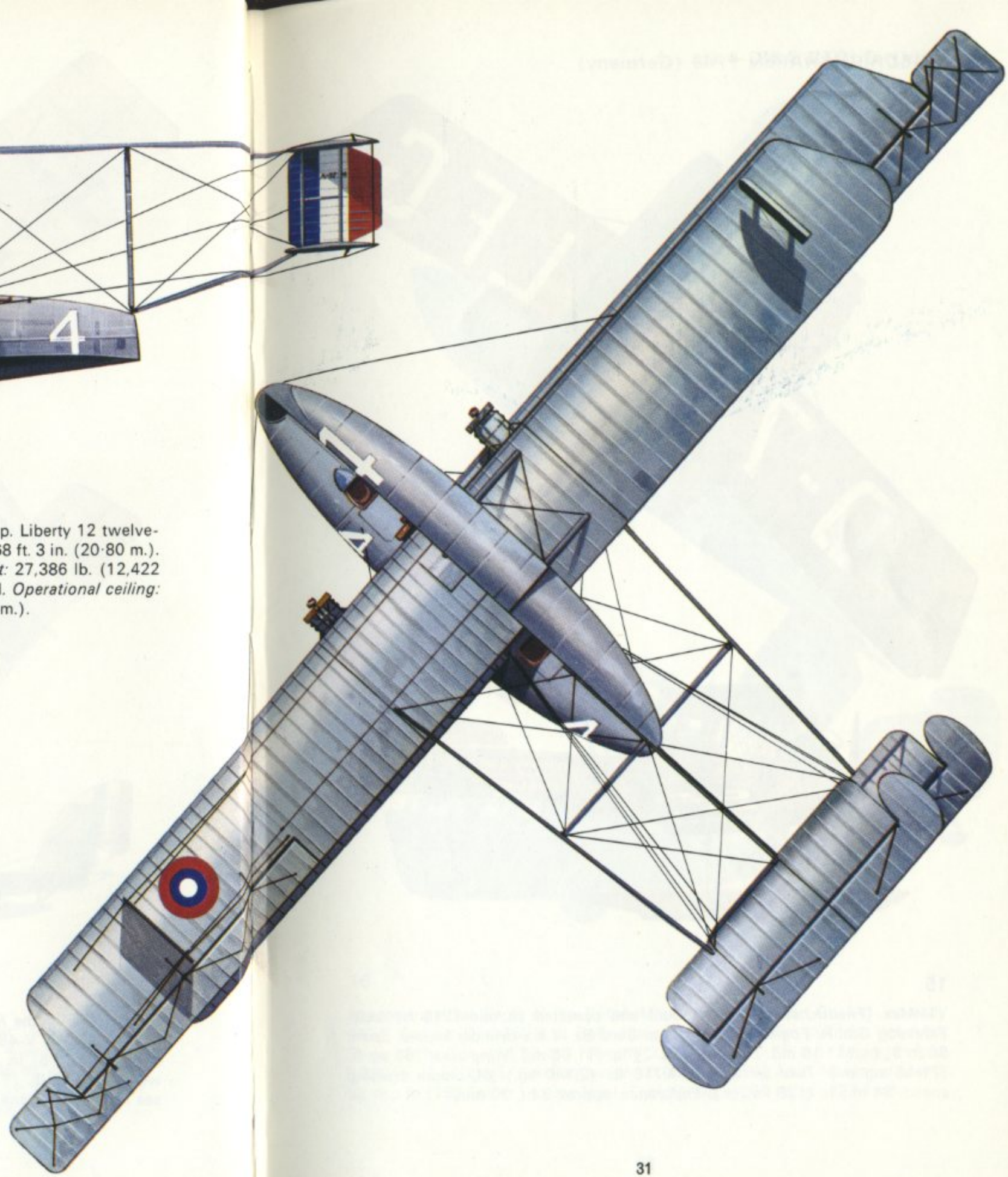
Macchi M.5 of the *Regia Marina Italiana, ca* 1918/19. *Engine:* One 160 h.p. Isotta-Fraschini V-4B twelve-cylinder Vee-type. *Span:* 39 ft. 0½ in. (11·90 m.). *Length:* 26 ft. 5¼ in. (8·06 m.). *Wing area:* 279·9 sq. ft. (26 sq. m.). *Take-off weight:* 2,138 lb. (970 kg.). *Maximum speed:* 117·4 m.p.h. (189 km/hr.) at sea level. *Operational ceiling:* 15,090 ft. (4,600 m.). *Endurance:* 3 hr. 0 min.

NAVY-CURTISS NC-4 (U.S.A.)



14

Navy-Curtiss NC-4 (NC-TA), 1919. *Engines:* Four 400 h.p. Liberty 12 twelve-cylinder Vee-type. *Span:* 126 ft. 0 in. (38·40 m.). *Length:* 68 ft. 3 in. (20·80 m.). *Wing area:* 2,380 sq. ft. (221·11 sq. m.). *Take-off weight:* 27,386 lb. (12,422 kg.). *Maximum speed:* 91 m.p.h. (146 km/hr.) at sea level. *Operational ceiling:* 4,500 ft. (1,372 m.). *Normal range:* 1,470 miles (2,366 km.).



FRIEDRICHSHAFEN FF49 (Germany)

15

V1 *Max* (Friedrichshafen FF49) built and operated *ca* mid-1919 by Luft-Fahrzeug GmbH. *Engine:* One 200 h.p. Benz Bz IV six-cylinder in-line. *Span:* 56 ft. 3¼ in. (17·15 m.). *Length:* 38 ft. 2¾ in. (11·65 m.). *Wing area:* 766 sq. ft. (71·16 sq. m.). *Take-off weight:* 4,718 lb. (2,140 kg.). *Maximum cruising speed:* 84 m.p.h. (135 km/hr.). *Endurance:* approx 5 hr. 30 min.

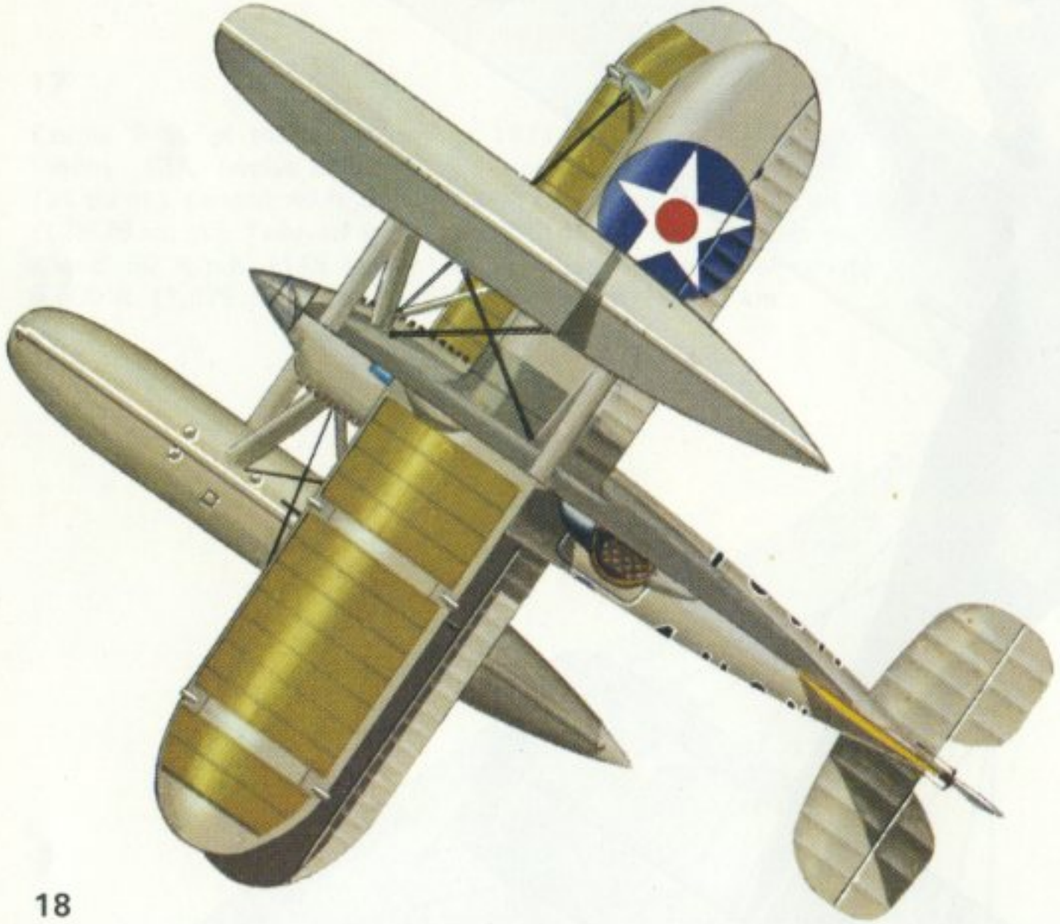
SEA EAGLE (U.K.)

16

Supermarine Sea Eagle of the British Marine Air Navigation Co. Ltd., *ca* early 1924. *Engine:* One 350 h.p. Rolls-Royce Eagle IX twelve-cylinder Vee-type. *Span:* 46 ft. 0 in. (14·02 m.). *Length:* 37 ft. 4 in. (11·38 m.). *Empty weight:* 3,950 lb. (1,996 kg.). *Take-off weight:* 6,050 lb. (2,949 kg.). *Maximum speed:* 93 m.p.h. (150 km/hr.) at sea level. *Typical range:* 200 miles (322 km.).

17

Curtiss F-5L of the US Navy, *ca* 1921. *Engines:* Two 400 h.p. Liberty 12A twelve-cylinder Vee-type. *Span:* 103 ft. 9¼ in. (31·63 m.). *Length:* 49 ft. 3¾ in. (15·03 m.). *Wing area:* 1,397 sq. ft. (128·78 sq. m.). *Take-off weight:* 13,600 lb. (6,169 kg.). *Maximum speed:* 90 m.p.h. (145 km/hr.) at sea level. *Operational ceiling:* 5,500 ft. (1,676 m.). *Normal range:* 830 miles (1,335 km.).



18

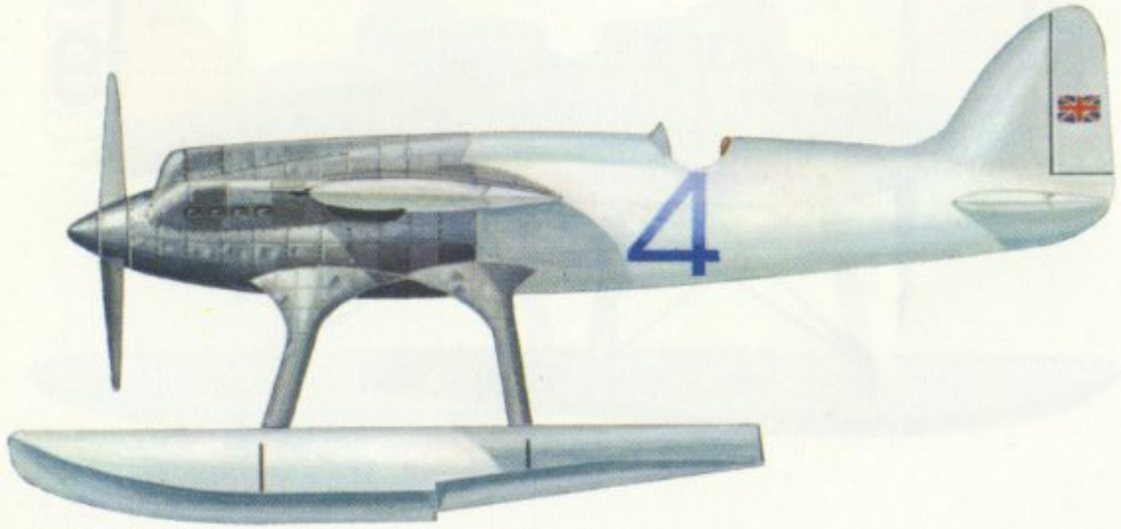
Curtiss CR-3 (A6081), winner of the 1923 Schneider Trophy race at Cowes, U.K. *Engine:* One 450 h.p. Curtiss D-12 twelve-cylinder Vee-type. *Span:* 22 ft. 8 in. (6·91 m.). *Length:* 25 ft. $0\frac{3}{8}$ in. (7·63 m.). *Wing area:* 168 sq. ft. (15·61 sq. m.). *Take-off weight:* 2,746 lb. (1,246 kg.). *Maximum speed:* 194 m.p.h. (312 km/hr.) at sea level. *Operational ceiling:* 19,200 ft. (5,852 m.). *Range:* 522 miles (840 km.).

19

Curtiss CR-4 (A6081) in later colour scheme, October 1924. Details as opposite, except for later version of D-12 engine. On 25 October 1924 this aircraft set a closed-circuit speed record for seaplanes of 188·078 m.p.h. (302·682 km/hr.).

20

Curtiss R3C-2 (A6979) flown by Lt. 'Jimmy' Doolittle, US Army, to win the 1925 Schneider Trophy race at Baltimore, Md., U.S.A. *Engine:* One 610 h.p. Curtiss V-1400 twelve-cylinder Vee-type. *Span:* 22 ft. 0 in. (6·71 m.). *Length:* 19 ft. $8\frac{1}{2}$ in. (6 m.). *Wing area:* 149 sq. ft. (13·84 sq. m.). *Take-off weight:* 2,150 lb. (975 kg.). *Maximum speed:* 265 m.p.h. (426 km/hr.) at sea level. *Operational ceiling:* 26,400 ft. (8,047 m.). *Range:* more than 250 miles (402 km.).

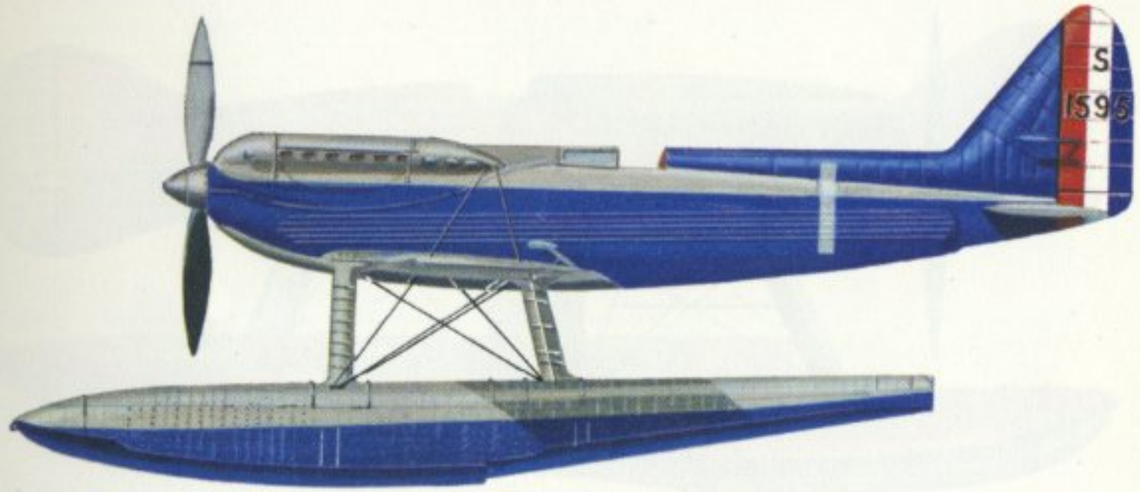


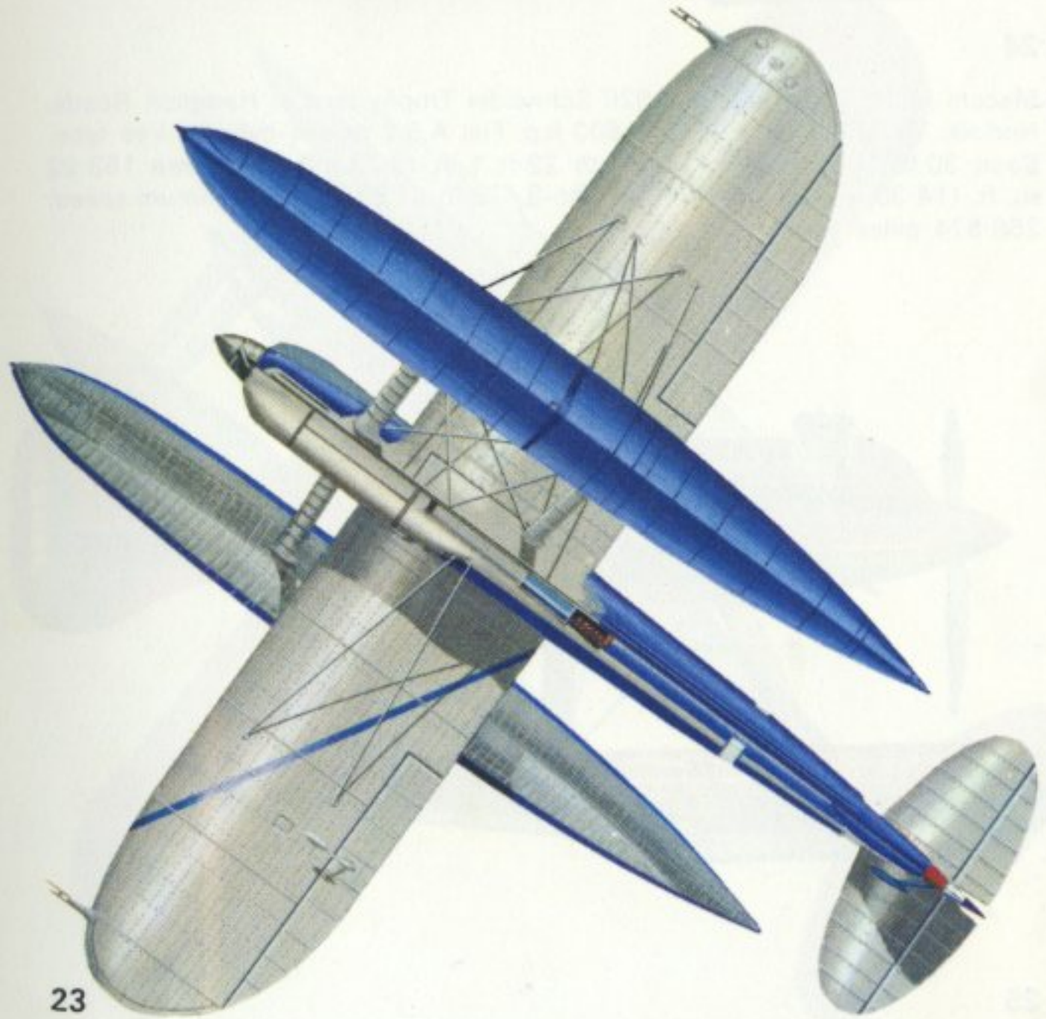
21

Supermarine S.4, built for the 1925 Schneider Trophy race at Baltimore, Md., U.S.A. *Engine:* One 700 h.p. Napier Lion twelve-cylinder 'W' type. *Span:* 30 ft. 6 in. (9·30 m.). *Length:* 27 ft. 0 in. (8·23 m.). *Wing area:* 136 sq. ft. (12·63 sq. m.). *Take-off weight:* 3,150 lb. (1,429 kg.). *Maximum speed:* 239 m.p.h. (385 km/hr.) at sea level. *Range:* 320 miles (515 km.).

22

Supermarine S.5/25, winner of the Schneider Trophy race of 1927 at Venice. *Engine:* One 875 h.p. Napier Lion VIIB twelve-cylinder 'W' type. *Span:* 26 ft. 9 in. (8·15 m.). *Length:* 24 ft. 2 in. (7·37 m.). *Wing area:* 115 sq. ft. (10·68 sq. m.). *Take-off weight:* 3,250 lb. (1,474 kg.). *Maximum speed:* 319·57 m.p.h. (514·285 km/hr.).



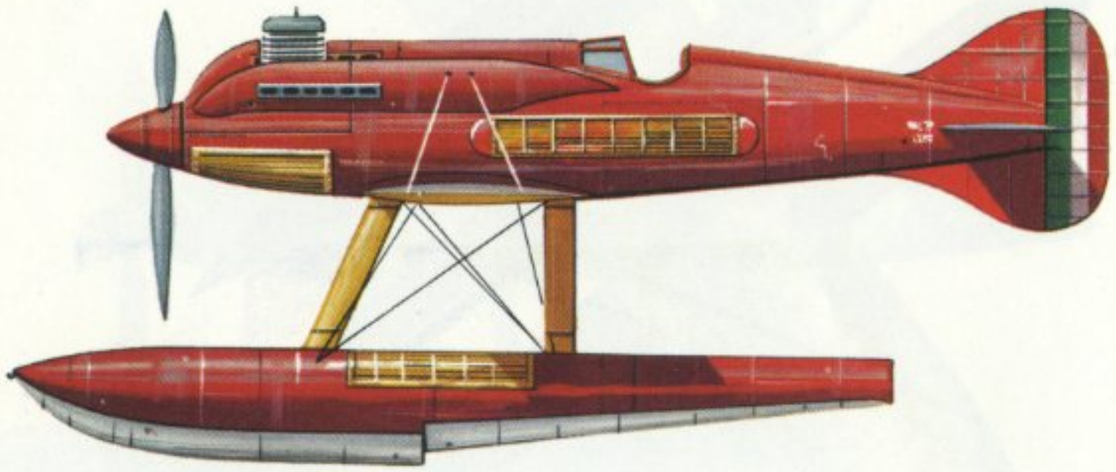


23

Supermarine S.6B, winning aircraft in the 1931 event for the Schneider Trophy in the U.K. *Engine:* One 2,350 h.p. Rolls-Royce 'R' twelve-cylinder Vee-type. *Span:* 30 ft. 0 in. (9·14 m.). *Length:* 28 ft. 10 in. (8·79 m.). *Wing area:* 145 sq. ft. (13·47 sq. m.). *Take-off weight:* 6,086 lb. (2,761 kg.). *Maximum speed:* 379·05 m.p.h. (610·75 km/hr.) with 2,350 h.p. engine.

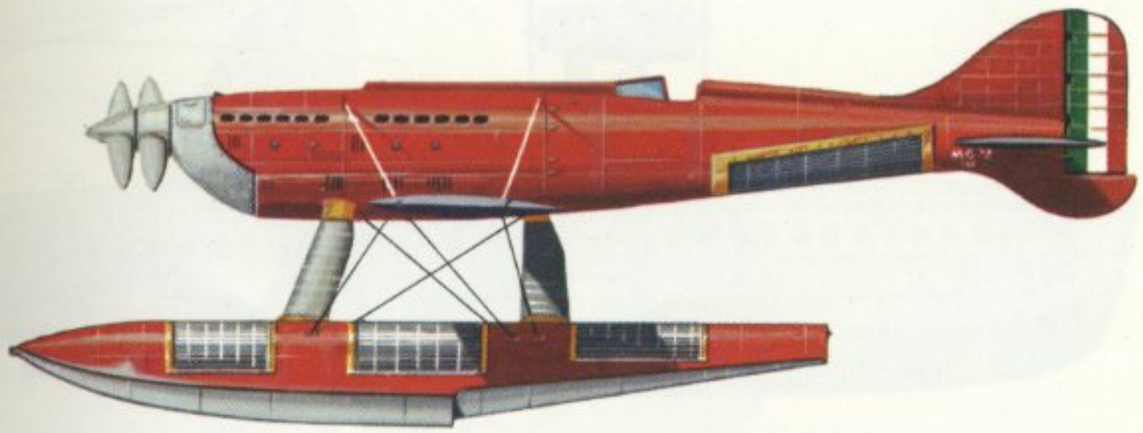
24

Macchi M.39, winner of the 1926 Schneider Trophy race at Hampton Roads, Norfolk, Va, U.S.A. *Engine:* One 800 h.p. Fiat A.S.2 twelve-cylinder Vee-type. *Span:* 30 ft. 4½ in. (9·26 m.). *Length:* 22 ft. 1 in. (6·73 m.). *Wing area:* 153·92 sq. ft. (14·30 sq. m.). *Take-off weight:* 3,472 lb. (1,575 kg.). *Maximum speed:* 258·874 miles (416·618 km/hr.).



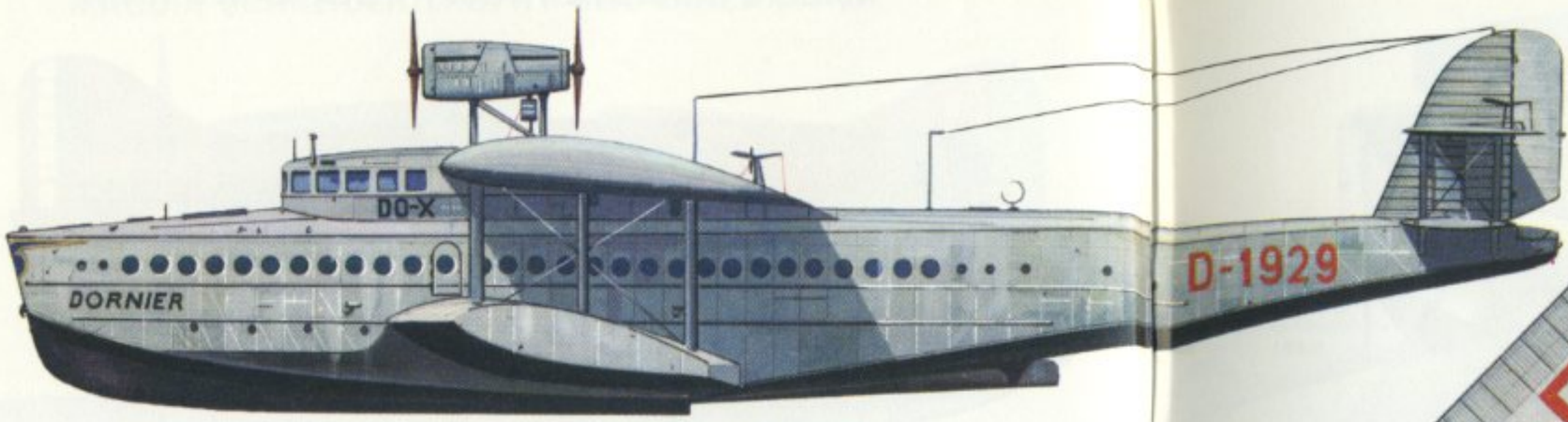
25

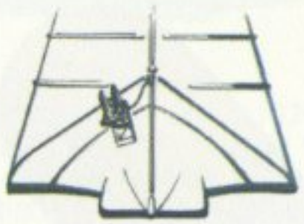
Macchi M.67, one of two entered for the 1929 Schneider Trophy race but which did not finish. *Engine:* One 1,400 h.p. Isotta-Fraschini Asso eighteen-cylinder 'W' type. *Span:* 29 ft. 5½ in. (8·98 m.). *Length:* approx 25 ft. 0 in. (7·62 m.). *Wing area:* 143·16 sq. ft. (13·30 sq. m.). *Take-off weight:* 4,806 lb. (2,180 kg.). *Maximum speed:* 363 m.p.h. (584 km/hr.).

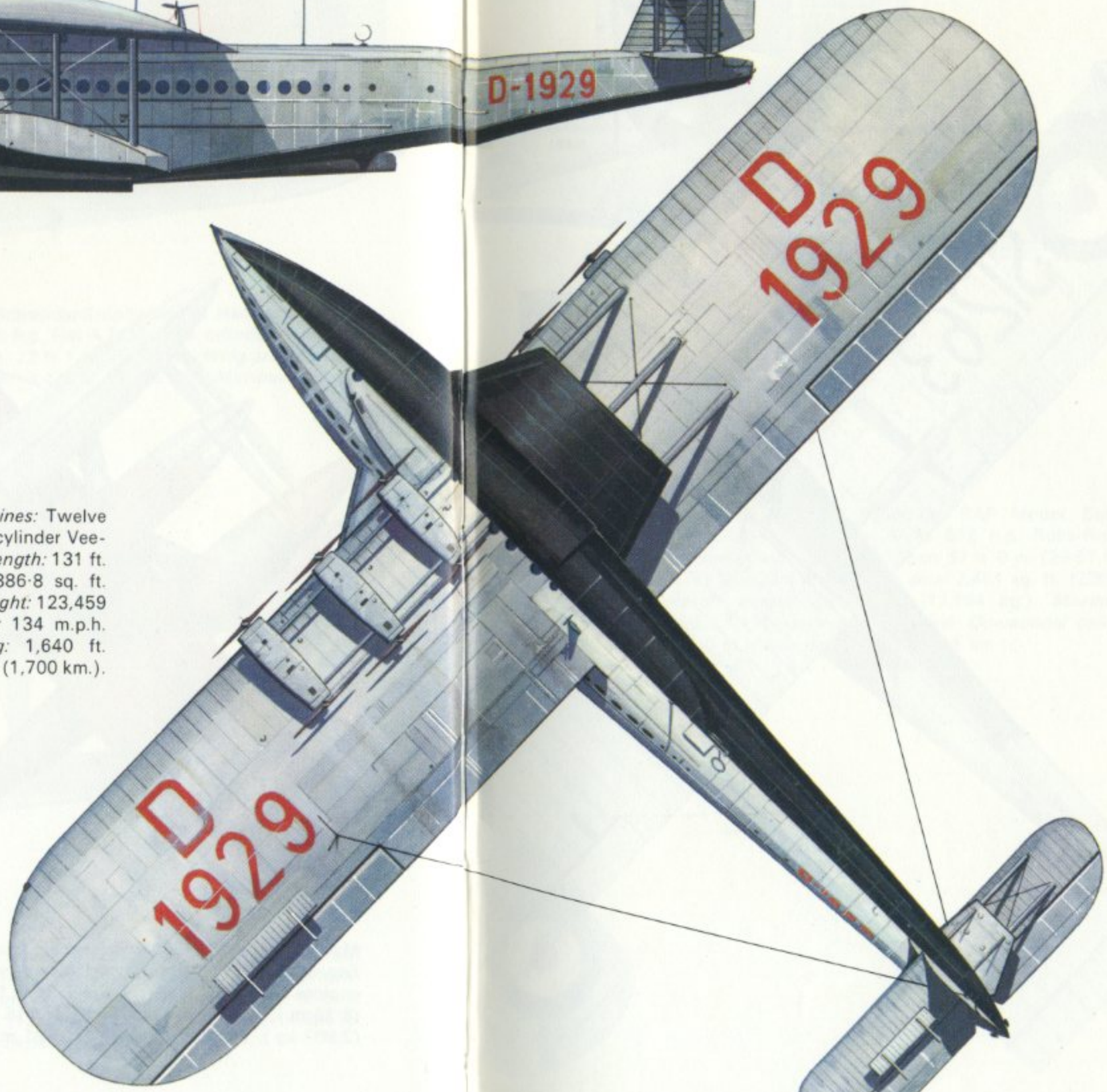


26

Macchi-Castoldi M.C.72 which set world seaplane record on 23 October 1934. *Engine:* One 2,800 h.p. Fiat A.S.6 twenty-four-cylinder Vee-type (two A.S.5 engines coupled in tandem). *Span:* 31 ft. 1¼ in. (9·48 m.). *Length:* 27 ft. 3½ in. (8·32 m.). *Wing area:* 161·46 sq. ft. (15 sq. m.). *Take-off weight:* 6,409 lb. (2,907 kg.). *Maximum speed:* 440·681 m.p.h. (709·209 km/hr.).







27

Dornier Do X No. 1, *ca* 1930. *Engines:* Twelve 600 h.p. Curtiss Conqueror twelve-cylinder Vee-type. *Span:* 157 ft. 5¾ in. (48 m.). *Length:* 131 ft. 4¾ in. (40·05 m.). *Wing area:* 4,886·8 sq. ft. (454 sq. m.). *Maximum take-off weight:* 123,459 lb. (56,000 kg.). *Maximum speed:* 134 m.p.h. (216 km/hr.). *Operational ceiling:* 1,640 ft. (500 m.). *Typical range:* 1,056 miles (1,700 km.).

28

Blackburn Iris III of No. 209 Squadron, RAF Mount Batten (Plymouth), *ca* 1930–31. *Engines:* Three 675 h.p. Rolls-Royce Condor IIIB twelve-cylinder Vee-type. *Span:* 97 ft. 0 in. (29·57 m.). *Length:* 67 ft. 4¾ in. (20·54 m.). *Wing area:* 2,461 sq. ft. (228·64 sq. m.). *Take-off weight:* 29,000 lb. (13,154 kg.). *Maximum speed:* 118 m.p.h. (190 km/hr.) at sea level. *Operational ceiling:* 10,000 ft. (3,050 m.). *Range:* 470 miles (756 km.).

DORNIER WAL (Germany)

29

Dornier-built Do J II b Bos *Grönland-Wal* of Deutsche Luft Hansa, *ca* 1933. (The aircraft flown by von Gronau across the Atlantic in August 1930). *Engines:* Two 600 h.p. BMW VI twelve-cylinder Vee-type. *Span:* 76 ft. 1½ in. (23·20 m.). *Length:* 59 ft. 8½ in. (18·20 m.). *Wing area:* 1,033·3 sq. ft. (96 sq. m.). *Take-off weight:* 17,637 lb. (8,000 kg.). *Maximum speed:* 140 m.p.h. (225 km/hr.). *Operational ceiling:* 9,845 ft. (3,000 m.). *Range:* 1,365 miles (2,200 km.).

CRDA CANT Z.501 (Italy)

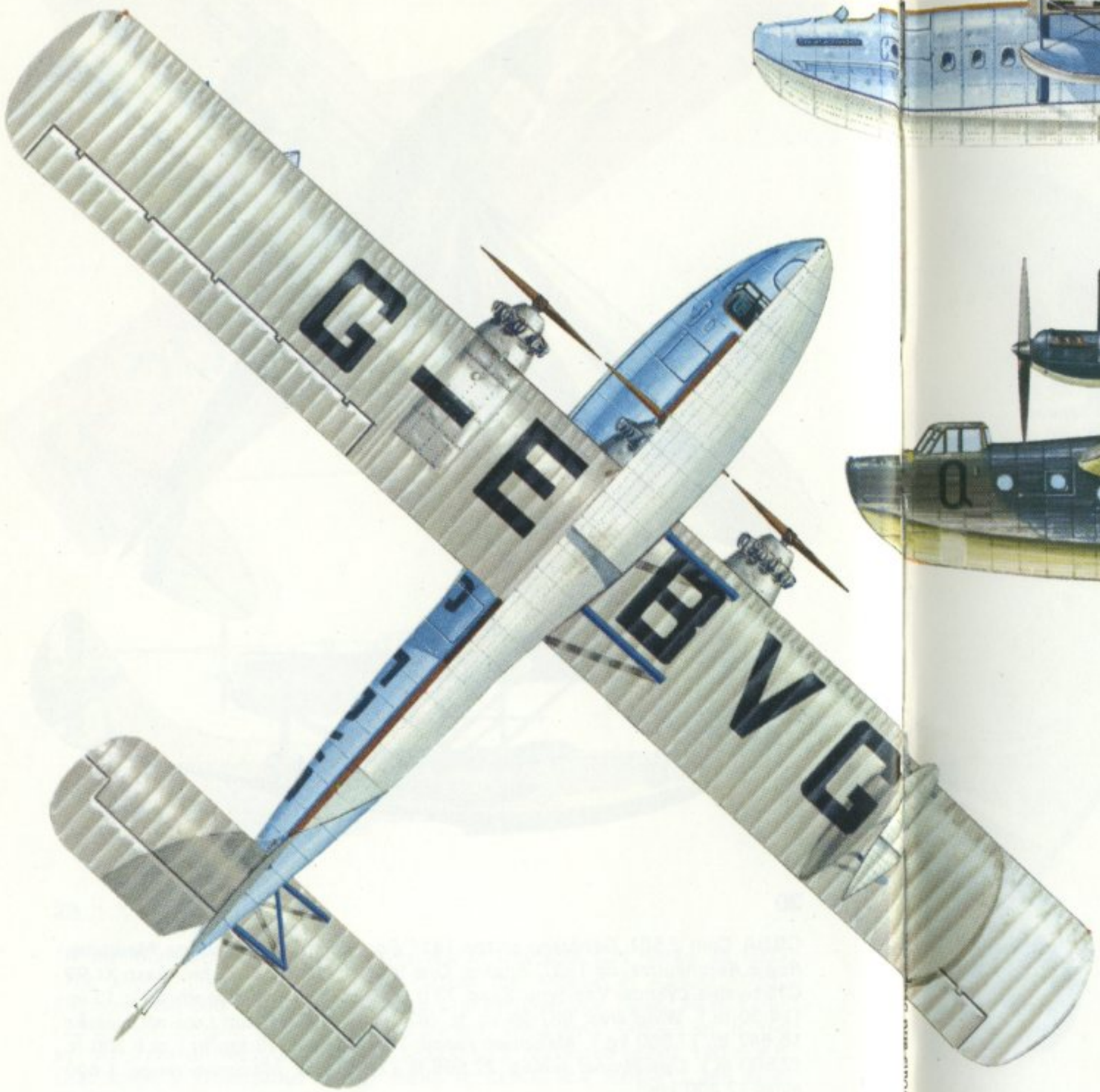
30

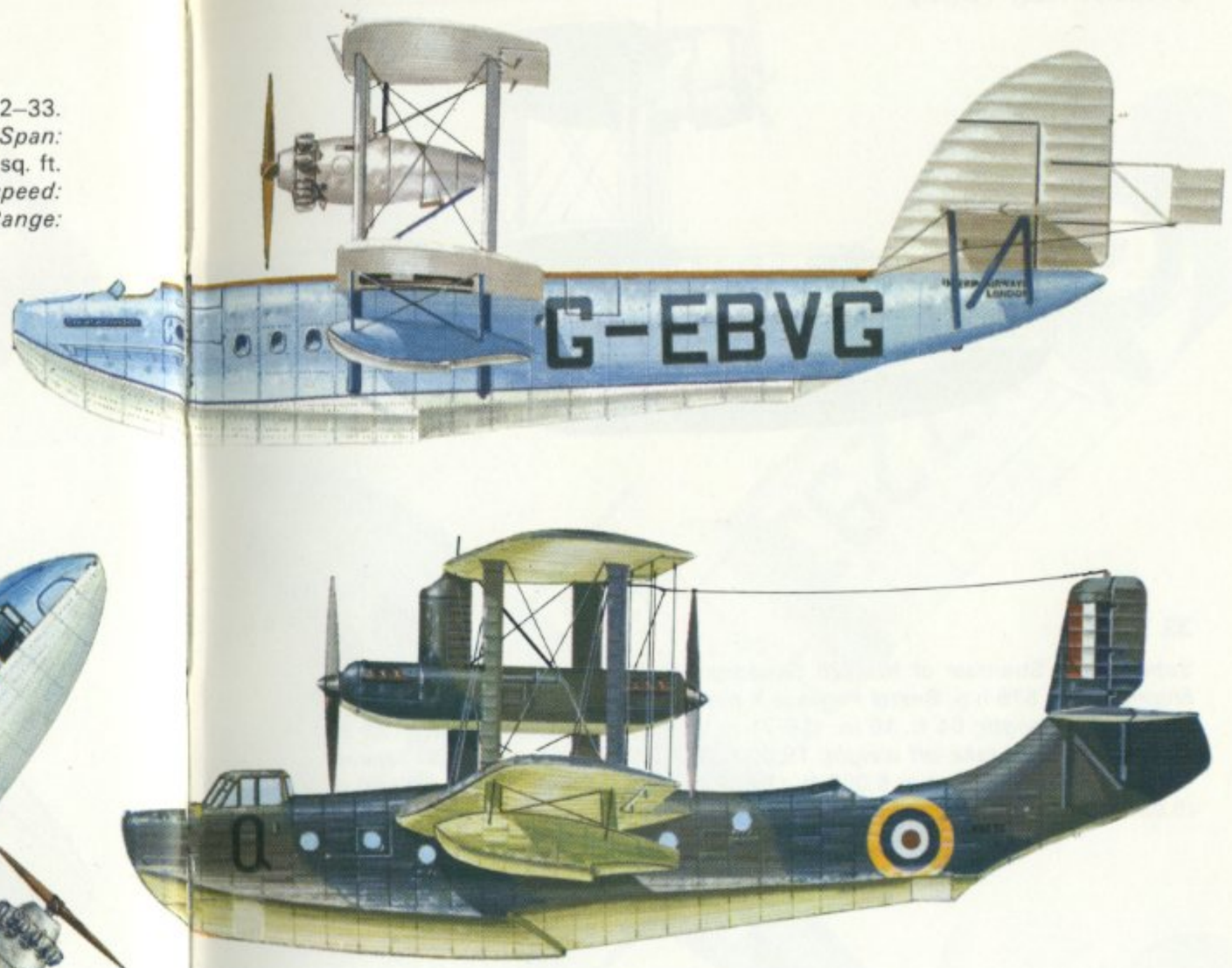
CRDA Cant Z.501 *Gabbiano of the* 141° *Squadriglia Ricognizione Marittima, Regia Aeronautica, ca* 1937. *Engine:* One 900 h.p. Isotta-Fraschini Asso XI R2 C15 twelve-cylinder Vee-type. *Span:* 73 ft. 9¾ in. (22·50 m.). *Length:* 46 ft. 11 in. (14·30 m.). *Wing area:* 667·36 sq. ft. (62 sq. m.). *Maximum take-off weight:* 15,542 lb. (7,050 kg.). *Maximum speed:* 171 m.p.h. (275 km/hr.) at 8,200 ft. (2,500 m.). *Operational ceiling:* 22,965 ft. (7,000 m.). *Maximum range:* 1,490 miles (2,400 km.).

CALCUTTA AND SINGAPORE (U.K.)

31

Short S.8 Calcutta *City of Alexandria* of Imperial Airways, *ca* 1932–33. *Engines:* Three 540 h.p. Bristol Jupiter XIF nine-cylinder radials. *Span:* 93 ft. 0 in. (28·35 m.). *Length:* 66 ft. 0 in. (20·12 m.). *Wing area:* 1,825 sq. ft. (169·55 sq. m.). *Take-off weight:* 22,500 lb. (10,206 kg.). *Maximum speed:* 118 m.p.h. (190 km/hr.). *Operational ceiling:* 13,500 ft. (4,115 m.). *Range:* 650 miles (1,046 km.).

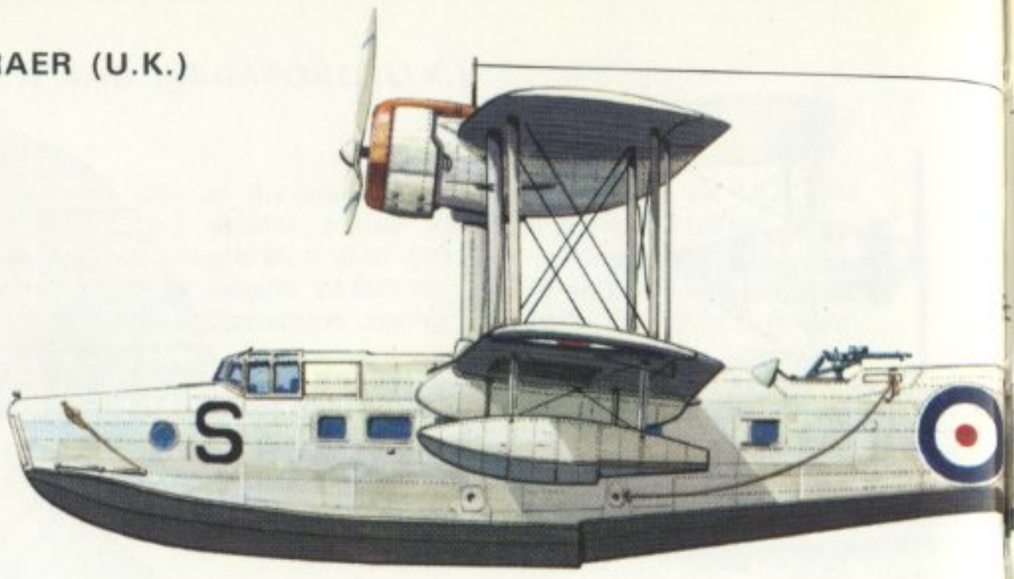


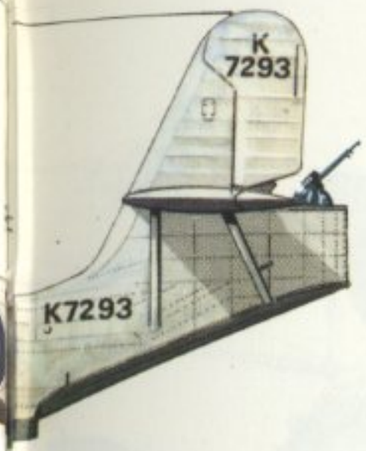


32

Short S.19 Singapore III of No. 209 Squadron RAF, mid-1940. *Engines:* Two 730 h.p. Rolls-Royce Kestrel VIII and two 730 h.p. Kestrel IX twelve-cylinder Vee-type. *Span:* 90 ft. 0 in. (27·43 m.). *Length:* 64 ft. 2 in. (19·56 m.). *Wing area:* 1,834 sq. ft. (170·39 sq. m.). *Take-off weight:* 27,500 lb. (12,474 kg.). *Maximum speed:* 145 m.p.h. (233 km/hr.) at 2,000 ft. (1,524 m.). *Operational ceiling:* 15,000 ft. (4,572 m.). *Normal range:* 1,000 miles (1,609 km.).

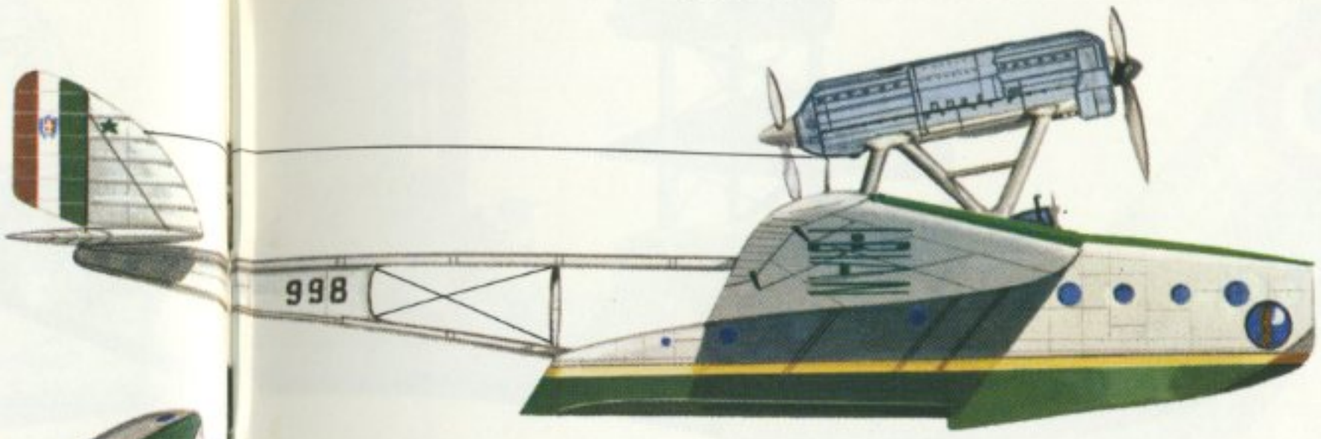
STRANRAER (U.K.)





33

Supermarine Stranraer of No 228 Squadron, RAF Pembroke Dock, *ca* 1937. *Engines:* Two 875 h.p. Bristol Pegasus X nine-cylinder radials. *Span:* 85 ft. 0 in. (25·91 m.). *Length:* 54 ft. 10 in. (16·71 m.). *Wing area:* 1,457 sq. ft. (135·36 sq. m.). *Normal take-off weight:* 19,000 lb. (8,618 kg.). *Maximum speed:* 165 m.p.h. (266 km/hr.) at 6,000 ft. (1,829 m.). *Operational ceiling:* 18,500 ft. (5,639 m.). *Normal range:* 1,025 miles (1,650 km.).



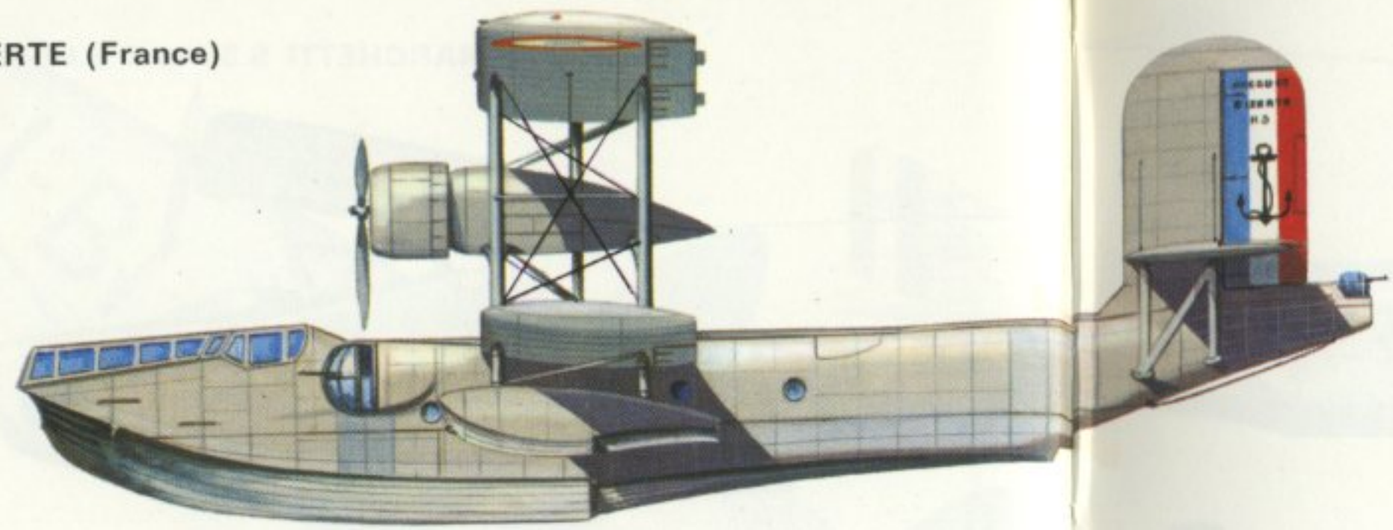
34

Savoia-Marchetti S.55X flown by Captain Biani, leader of the 'Green Squadron' of the 1933 flight to North America. *Engines:* Two 750 h.p. Isotta-Fraschini Asso R eighteen-cylinder 'W' type. *Span:* 78 ft. 9 in. (24 m.). *Length:* 54 ft. 1½ in. (16·50 m.). *Wing area:* 990·28 sq. ft. (92 sq. m.). *Take-off weight:* 20,944 lb. (9,500 kg.). *Maximum speed:* 165 m.p.h. (265 km/hr.). *Operational ceiling:* 13,780 ft. (4,200 m.). *Range:* 1,245 miles (2,000 km.). *(Weight and performance data are for S.55M.)*

35

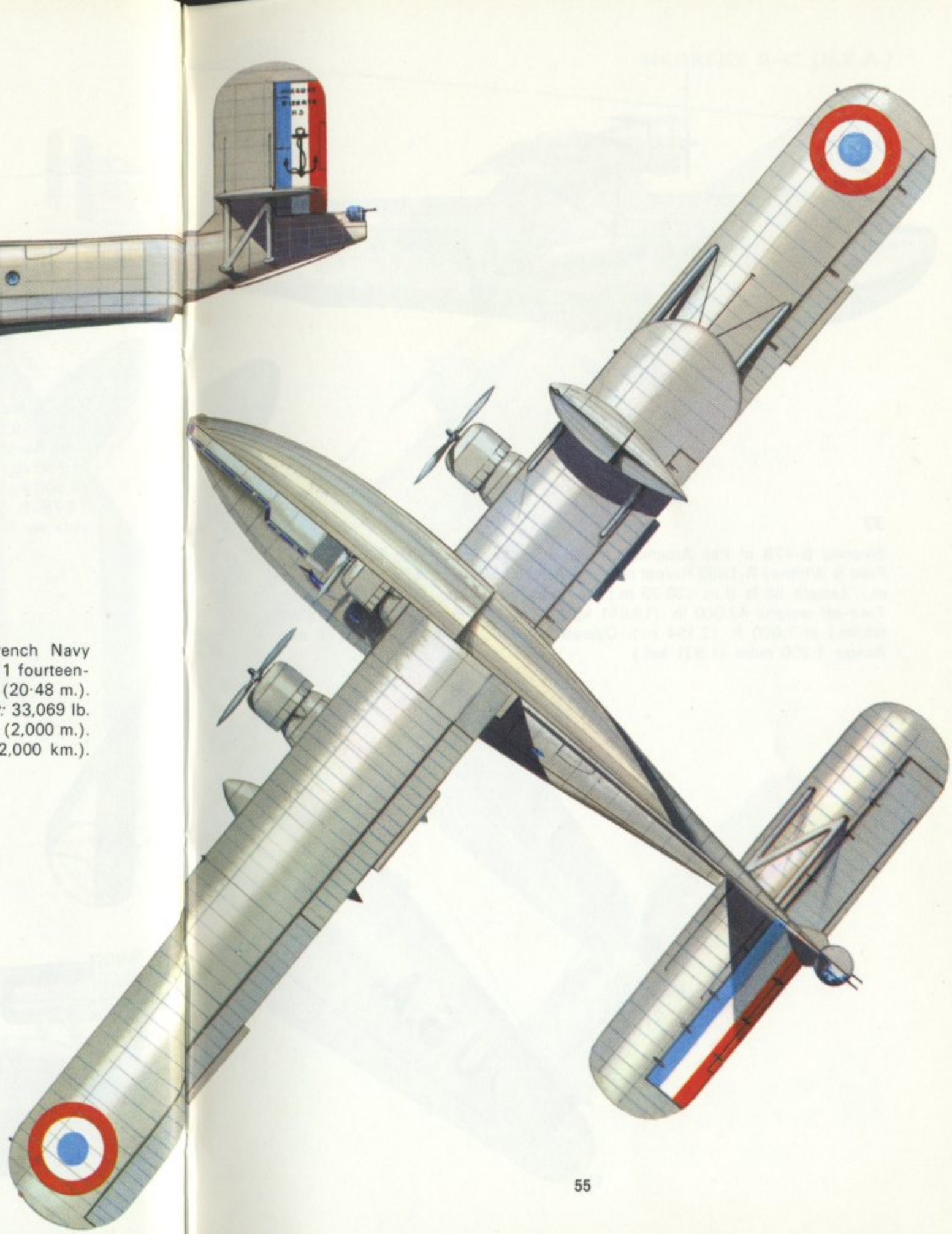
Savoia-Marchetti S.66 of Ala Littoria, *ca* 1936. *Engines:* Three 750 h.p. Fiat A.24R twelve-cylinder Vee-type. *Span:* 108 ft. 3¼ in. (33 m.). *Length:* 54 ft. 6¾ in. (16·63 m.). *Wing area:* 1,363·79 sq. ft. (126·7 sq. m.). *Normal take-off weight:* 24,139 lb. (10,950 kg.). *Maximum speed:* 164 m.p.h. (264 km/hr.). *Operational ceiling:* 18,045 ft. (5,500 m.). *Endurance:* 5 hr. 20 min.

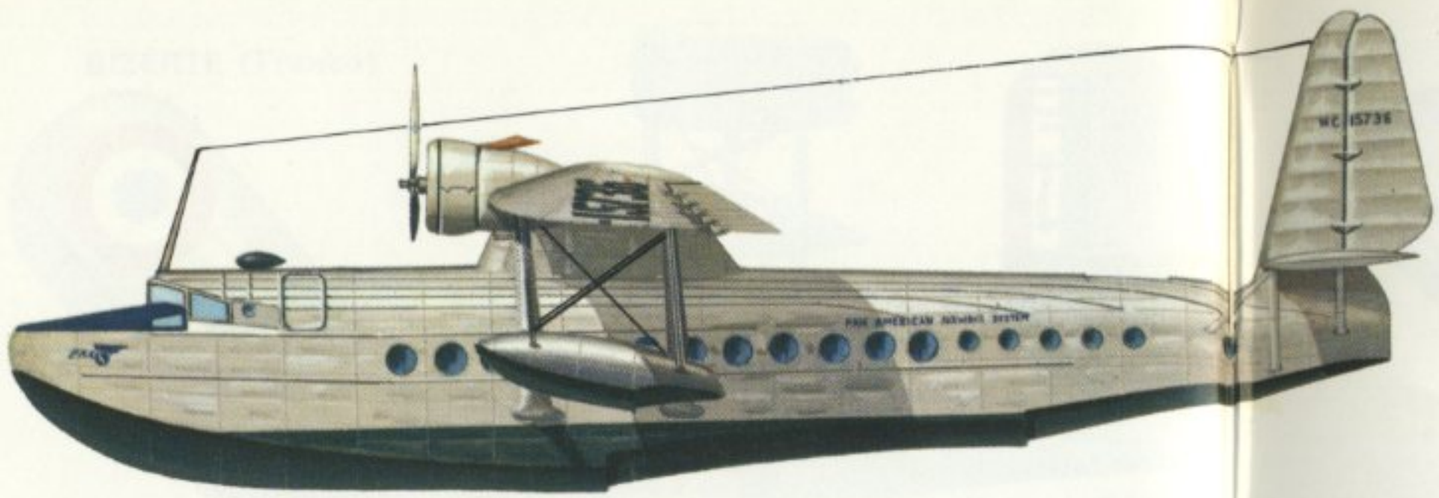
BIZERTE (France)

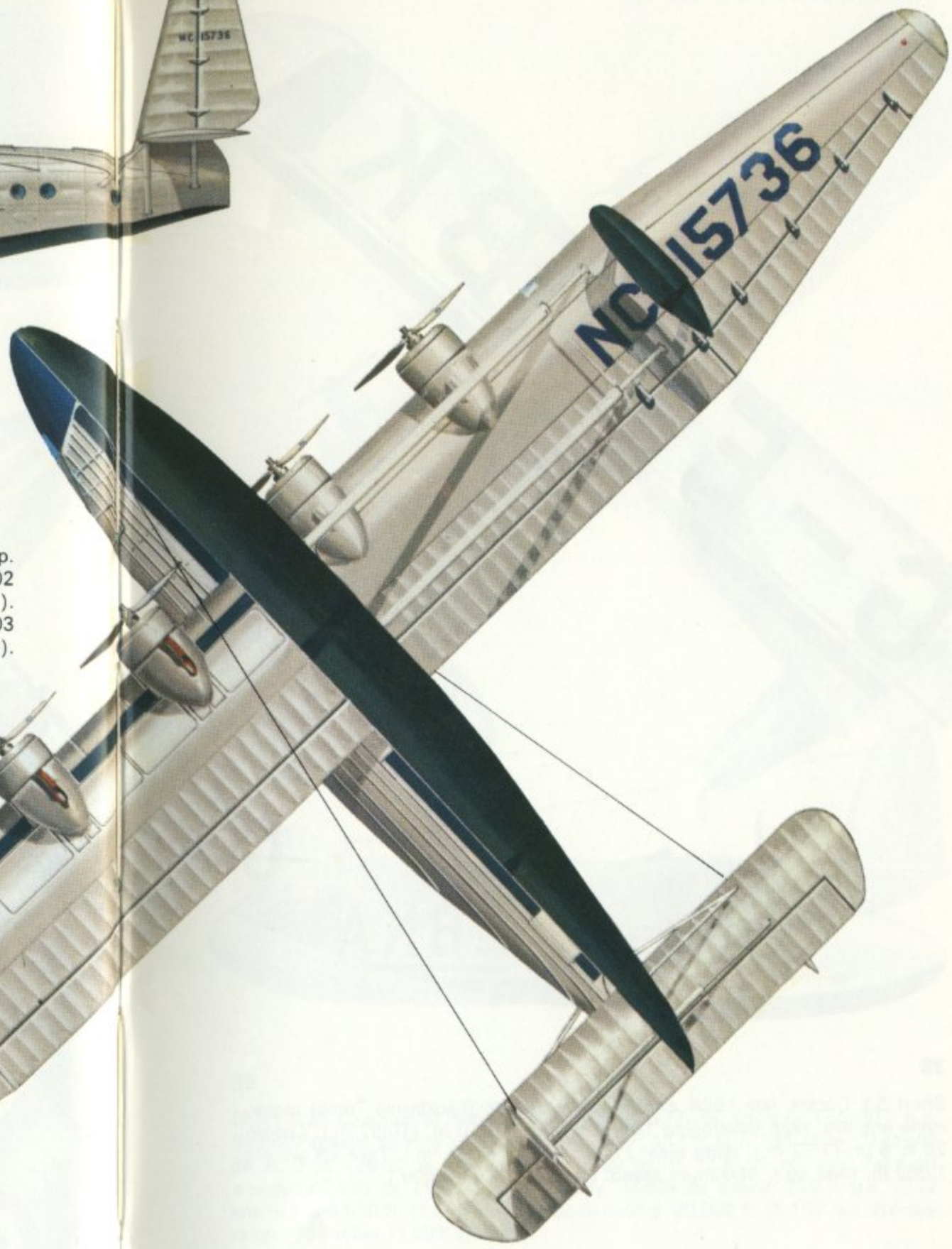


36

Breguet 521-03 Bizerte (second pre-production aircraft) in French Navy markings, *ca* 1939. *Engines:* Three 900 h.p. Gnome-Rhône 14 Kirs 1 fourteen-cylinder radials. *Span:* 115 ft. 3 in. (35·13 m.). *Length:* 67 ft. 2¼ in. (20·48 m.). *Wing area:* 1,827·2 sq. ft. (169·75 sq. m.). *Normal take-off weight:* 33,069 lb. (15,000 kg.). *Maximum speed:* 158 m.p.h. (255 km/hr.) at 6,560 ft. (2,000 m.). *Operational ceiling:* 19,685 ft. (6,000 m.). *Range:* 1,245 miles (2,000 km.).







37

Sikorsky S-42B of Pan American Airways, *ca* 1937. *Engines:* Four 750 h.p. Pratt & Whitney R-1860 Hornet nine-cylinder radials. *Span:* 118 ft. 2 in. (36·02 m.). *Length:* 68 ft. 0 in. (20·73 m.). *Wing area:* 1,340 sq. ft. (124·49 sq. m.). *Take-off weight:* 42,000 lb. (19,051 kg.). *Maximum speed:* 188 m.p.h. (303 km/hr.) at 7,000 ft. (2,134 m.). *Operational ceiling:* 15,000 ft. (4,572 m.). *Range:* 1,200 miles (1,931 km.).

38

Short S.1 Cockle, late 1924. *Engines:* Two 697 cc Blackburne Tomtit motor-cycle engines, each developing 16 h.p. *Span:* 36 ft. 0 in. (10·97 m.). *Length:* 24 ft. 8 in. (7·52 m.). *Wing area:* 210 sq. ft. (19·51 sq. m.). *Take-off weight:* 1,062 lb. (482 kg.). *Maximum speed:* 68 m.p.h. (109 km/hr.).

39

Short S.23 *Canopus* of Imperial Airways, *ca* 1937–38. *Engines:* Four 910 h.p. Bristol Pegasus Xc nine-cylinder radials. *Span:* 114 ft. 0 in. (34·75 m.). *Length:* 88 ft. 0 in. (26·82 m.). *Wing area:* 1,500 sq. ft. (139·35 sq. m.). *Take-off weight:* 40,500 lb. (18,371 kg.) initially. *Maximum speed:* 200 m.p.h. (322 km/hr.) at 5,500 ft. (1,676 m.). *Absolute ceiling:* 20,000 ft. (6,100 m.). *Normal range:* 760 miles (1,223 km.).

MARTIN 130 (U.S.A.)

40

Martin 130 *China Clipper* of Pan American Airways, *ca* late 1936. *Engines:* Four 830 h.p. Pratt & Whitney R-1830-S1A4G Twin Wasp fourteen-cylinder radials. *Span:* 130 ft. 0 in. (39·62 m.). *Length:* 90 ft. 7½ in. (27·62 m.). *Wing area:* 2,315 sq. ft. (215·07 sq. m.) including sponsons. *Take-off weight:* 52,000 lb. (23,587 kg.). *Maximum cruising speed:* 163 m.p.h. (262 km/hr.) at 7,000 ft. (2,135 m.). *Operational ceiling:* 17,000 ft. (5,182 m.). *Range:* 3,200 miles. (5,150 km.).

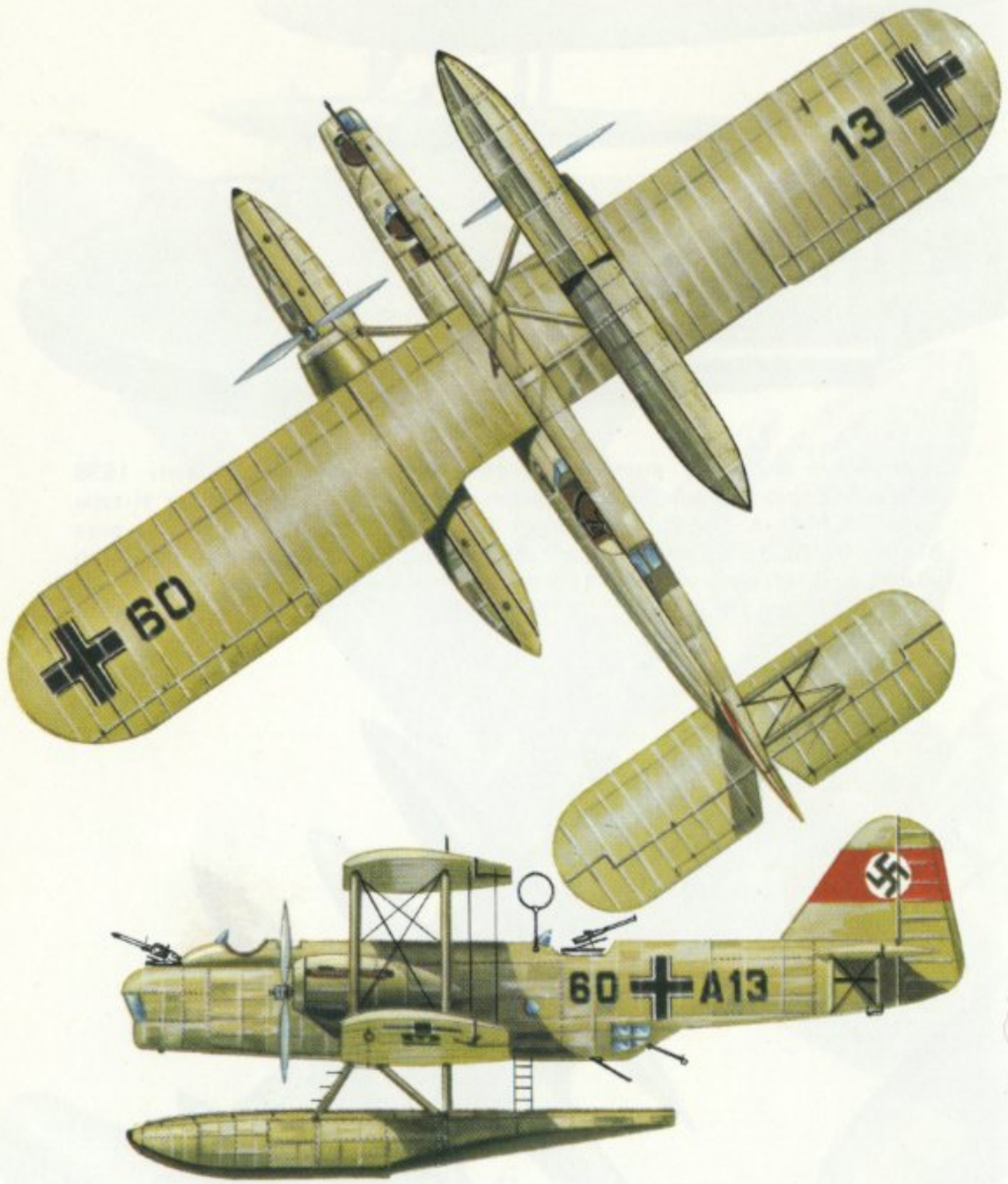
SHORT-MAYO COMPOSITE (U.K.)

41

Maia: Engines: Four 910 h.p. Bristol Pegasus Xc nine-cylinder radials. *Span:* 114 ft. 0 in. (34·75 m.). *Length:* 84 ft. 10¾ in. (25·88 m.). *Wing area:* 1,750 sq. ft. (162·59 sq. m.). *Take-off weight* (without *Mercury*): 38,000 lb. (17,237 kg.). *Maximum speed:* 200 m.p.h. (322 km/hr.). *Operational ceiling:* 20,000 ft. (6,100 m.). *Normal range:* 850 miles (1,368 km.).

Short-Mayo S.20/S.21 composite aircraft (*Mercury/Maia*), *ca* early 1938. *Mercury: Engines:* Four 340 h.p. Napier Rapier V sixteen-cylinder H-type. *Span:* 73 ft. 0 in. (22·25 m.). *Length:* 50 ft. 11½ in. (15·53 m.). *Wing area:* 611 sq. ft. (56·76 sq. m.). *Normal take-off weight* (for air launch): 20,800 lb. (9,435 kg.). *Maximum speed:* 195 m.p.h. (314 km/hr.). *Normal range:* 3,900 miles (6,276 km.).

HEINKEL He 59 (Germany)



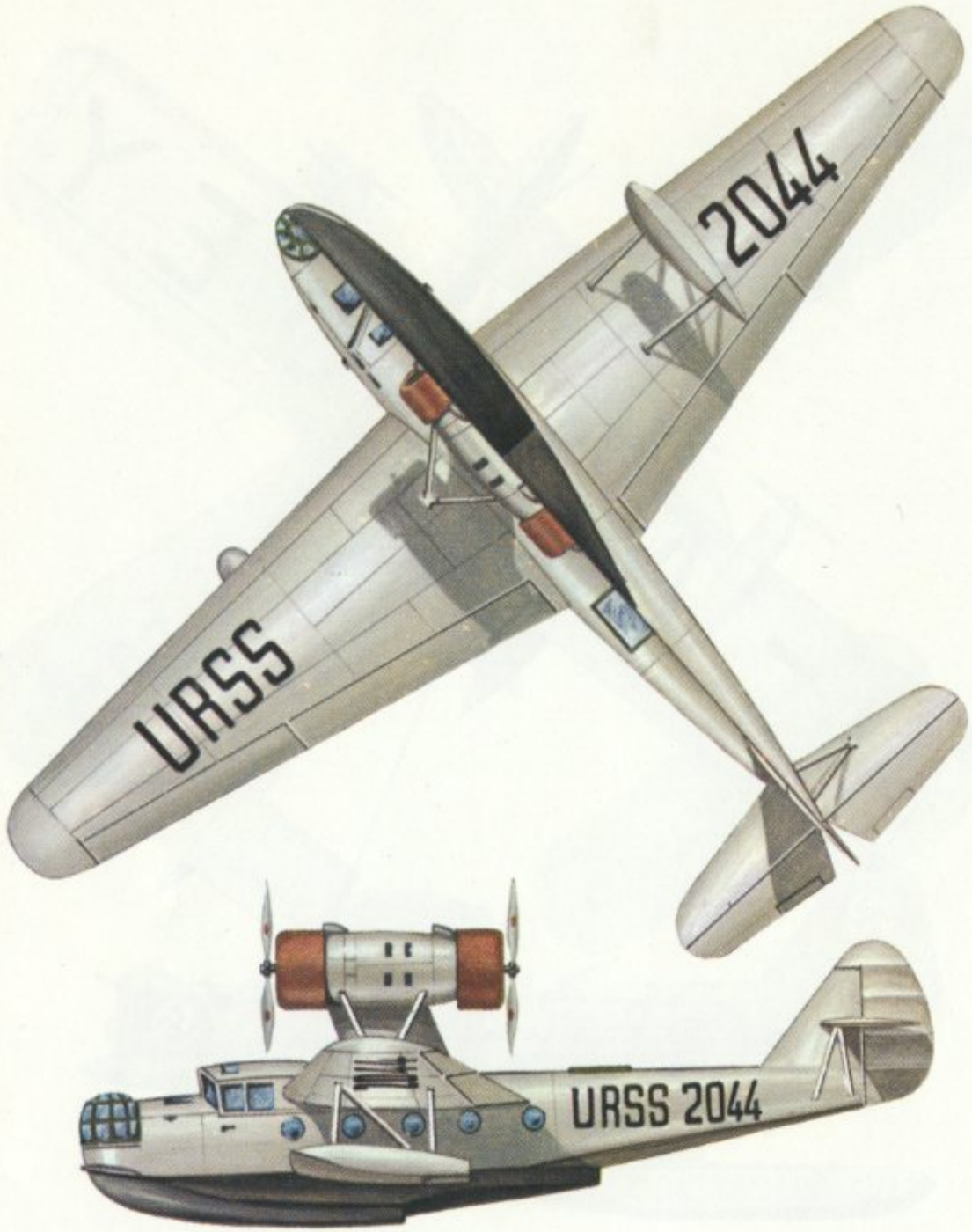
42

Heinkel He 59B-2 of the 1st Staffel, K.Fl.Gr. 106, *Luftwaffe, ca* 1937. *Engines:* Two 660 h.p. BMW VI 6·0 ZU twelve-cylinder Vee-type. *Span:* 77 ft. 9 in. (23·70 m.). *Length:* 57 ft. 1 in. (17·40 m.). *Wing area:* 1,649 sq. ft. (153·2 sq. m.). *Take-off weight:* 19,842 lb. (9,000 kg.). *Maximum speed:* 137 m.p.h. (220 km/hr.) at sea level. *Operational ceiling:* 11,480 ft. (3,500 m.). *Maximum range:* 1,085 miles (1,750 km.).

BLOHM und VOSS Ha 139 (Germany)

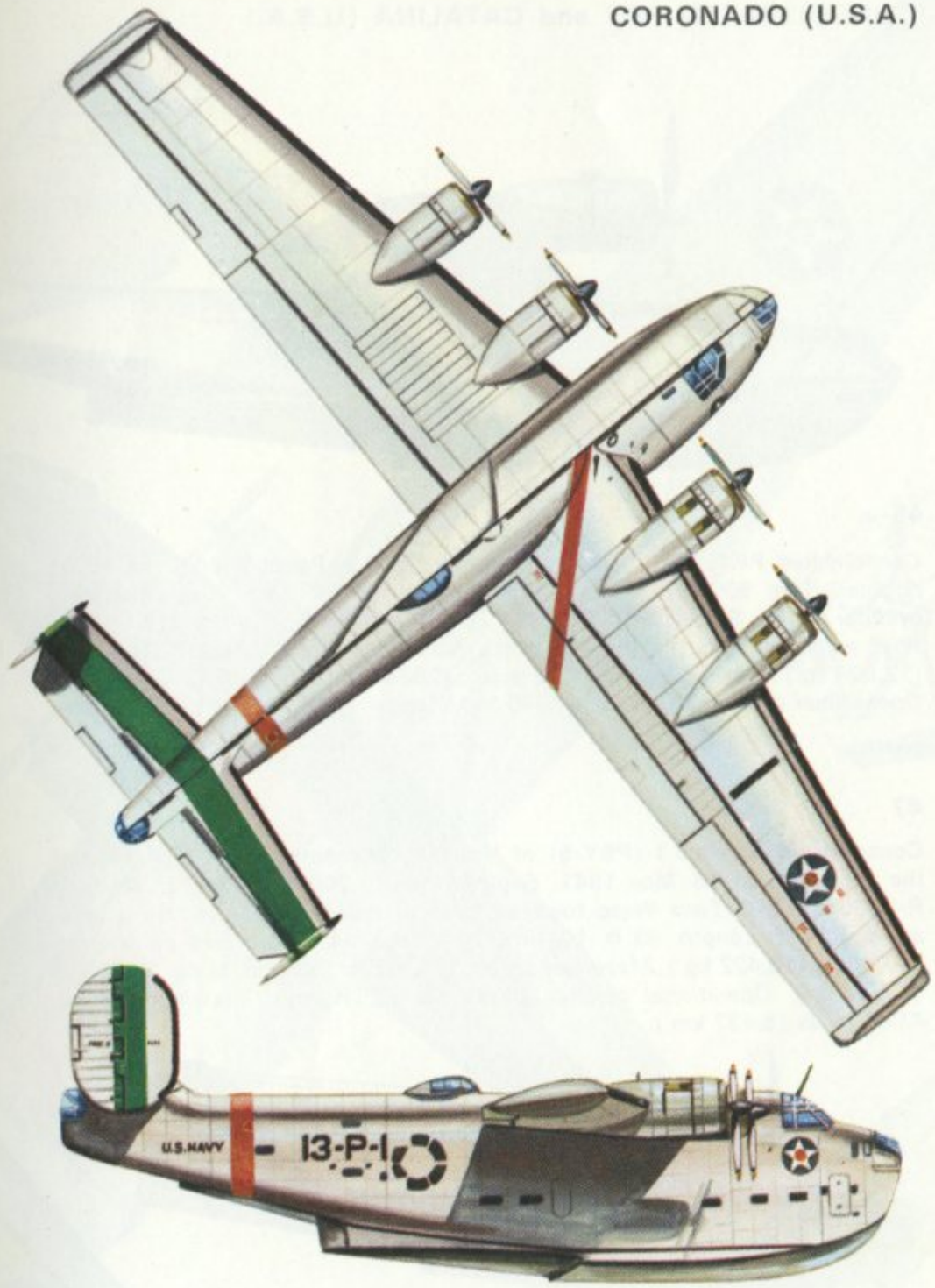
43

Blohm und Voss Ha 139 V2 *Nordwind* in Deutsche Luft Hansa livery, *ca* 1938. *Engines:* Four 600 h.p. Junkers Jumo 205C twelve-cylinder diesels. *Span:* 88 ft. 7 in. (27 m.). *Length:* 63 ft. 11¾ in. (19·50 m.). *Wing area:* 1,259·38 sq. ft. (117 sq. m.). *Catapult take-off weight:* 38,581 lb. (17,500 kg.). *Maximum speed:* 196 m.p.h. (315 km/hr.) at sea level. *Operational ceiling:* 11,480 ft. (3,500 m.). *Maximum range:* 3,295 miles (5,300 km.).



44

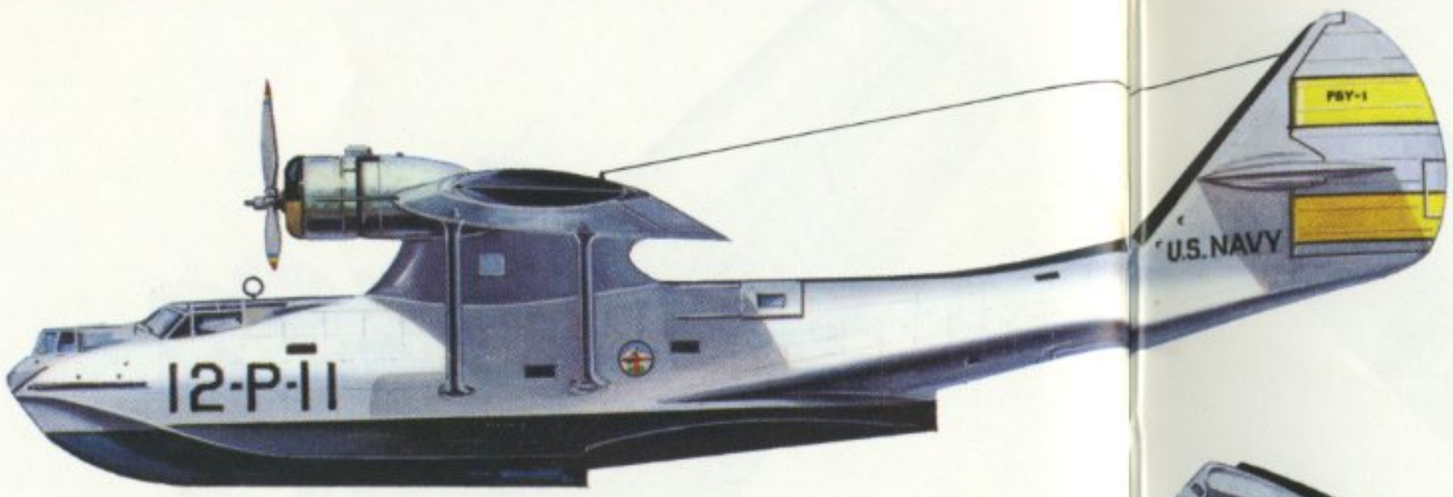
Chetverikov ARK-3-2 (second prototype), Sebastopol, spring 1939. *Engines:* Two 650 h.p. M-25A nine-cylinder radials. *Span:* 65 ft. 10¼ in. (20·07 m.). *Length:* 48 ft. 0¾ in. (14·65 m.). *Wing area:* 641 sq. ft. (59·55 sq. m.). *Maximum take-off weight:* 12,346 lb. (5,600 kg.). *Maximum speed:* 199 m.p.h. (320 km/hr.) at 4,920 ft. (1,500 m.). *Operational ceiling:* approx 19,360 ft. (5,900 m.). *Normal range:* approx 930 miles (1,500 km.).



45

Consolidated PB2Y-2 Coronado of US Navy Squadron VP-13, early 1941. *Engines:* Four 1,200 h.p. Pratt & Whitney R-1830-78 Twin Wasp fourteen-cylinder radials. *Span:* 115 ft. 0 in. (35·05 m.). *Length:* 79 ft. 0 in. (24·08 m.). *Wing area:* 1,780 sq. m. (165·37 sq. m.). *Normal take-off weight:* 60,441 lb. (27,416 kg.). *Maximum speed:* 255 m.p.h. (410 km/hr) at 19,000 ft. (5,791 m.). *Operational ceiling:* 24,100 ft. (7,346 m.). *Normal range:* 3,705 miles (5,963 km.).

CONSOLIDATED PBY and CATALINA (U.S.A.)

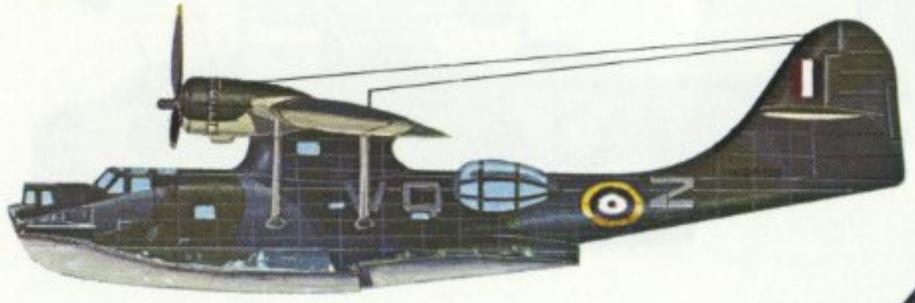


46

Consolidated PBY-1 of US Navy Squadron VP-12, Patrol Wing 1, *ca* 1937. *Engines:* Two 900 h.p. Pratt & Whitney R-1830-64 Twin Wasp fourteen-cylinder radials. *Span:* 104 ft. 0 in. (31·70 m.). *Length:* 65 ft. 1¾ in. (19·86 m.). *Wing area:* 1,400 sq. ft. (130·06 sq. m.). *Maximum take-off weight:* 28,447 lb. (12,904 kg.). *Maximum speed:* 178 m.p.h. (286 km/hr.) at 8,000 ft. (2,438 m.). *Operational ceiling:* 20,800 ft. (6,340 m.). *Range:* 2,115 miles (3,404 km.).

47

Consolidated Catalina I (PBY-5) of No. 209 Squadron RAF which spotted the *Bismarck* on 26 May 1941. *Engines:* Two 1,200 h.p. Pratt & Whitney R-1830-S1C3-G Twin Wasp fourteen-cylinder radials. *Span and Wing area:* as for PBY-1. *Length:* 63 ft. 10½ in. (19·47 m.). *Maximum take-off weight:* 34,000 lb. (15,422 kg.). *Maximum speed:* 190 m.p.h. (306 km/hr.) at 10,500 ft. (3,200 m.). *Operational ceiling:* 24,000 ft. (7,315 m.). *Maximum range:* 4,000 miles (6,437 km.).



LATÉCOÈRE 302 (France)

48

Latécoère 302 *Mouneyres* of *Escadrille* E4, French Navy, *ca* late 1939. *Engines:* Four 930 h.p. Hispano-Suiza 12 Ydrs twelve-cylinder Vee-type. *Span:* 144 ft. 4½ in. (44 m.). *Length:* 85 ft. 9½ in. (26·15 m.). *Wing area:* 2,755·6 sq. ft. (256 sq. m.). *Take-off weight:* 52,911 lb. (24,000 kg.). *Maximum speed:* 149 m.p.h. (240 km/hr.) at 6,560 ft. (2,000 m.). *Operational ceiling:* 16,400 ft. (5,000 m.). *Maximum range:* 2,050 miles (3,300 km.).

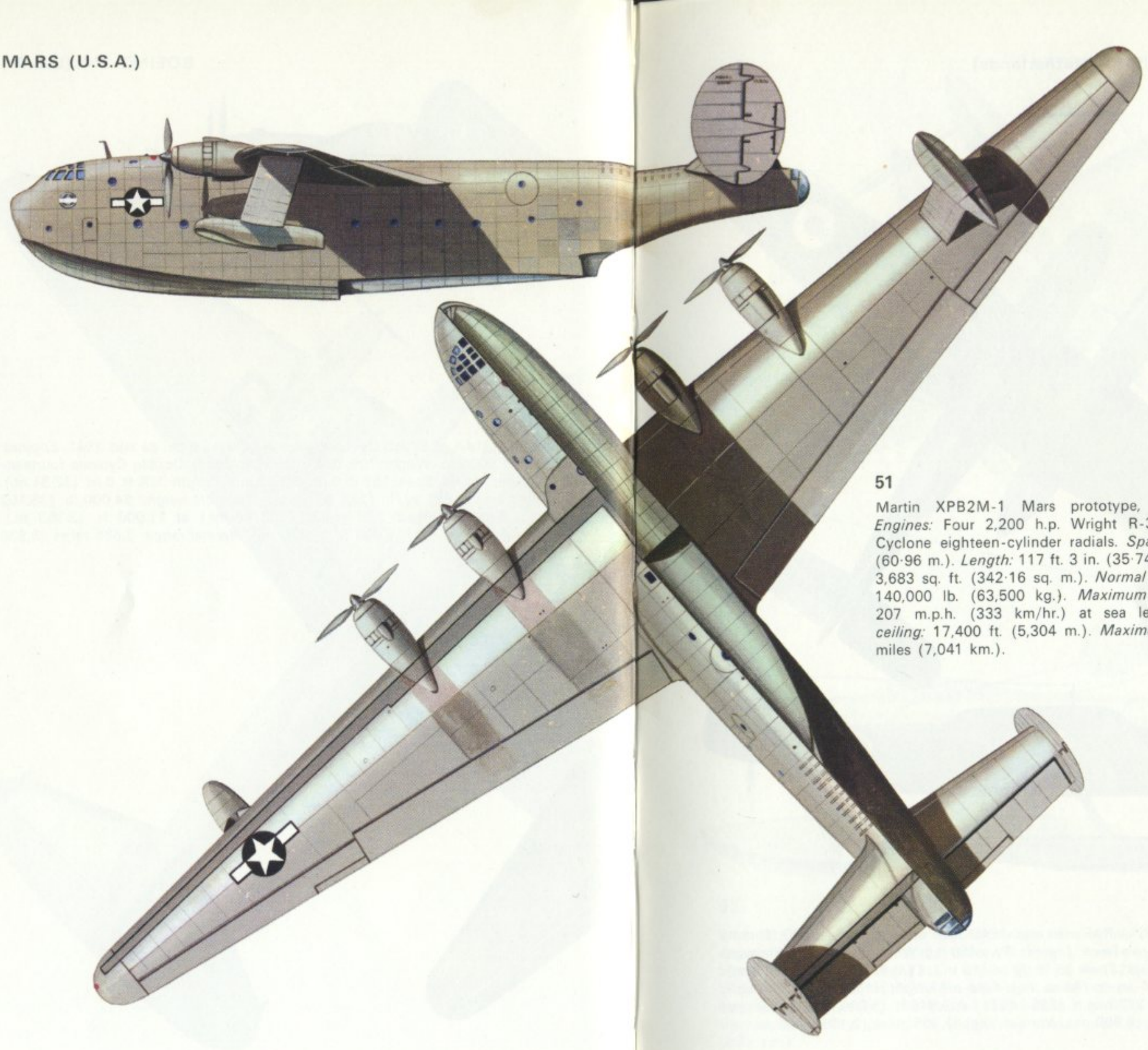
WALRUS (U.K.)

49

Saunders-Roe-built Walrus II of No. 711 Squadron Fleet Air Arm, *ca* spring 1941. *Engine:* One 775 Bristol Pegasus VI nine-cylinder radial. *Span:* 45 ft. 10 in. (13·97 m.). *Length:* 37 ft. 7 in. (11·46 m.). *Wing area:* 610 sq. ft. (56·67 sq. m.). *Normal take-off weight:* 7,200 lb. (3,266 kg.). *Maximum speed:* 135 m.p.h. (217 km/hr.) at 4,750 ft. (1,448 m.). *Operational ceiling:* 18,500 ft. (5,639 m.). *Range:* 600 miles (966 km.).

50

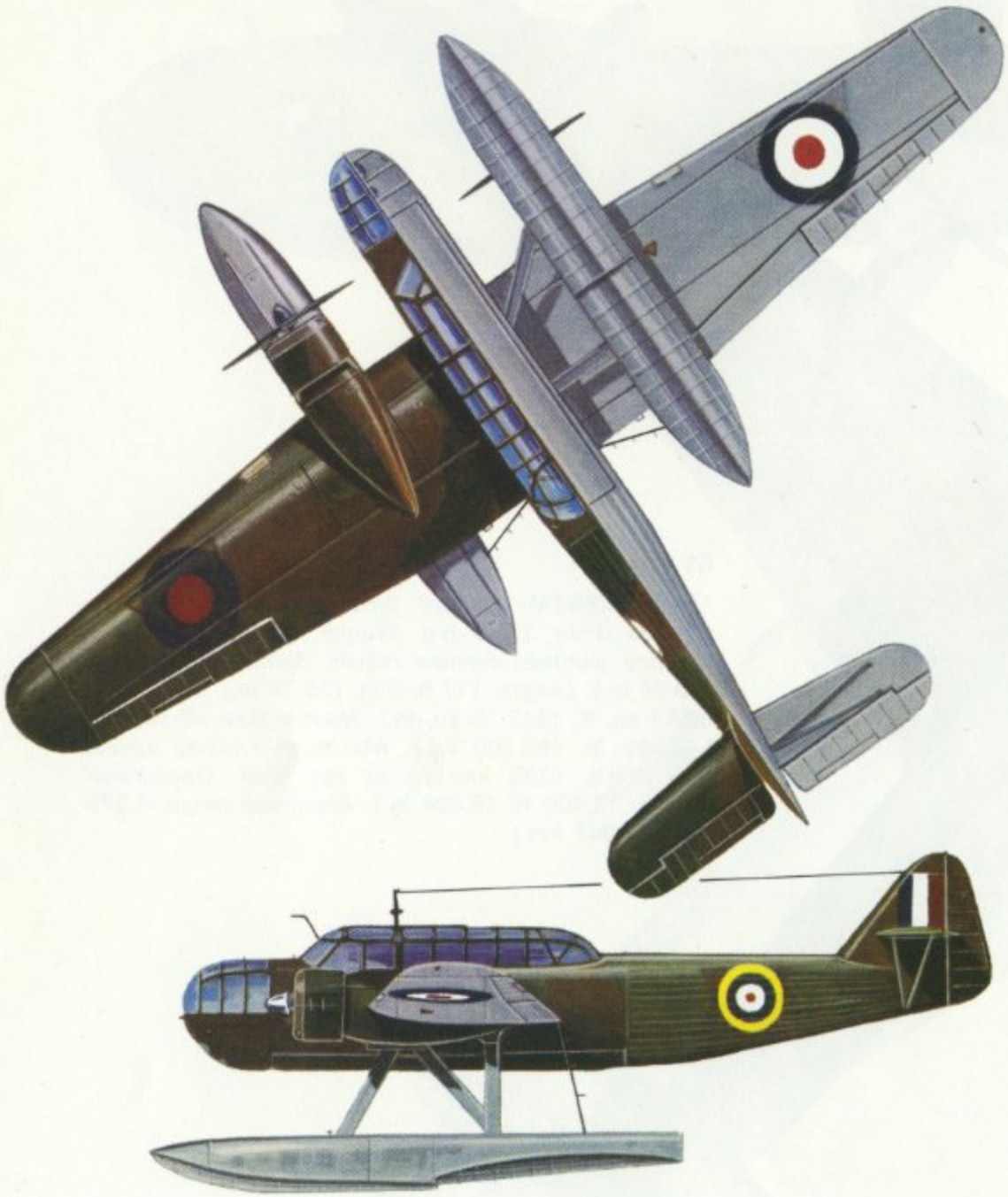
Boeing 314A of British Overseas Airways Corporation, *ca* mid-1941. *Engines:* Four 1,600 h.p. Wright 709-C14-AC1 (GR-2600) Double Cyclone fourteen-cylinder radials. *Span:* 152 ft. 0 in. (46·33 m.). *Length:* 106 ft. 0 in. (32·31 m.). *Wing area:* 2,867 sq. ft. (266·35 sq. m.). *Take-off weight:* 84,000 lb. (38,102 kg.). *Cruising speed:* 188 m.p.h. (303 km/hr.) at 11,000 ft. (3,353 m.). *Operational ceiling:* 16,000 ft. (4,875 m.). *Normal range:* 3,685 miles (5,930 km.).



51

Martin XPB2M-1 Mars prototype, *ca* late 1943. *Engines:* Four 2,200 h.p. Wright R-3350-18 Duplex Cyclone eighteen-cylinder radials. *Span:* 200 ft. 0 in. (60·96 m.). *Length:* 117 ft. 3 in. (35·74 m.). *Wing area:* 3,683 sq. ft. (342·16 sq. m.). *Normal take-off weight:* 140,000 lb. (63,500 kg.). *Maximum cruising speed:* 207 m.p.h. (333 km/hr.) at sea level. *Operational ceiling:* 17,400 ft. (5,304 m.). *Maximum range:* 4,375 miles (7,041 km.).

FOKKER T.VIII-W (Netherlands)



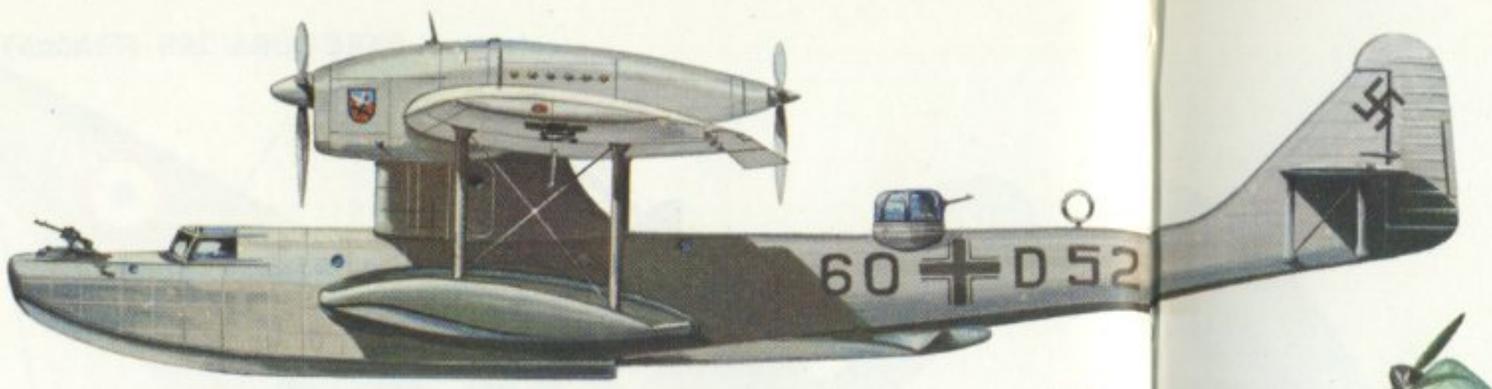
52

Fokker T.VIII-W/G in RAF markings, 1940; later operated by No. 320 (Dutch) Squadron, Pembroke Dock. *Engines:* Two 450 h.p. Wright R-975-E3 Whirlwind nine-cylinder radials. *Span:* 59 ft. 0¾ in. (18 m.). *Length:* 42 ft. 7¾ in. (13 m.). *Wing area:* 473·61 sq. ft. (44 sq. m.). *Take-off weight:* 11,023 lb. (5,000 kg.). *Maximum speed:* 177 m.p.h. (285 km/hr.) at 9,845 ft. (3,000 m.). *Operational ceiling:* 22,310 ft. (6,800 m.). *Normal range:* 1,305 miles (2,100 km.).

LATECOÈRE 298 (France)

53

Latécoère 298A of *Escadrille* T3, *Aéronavale,* Boulogne, late autumn 1939. *Engine:* One 880 h.p. Hispano-Suiza 12 Ycrs 1 twelve-cylinder Vee-type. *Span:* 50 ft. 10¼ in. (15·50 m.). *Length:* 41 ft. 2½ in. (12·56 m.). *Wing area:* 340·14 sq. ft. (31·60 sq. m.). *Take-off weight with torpedo:* 10,141 lb. (4,600 kg.). *Maximum speed:* 180 m.p.h. (290 km/hr.) at 6,560 ft. (2,000 m.). *Operational ceiling:* 21,325 ft. (6,500 m.). *Range with torpedo:* 495 miles (800 km.).



54

Dornier Do 18D of the 2nd Staffel, K.Fl.Gr.506, *Luftwaffe* 1938. *Engines:* Two 600 h.p. Junkers Jumo 205C six-cylinder double-opposed diesels. *Span:* 77 ft. 9 in. (23·70 m.). *Length:* 63 ft. 1¾ in. (19·25 m.). *Wing area:* 1,054·9 sq. ft. (98 sq. m.). *Maximum take-off weight:* 23,810 lb. (10,800 kg.). *Maximum speed:* 165 m.p.h. (265 km/hr.) at 6,560 ft. (2,000 m.). *Operational ceiling:* 13,780 ft. (4,200 m.). *Range:* 2,175 miles (3,500 km.). *(Weight and performance data are for Do 18G with 880 h.p. Jumo 205D engines.)*

55

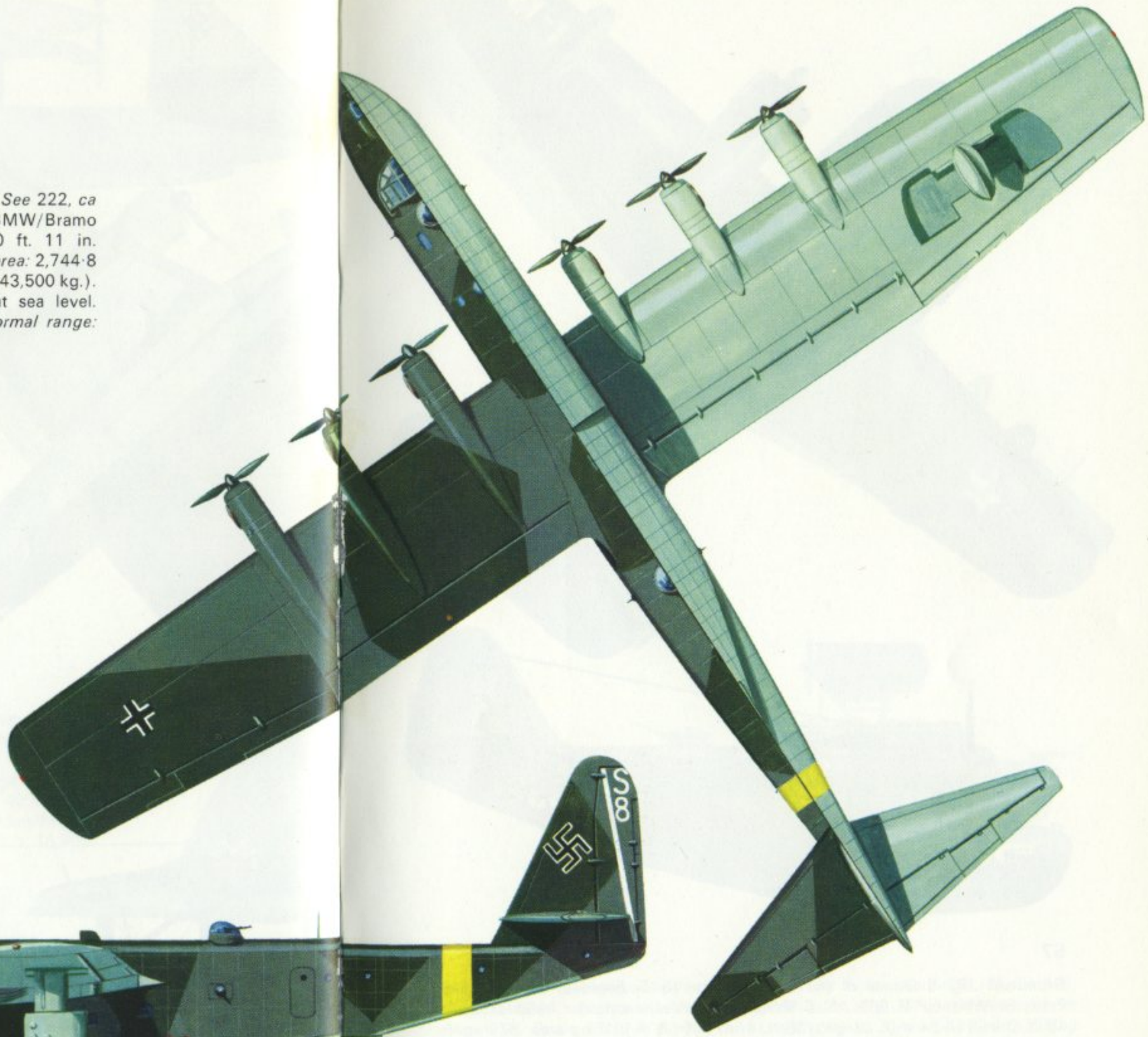
Dornier Do 24N-1 of the *Luftwaffe* Sea Rescue Service, Cherbourg, *ca* 1940–41. *Engines:* Three 1,000 h.p. BMW/Bramo Fafnir 323R-2 nine-cylinder radials. *Span:* 88 ft. 7 in. (27 m.). *Length:* 72 ft. 2¼ in. (22 m.). *Wing area:* 1,162·5 sq. ft. (108 sq. m.). *Normal take-off weight:* 40,565 lb. (18,400 kg.). *Maximum speed:* 211 m.p.h. (340 km/hr.) at 6,560 ft. (2,000 m.). *Operational ceiling:* 19,360 ft. (5,900 m.). *Normal range:* 1,800 miles (2,900 km.).

56

Blohm und Voss Bv 222 V8 (Bv 222A) of LTS *See* 222, *ca* early 1942. *Engines:* Six 1,000/1,200 h.p. BMW/Bramo Fafnir 323R nine-cylinder radials. *Span:* 150 ft. 11 in. (46 m.). *Length:* 119 ft. 9 in. (36·50 m.). *Wing area:* 2,744·8 sq. ft. (255 sq. m.). *Take-off weight:* 95,901 lb. (43,500 kg.). *Maximum speed:* 214 m.p.h. (345 km/hr.) at sea level. *Operational ceiling:* 21,980 ft. (6,700 m.). *Normal range:* 2,115 miles (3,400 km.).

80

WIKING (Germany)



81

GOOSE (U.S.A.)

57

Grumman JRF-5 Goose of the US Navy, *ca* 1945. *Engines:* Two 450 h.p. Pratt & Whitney R-985-AN-6 Wasp Junior nine-cylinder radials. *Span:* 49 ft. 0 in. (14·94 m.). *Length:* 38 ft. 4 in. (11·68 m.). *Wing area:* 375 sq. ft. (34·84 sq. m.). *Take-off weight:* 8,000 lb. (3,629 kg.). *Maximum speed:* 201 m.p.h. (323 km/hr.) at 5,000 ft. (1,524 m.). *Operational ceiling:* 21,300 ft. (6,492 m.). *Maximum range:* 640 miles (1,030 km.).

BERIEV MBR-2 (U.S.S.R.)

58

Beriev MBR-2, captured aircraft in Finnish Air Force markings (TLeLv 12), August 1941. *Engine:* One 750 h.p. Mikulin AM-34NB twelve-cylinder Vee-type. *Span:* 62 ft. 4 in. (19 m.). *Length:* 44 ft. 3½ in. (13·50 m.). *Wing area:* 592 sq. ft. (55 sq. m.). *Maximum take-off weight:* 9,359 lb. (4,245 kg.). *Maximum speed:* 171 m.p.h. (275 km/hr.) at 6,560 ft. (2,000 m.). *Operational ceiling:* 25,920 ft. (7,900 m.). *Typical range:* 405 miles (650 km.).

BLACKBURN B.20 (U.K.)

59

Blackburn B.20, early 1940. *Engines:* Two 1,720 h.p. Rolls-Royce Vulture twenty-four-cylinder X-type engines. *Span* (over floats): 82 ft. 2 in. (25·04 m.). *Length:* 69 ft. 7½ in. (21·22 m.). *Wing area* (including floats): 1,066 sq. ft. (99·03 sq. m.). *Normal take-off weight:* 35,000 lb. (15,876 kg.). *Estimated maximum speed* (with armament): 306 m.p.h. (492 km/hr.) at 15,000 ft. (4,575 m.). *Estimated maximum speed* (without armament): 322 m.p.h. (518 km/hr.) at 15,000 ft. (4,575 m.). *Estimated range* (with armament): 1,500 miles (2,414 km.).

KAWANISHI H8K (Japan)

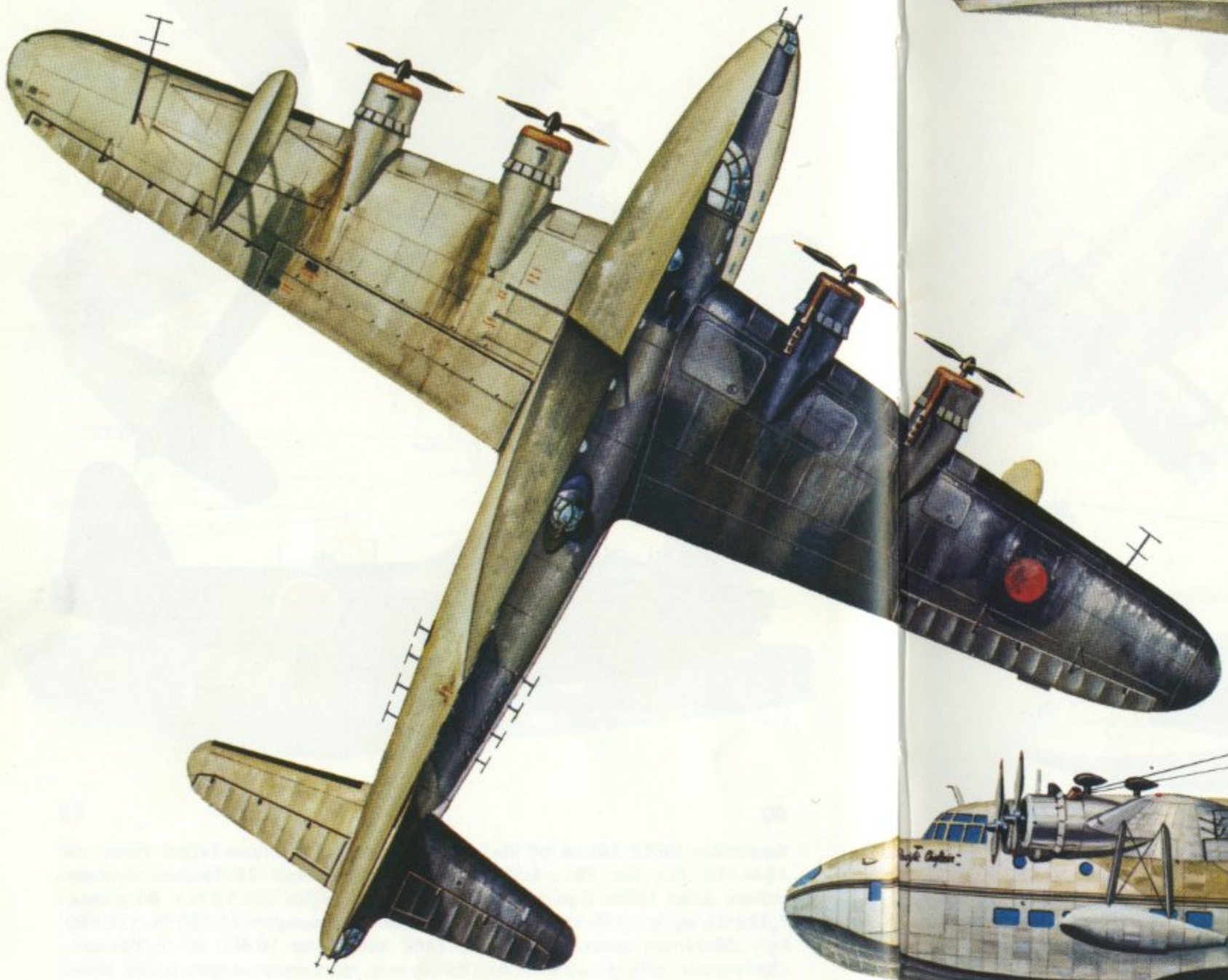
60

Kawanishi H8K2 Model of the JNAF Combined Maritime Escort Force, *ca* 1944–45. *Engines:* Four 1,850 h.p. Mitsubishi Kasei 22 fourteen-cylinder radials. *Span:* 124 ft. 8 in. (38 m.). *Length:* 92 ft. 3½ in. (28·13 m.). *Wing area:* 1,722·23 sq. ft. (160 sq. m.). *Maximum take-off weight:* 71,650 lb. (32,500 kg.). *Maximum speed:* 290 m.p.h. (467 km/hr.) at 16,400 ft. (5,000 m.). *Operational ceiling:* 28,770 ft. (8,770 m.). *Maximum range:* 4,475 miles (7,200 km.).

SUNDERLAND and SANDRINGHAM (U.K.)

61

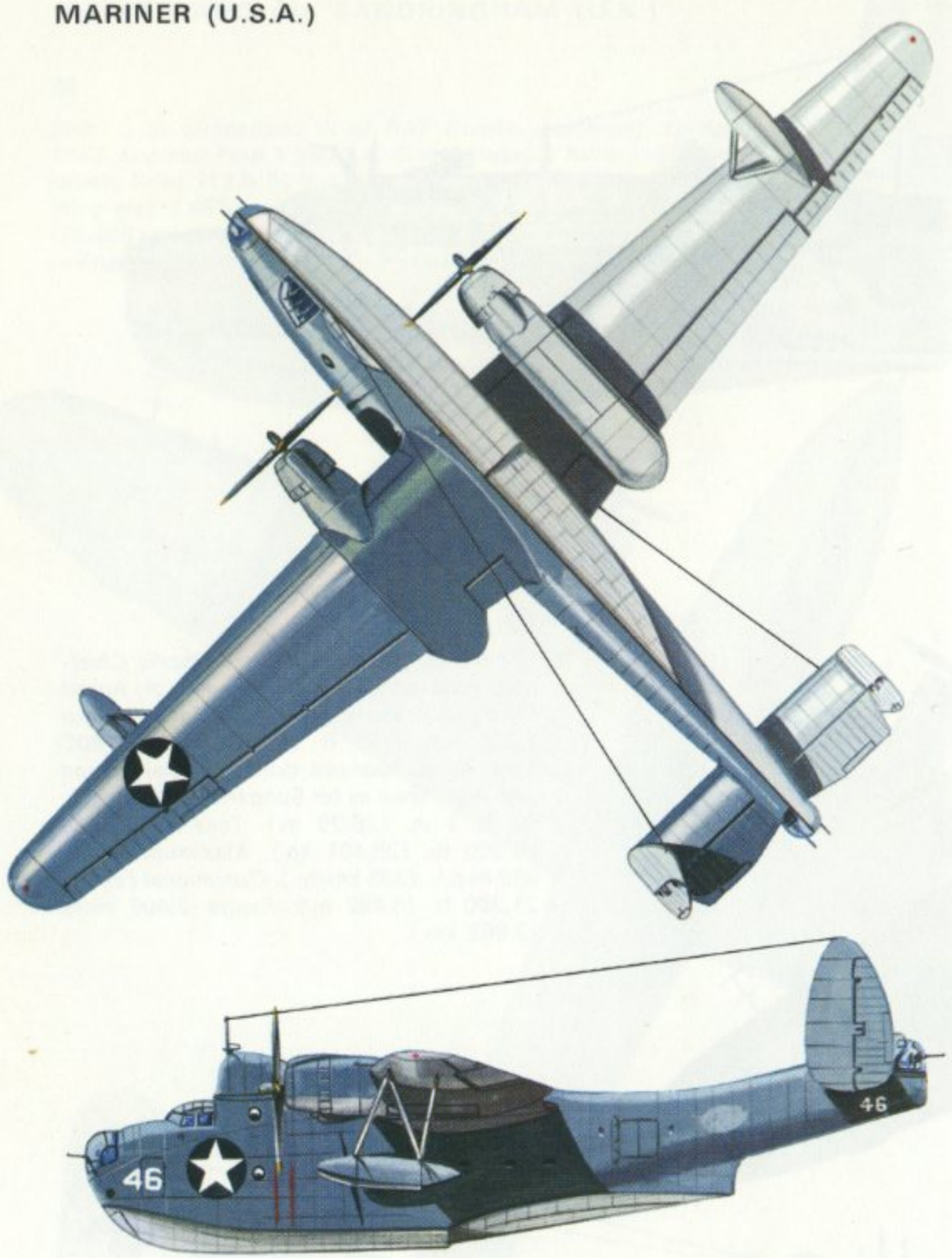
Short S.25 Sunderland III of RAF Coastal Command, *ca* spring 1942. *Engines:* Four 1,050 h.p. Bristol Pegasus XVIII nine-cylinder radials. *Span:* 112 ft. 9½ in. (34·38 m.). *Length:* 85 ft. 4 in. (26·01 m.). *Wing area:* 1,487 sq. ft. (138·14 sq. m.). *Take-off weight:* 58,000 lb. (26,308 kg.). *Maximum speed:* 205 m.p.h. (330 km/hr.). *Operational ceiling:* 20,500 ft. (6,248 m.). *Endurance:* 13 hr. 30 min.



62

Short S.25/V Sandringham 4 *Pacific Chieftain* (converted Sunderland III) of Ansett Flying Boat Services, *ca* 1956. *Engines:* Four 1,200 h.p. Pratt & Whitney R-1830-90C Twin Wasp fourteen-cylinder radials. *Span and Wing area:* as for Sunderland III. *Length:* 86 ft. 3 in. (26·29 m.). *Take-off weight:* 56,000 lb. (25,401 kg.). *Maximum speed:* 238 m.p.h. (383 km/hr.). *Operational ceiling:* 21,300 ft. (6,492 m.). *Range:* 2,400 miles (3,862 km.).

MARINER (U.S.A.)



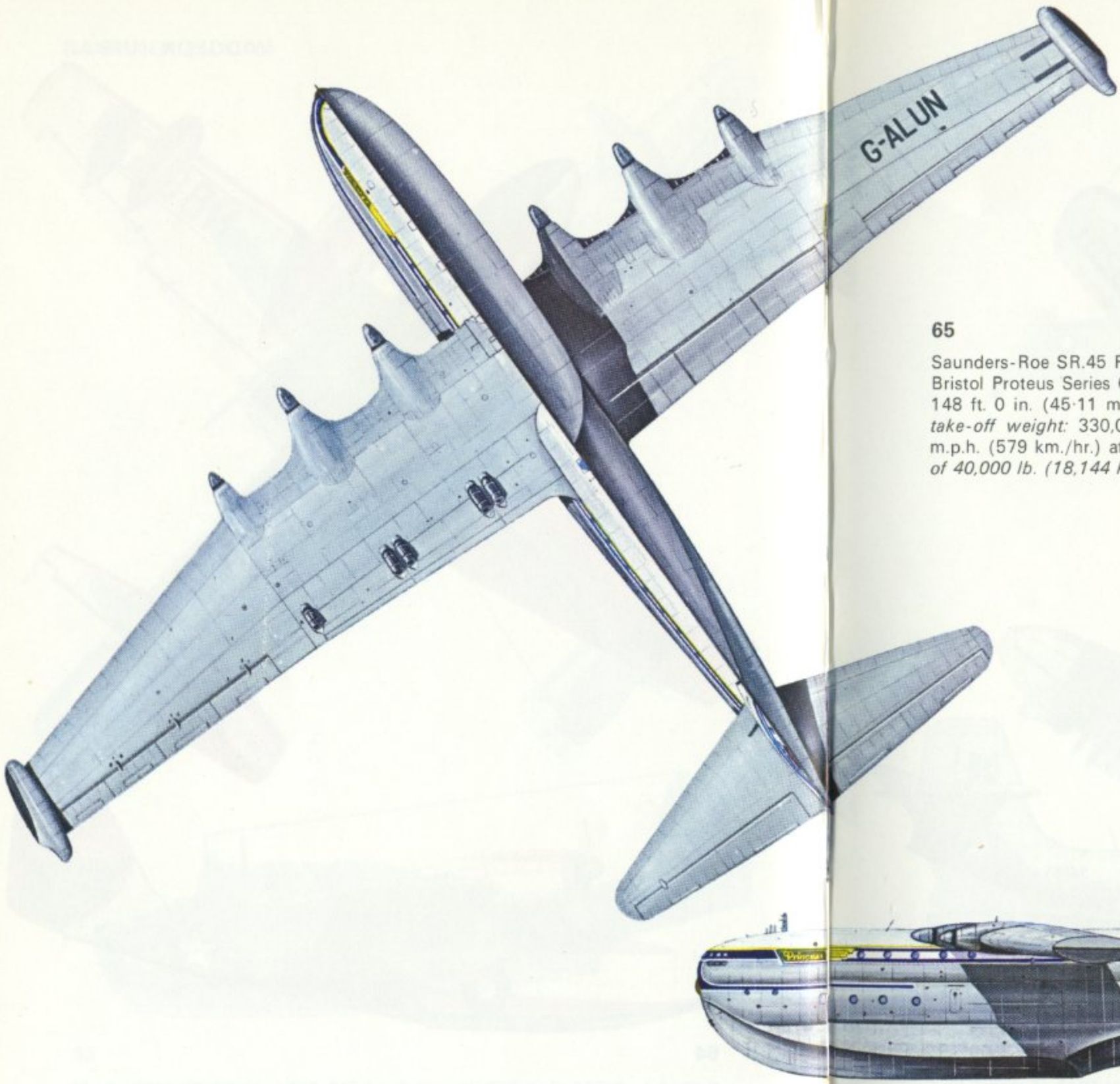
63

Martin PBM-3D Mariner of the US Navy, March 1944. *Engines:* Two 1,900 h.p. Wright R-2600-22 Cyclone fourteen-cylinder radials. *Span:* 118 ft. 0 in. (35·97 m.). *Length:* 79 ft. 10 in. (24·33 m.). *Wing area:* 1,408 sq. ft. (130·80 sq. m.). *Normal take-off weight:* 51,330 lb. (23,283 kg.). *Maximum speed:* 211 m.p.h. (340 km/hr.) at 16,100 ft. (4,907 m.). *Operational ceiling:* 19,800 ft. (6,035 m.). *Range:* 2,420 miles (3,895 km.).

WIDGEON (U.S.A.)

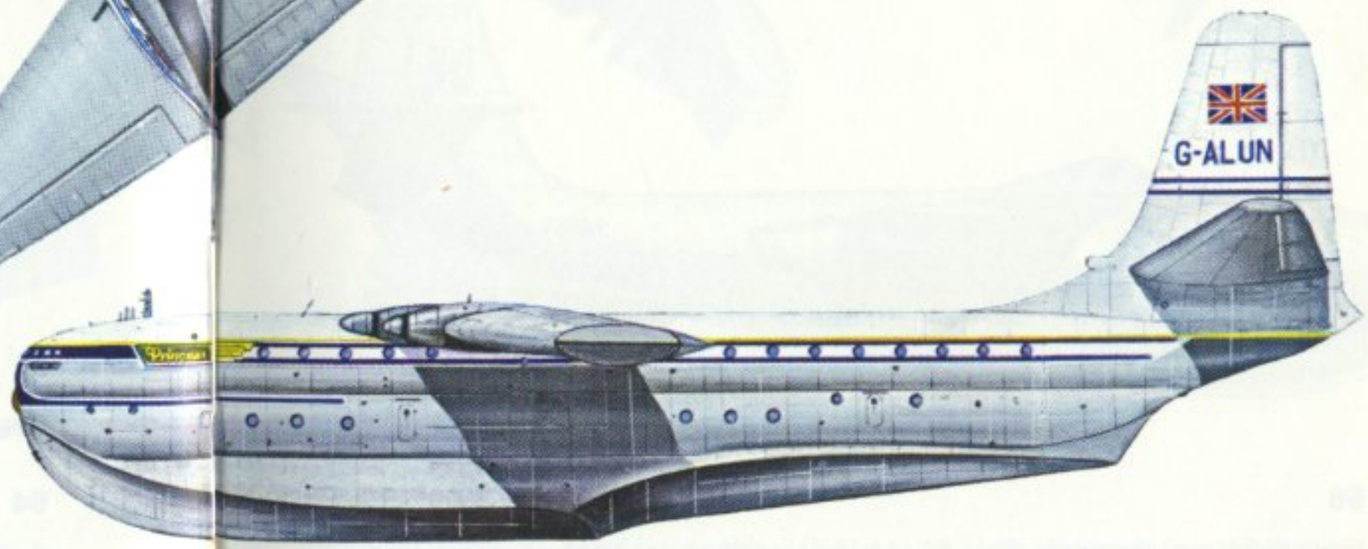
64

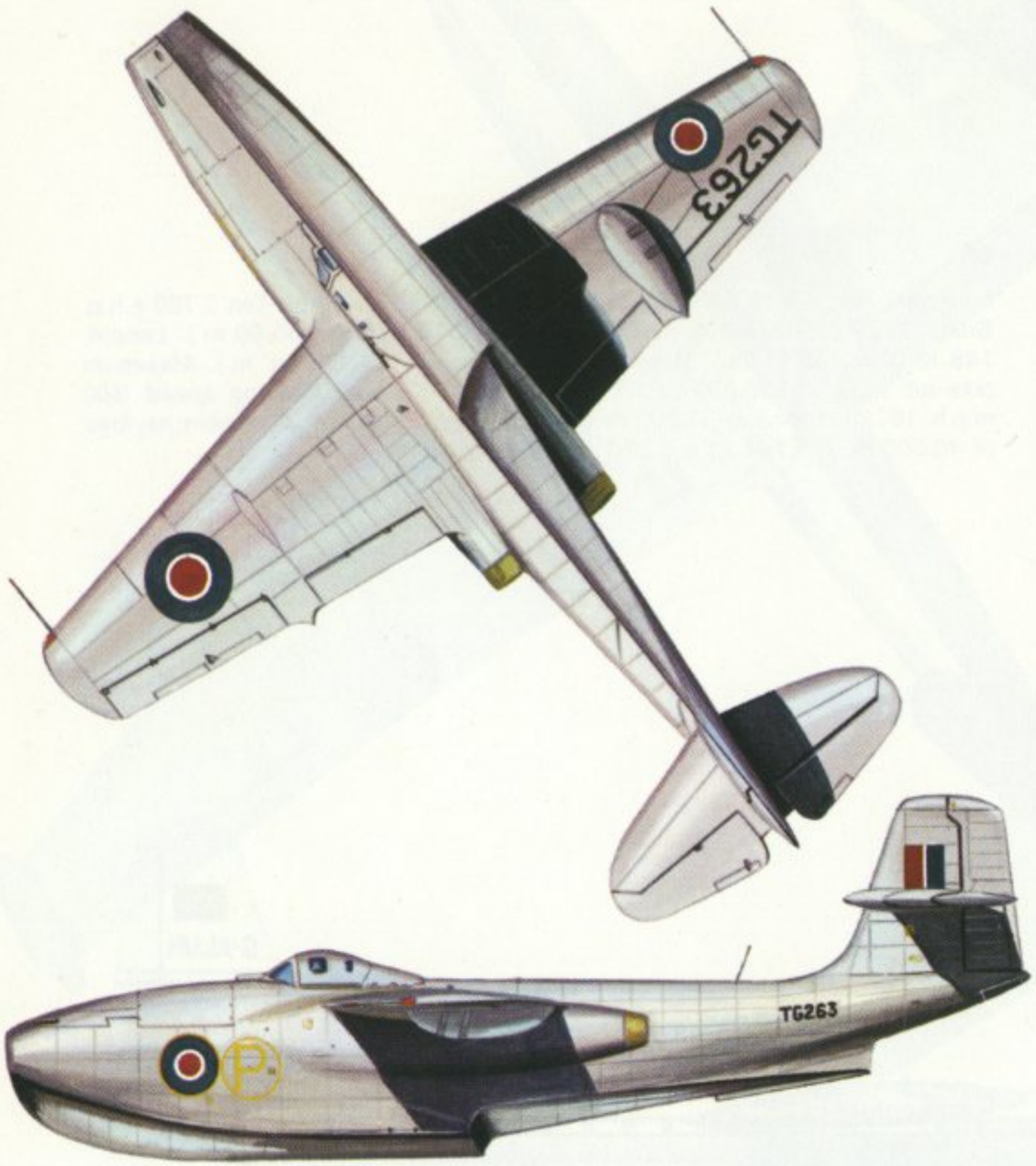
Grumman G-44A Super Widgeon of the US Fish and Wildlife Service, *ca* 1966. *Engines:* Two 270 h.p. Lycoming GO-480-B1D 'flat six'. *Span:* 40 ft. 0 in. (12·19 m.). *Length:* 31 ft. 1 in. (9·47 m.). *Wing area:* 245 sq. ft. (22·76 sq. m.). *Take-off weight:* 5,500 lb. (2,495 kg.). *Maximum speed:* 185 m.p.h. (298 km/hr.). *Operational ceiling:* 18,000 ft. (5,486 m.). *Range:* 1,000 miles (1,610 km.).



65

Saunders-Roe SR.45 Princess, first prototype, 1952. *Engines:* Ten 3,780 e.h.p. Bristol Proteus Series 600 turboprops. *Span:* 219 ft. 6 in. (66·90 m.). *Length:* 148 ft. 0 in. (45·11 m.). *Wing area:* 5,250 sq. ft. (487·75 sq. m.). *Maximum take-off weight:* 330,000 lb. (149,690 kg.). *Maximum cruising speed:* 360 m.p.h. (579 km./hr.) at 37,000 ft. (11,280 m.). *Range with maximum payload of 40,000 lb. (18,144 kg.):* 5,270 miles (8,481 km.).





66

First prototype Saunders-Roe SR/A1, as modified in 1948. *Engine:* One 3,250 lb. (1,474 kg.). st Metropolitan-Vickers F.2/4 Beryl MVB 1 turbojet. *Span:* 46 ft. 0 in. (14·02 m.). *Length:* 50 ft. 0 in. (15·24 m.). *Wing area:* 415 sq. ft. (38·55 sq. m.). *Normal take-off weight:* 16,255 lb. (7,373 kg.). *Maximum speed:* 512 m.p.h. (824 km/hr.), achieved by third prototype with 3,850 lb. (1,746 kg.) st engine.

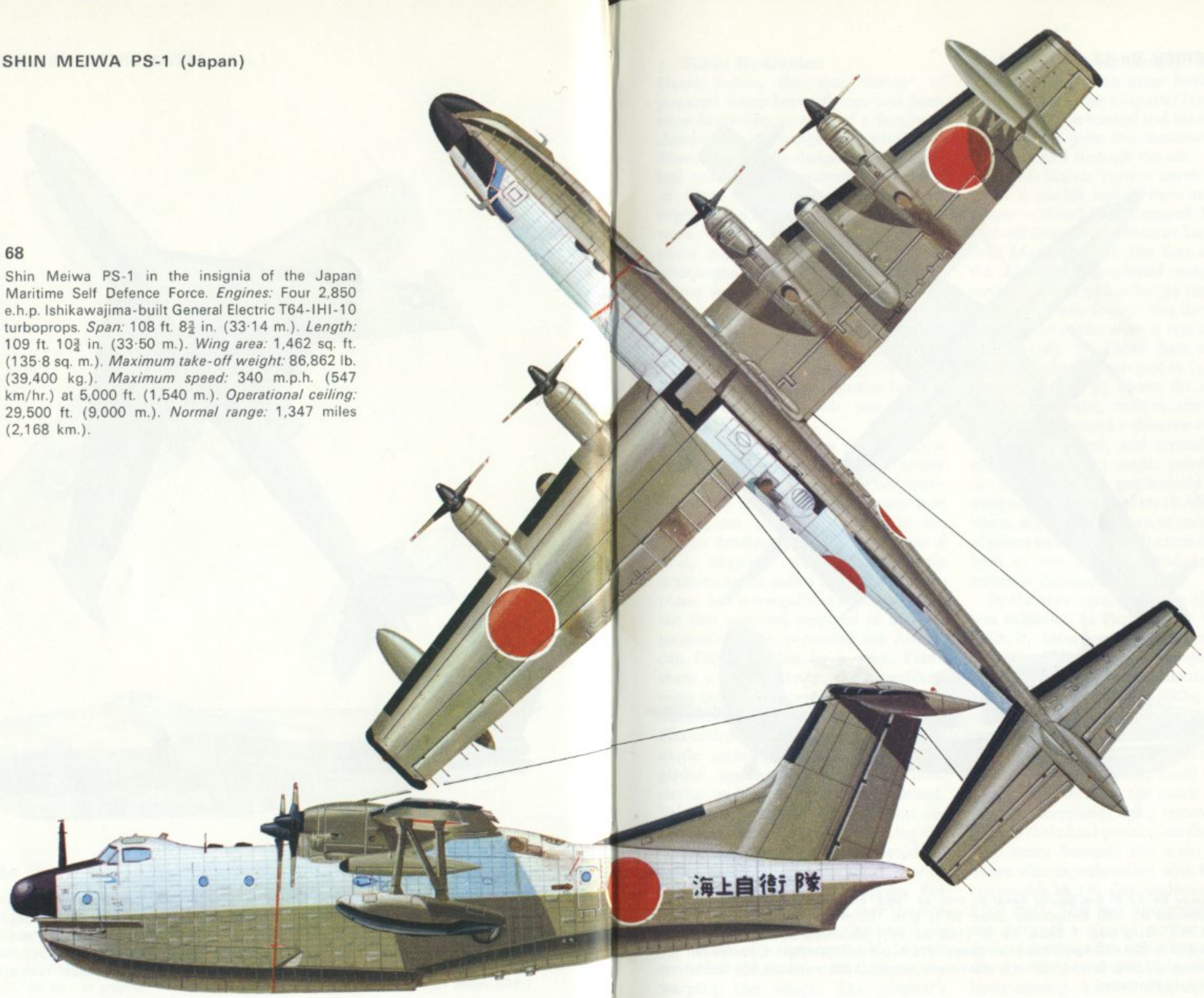
67

Martin P6M-2 SeaMaster of the US Navy, *ca* 1960. *Engines:* Four 17,500 lb. (7,938 kg.) st Pratt & Whitney J75-P-2 turbojets. *Span:* 100 ft. 0 in. (30·48 m.). *Length:* 134 ft. 0 in. (40·84 m.). *Wing area:* 1,900 sq. ft. (176·52 sq. m.). *Take-off weight:* 160,000 lb. (72,570 kg.). *Maximum speed:* over 600 m.p.h. (966 km/hr.). *Operational ceiling:* 40,000 ft. (12,192 m.). *Combat radius:* 1,500 miles (2,414 km.).

SHIN MEIWA PS-1 (Japan)

68

Shin Meiwa PS-1 in the insignia of the Japan Maritime Self Defence Force. *Engines:* Four 2,850 e.h.p. Ishikawajima-built General Electric T64-IHI-10 turboprops. *Span:* 108 ft. 8¾ in. (33·14 m.). *Length:* 109 ft. 10¾ in. (33·50 m.). *Wing area:* 1,462 sq. ft. (135·8 sq. m.). *Maximum take-off weight:* 86,862 lb. (39,400 kg.). *Maximum speed:* 340 m.p.h. (547 km/hr.) at 5,000 ft. (1,540 m.). *Operational ceiling:* 29,500 ft. (9,000 m.). *Normal range:* 1,347 miles (2,168 km.).



BERIEV Be-12 (U.S.S.R.)

69

Beriev Be-12 of the Soviet naval air arm, *ca* 1968. *Engines:* Two 4,000 s.h.p. Ivchenko AI-20D turboprops. *Span:* 98 ft. 5 in. (30 m.). *Length:* 98 ft. 5 in. 30 m.). *Wing area:* 1,130·2 sq. ft. (105 sq. m.). *Maximum take-off weight:* 64,926 lb. (29,450 kg.). *Maximum speed:* 378 m.p.h. (608 km/hr.). *Operational ceiling:* 37,040 ft. (11,290 m.). *Maximum range:* 2,485 miles (4,000 km.). *All data estimated.*

1 Fabre Hydravion

Henri Fabre, the true 'father' of powered water-borne flying, was born near Marseilles in 1882 of a family of shipowners, a background which influenced both the design and the control system of his successful *Hydravions* of 1910–11. After qualifying as an engineer, he began in 1905 to study the work of Blériot, Ferber, Voisin and other pioneer French aviators, and later began to carry out selected experiments in aerodynamics. In 1909 he designed and built his first seaplane, a triple-float machine with three Anzani engines driving a single propeller. This aeroplane did not fly, but later the same year Fabre began to build a second machine which was to be successful.

The new aircraft was powered by a single Gnome seven-cylinder rotary engine, and was one of the first aeroplanes to use this revolutionary new powerplant created in 1909 by the Seguin brothers. The *Hydravion* was a frail, ungainly affair, and scarcely deserves to be called a practical aeroplane, but it is significant historically as the first powered seaplane to make a successful flight, preceding the American Glenn Curtiss by a year. Fabre chose a canard layout, the monoplane wing being at the rear with the engine installed behind it driving a two-blade Chauvière propeller. The wings had a single main spar of a novel lattice-girder construction that was both strong and aerodynamically efficient. Fabre's nautical background was reflected in the technique of covering the wings, the canvas of which could be reefed up to the spar during storage or for protective or repair purposes. For flight, it was stretched out over the ribs and held taut by fastening it to each rib by means of a sprung hook. Lateral control of the machine was effected by warping the wings. The aircraft's 'fuselage' consisted simply of two girders, built to the same lattice-type construction as the wing spar but boxed in. A tiller-type control rod attached to each rudder gave the machine directional control through the air.

On 28 March 1910 – never having flown in his life before, even as a passenger – Henri Fabre essayed his first take-off from the harbour at La Mède, near Marseilles. On the first attempt the aircraft hydroplaned across the water at about 55 km/hr (34 mph) but did not rise into the air. On the second attempt, however, after a run of some 300 m (984 ft), Fabre took off and made a flight of about 500 m (1,640 ft) some 2 m (6·5 ft) above the surface. On his fifth flight, made on the following day, he covered a distance of about 6 km (3·75 miles), and several subsequent flights were made, proving the aircraft to be a particularly stable design. It came to grief on 18 May 1910 when, after having flown to an altitude of about 20 m (65·5 ft), it came down to land at too high a speed and was seriously damaged.

By October 1910, when the *Hydravion* was exhibited in Paris, Fabre had rebuilt it, incorporating a number of alterations. Believing the original design to be too stable, he doubled the area of the forward lower lifting surface and replaced the aerofoil-shaped elevator with a completely flat surface from which the two small front rudders were omitted. At a later date, small vertical areas were added at the outer ends of the fixed foreplane, being removed still later to their final position on the warp-wire struts beneath the main wings. Fabre also experimented with a small retractable keel surface underneath the front float. This was unsuccessful, but the siting of a similar surface behind each of the main floats did improve the directional control of the aircraft while hydroplaning. A series of six *Hydravions*

is said to have been started after the May 1910 crash, but it is uncertain whether all were completed.

At Monaco in March 1911 the *Hydravion*, in its latest form, made two flights in the hands of Jean Bécue; but on returning from the second of these Bécue landed the aircraft too near to the shore, where it broke up in the surf. After this accident, Fabre could no longer find the money to continue his flying experiments, but he concentrated on the design and manufacture of floats for other aircraft with considerable success during the period up to the outbreak of World War 1. In 1911 he designed floats for a Voisin canard biplane, which thus became the world's first amphibious aeroplane, and in the various events at the Monaco meeting in 1913 every winning machine was fitted with floats of Fabre design. The remains of the *Hydravion* were eventually acquired and restored by the *Musée de l'Air* at Chalais-Meudon, near Paris, where it is now on permanent display.

2 Sopwith Bat Boat

Thomas (now Sir Thomas) Sopwith, founder of the present-day Hawker Siddeley Group, made his first flight as a passenger in a Farman biplane at Brooklands in 1910. He subsequently bought an Avis monoplane, which he crashed, and a Howard Wright biplane, on which he taught himself to fly. By mid-1912 he was running a flying school at Brooklands, and after the disappointment of the Coventry Ordnance Works biplane which he flew in the Military Trials in August of that year he began to think in terms of building aircraft of his own.

The first truly original design to emanate from the Sopwith company was one of some significance in the annals of British aviation, for it was the first hull-type British flying-boat and, as modified later, one of the first amphibious flying-boats to be produced in Europe. Following the example of Curtiss in America, Sopwith had a beautifully streamlined 21 ft (6·40 m) hull designed and built by S. E. Saunders. Equal-span biplane wings were mounted on top of the hull, with a 90 hp Austro-Daimler engine driving a pusher propeller, and the twin-rudder tail unit was supported by outrigged booms. Before its appearance at the Olympia Aero Show in February 1913, the Bat Boat, as the aircraft had been named, had been modified by lengthening the tail-booms and fitting a twin-wheel land undercarriage that could be raised above water level. It was test-flown at Cowes shortly after Olympia, and Sopwith then set his sights on the £500 Mortimer Singer prize for amphibians. To qualify for this an English powerplant was necessary, and so the Austro-Daimler was replaced by a 100 hp Green engine; the forward elevator was also removed. In this form the Bat Boat competed successfully for the Singer Prize on 9 July 1913.

After the competition the original engine was restored, the undercarriage removed and the aircraft sold to the Admiralty. It crashed in August 1913, but an immediate replacement was ordered. An enlarged version, the Bat Boat 2, appeared at Olympia in March 1914. This was a 'pure' flying-boat, with a mahogany-skinned hull, 200 hp Salmson radial engine and gross weight of 3,180 lb (1,442 kg). The lower wings had pronounced dihedral, and the span of the upper wings was increased to 55 ft 0 in (16·76 m). Howard Pixton was to have flown the Bat Boat 2 in the 1914 Circuit of Britain race, but the event was forestalled by the outbreak of World War 1.

However, before the intervention of war another Sopwith aircraft did succeed in making its mark in a competition for water-borne aircraft. This was a special twin-float version of the Tabloid landplane, fitted with a 100 hp Gnome Monosoupape rotary engine. In April 1914, flown by Pixton, it swept the board in the competition for the Schneider Trophy with a course average of nearly 87 mph (140 km/hr), flying on to complete two extra laps and set a new world's speed record for seaplanes of 92 mph (148 km/hr).

3 Denhaut/Donnet-Lévêque

On 15 March 1912 the French engineer and pilot F. Denhaut took off from the River Seine at Juvisy in a flying-boat of his own design – the first of its kind in Europe. The flight nearly ended in tragedy, but Denhaut survived to rebuild the machine, incorporating many points gleaned from a study of the American Curtiss flying-boats, and on 13 April 1912 he made more than half a dozen water take-offs and landings without further incident. A 2-seater with a 50 hp Gnome rotary engine, the Denhaut flying-boat attracted the attention of MM Donnet and Lévêque, who shortly afterwards established a company to build and market it. Premises were acquired at Quay de Seine, Argenteuil, and among the other executives were Denhaut and the celebrated French competition flier Lieutenant de Vaisseau Conneau, better known publicly by his pseudonym of André Beaumont.

The first two Donnet-Lévêque flying-boats were completed under Denhaut's direction at Juvisy and flown to Argenteuil on 26 July 1912 by Beaumont. On 9 August 1912, Beaumont set out on an attempted flight from Paris to London, calling at various other towns en route; but a take-off accident at Boulogne prematurely ended his attempt. However, he made up for this disappointment by winning the King of Belgium's prize for seaplanes on 6–7 September, when the aircraft proved entirely reliable. The highly-polished Donnet-Lévêque Type A exhibited at the Paris *Salon* in October 1912 revealed one major design improvement: it was now amphibious, having a twin-wheel land undercarriage which could be wound up above water level when not required.

First positive interest in the Donnet-Lévêque came from Britain, when Vickers sent pilot Archibald Low to Argenteuil to try out the aircraft. He was not over-enthusiastic, claiming that the narrow hull and the high position of the underwing floats caused the aircraft to lack control on the water. Nevertheless, one example was ordered by the Admiralty for the Royal Naval Air Station at Eastchurch. Powered by an 80 hp Gnome engine (which alternated with the 50 hp Gnome as the standard installation), it was delivered to Sheerness on 20 December 1912 and was given the number 18 in the first batch of military serial numbers to be allocated to British Naval aircraft. During 1912–13, Donnet-Lévêque flying boats were also supplied to the navies of Austro-Hungary (three), Denmark (two) and Sweden (one). At the beginning of 1913 Donnet left the company, which took the new name Hydro-aéroplanes Lévêque for a short while until, in association with Louis Schreck, it became FBA (Franco-British Aviation, which see) with a new base at Vernon (Eure). Donnet and Denhaut came together again in a new partnership at Île de la Jatte, and both companies subsequently produced flying-boats which were used extensively during World War 1.

The Denhaut/Donnet-Lévêque design, although 'borrowing' from Curtiss early in its career, established the classic flying-boat configuration of the fuselage-hull (as opposed simply to a

nacelle) with an upswept rear end supporting the tail, and the later Curtiss flying-boats in their turn benefited from the design trends indicated by the French machines.

4 Benoist flying-boats

Among the earliest American aeroplane manufacturing companies, the Benoist Aircraft Company also ran a flying school at its headquarters at St Louis, Missouri. One of its first pilots and instructors was Antony Jannus, joined there by his elder brother Rodger in 1913. In March of the previous year Tony Jannus was the pilot of a Benoist aircraft from which one Albert Berry, baling out at about 1,500 ft (500 m), attempted the first parachute descent from an aeroplane in the United States. (Berry failed on this occasion, but made a successful attempt nine days later.)

Tony Jannus, however, was to achieve a more permanent place in aviation history, for on 1 January 1914 he was pilot of the Benoist Type XIV flying-boat which inaugurated the first daily scheduled commercial service by aeroplane anywhere in the world. Known as the St Petersburg and Tampa Airboat Line, it was the inspiration of a St Petersburg businessman, P. E. Fansler, and linked the two Florida townships which lay 22 miles (35 km) apart across Tampa Bay. At 10 am on New Year's Day 1914, Jannus took off with Mayor Pheil of St Petersburg as his first passenger – and his only one, for the Type XIV was only a 2-seater. They landed at Tampa 23 minutes later. The service ran for nearly four months, making two (occasionally more) round trips per day, at a fare of $5 per passenger – provided that the passenger weighed no more than 200 lb (91 kg): fat people were charged more! During its brief life the Airboat Line covered some 11,000 miles (17,700 km); only 18 flights were cancelled due to bad weather and four from other causes, and a total of 1,205 passengers was carried. The operating economics were, however, not good enough to justify the line's continued existence.

The Benoist XIV was a three-bay, equal-span biplane with a single-step hull having two side-by-side seats ahead of the lower wing; the pilot occupied the left-hand seat. Aft of the cockpit, the engine was mounted low down inside the hull (giving a low centre of gravity for good stability on the water), flanked by the fuel tanks and with a chain drive to the pusher propeller. A small portion of the rudder projected downwards to serve as a water rudder during take-off, landing and taxying.

A larger flying-boat, the Model C, appeared during 1915. This was powered by two 100 hp Roberts in-line engines and could carry up to five passengers. The Jannus brothers also built a flying-boat of their own design, based largely on the Benoist XIV, and this was test-flown in late 1914/early 1915. By then both had left the Benoist company; Tony was killed in Europe in 1916, and Rodger in 1918, both in flying accidents, and by the end of World War 1 the Benoist company had ceased to exist.

5 Burgess seaplanes

The Burgess Company of Marblehead, Massachusetts, headed by W. Starling Burgess, was already well known for its boat-building activities when it entered the aviation arena in 1910 by building landplanes based on the Wright formula. It was, however, notable chiefly for the range of floatplanes and flying-boats which it produced between 1912 and 1917. The first of these, known variously as the I-Scout, Model I or Coast Defense Hydro, was built to an Army Signal Corps specification and

flew for the first time on 1 January 1913. It was a 2-seat biplane, mounted on twin floats and powered by a 60 hp Sturtevant engine with chain drive, Wright-fashion, to a pair of pusher propellers. After delivery the Model I served with the US Army in the Philippines, where it eventually crashed in January 1915.

Three flying-boat designs which appeared in 1913 were the Models H, I and K. The Model K, which first flew on 16 April, was accepted in the following month by the US Navy, which gave it the designation D-1 (later changed to AB-6). A 2-seater, powered by a 70 hp Renault engine, it crashed in February 1914. Also in May 1913 the USN took delivery of the Model H, as the D-2 (later AB-7). The Model I (some early Burgess types used the same Model letter for quite different floatplane and flying-boat designs) was a civil machine, built to the order of Robert J. Collier, donor of the Collier Trophy. Seating two persons in tandem, with the pilot in the rear cockpit, the flying-boat was powered by a 220 hp Anzani engine and was completed in July 1913.

During 1913, following a dispute with the Wright brothers, Burgess severed his business connections with them and sought the basis of new designs with which to continue the company's activities. This he found in the swept-wing, tail-less biplanes designed in England by Captain John W. Dunne (see *Pioneer Aircraft* 1903–14). At about this time it was becoming clear to Dunne that he could expect little or no further backing for his work from the British government, and he agreed to allow Burgess to undertake further development of his designs in the United States. The first Burgess-Dunne 'hydro-aeroplane' – basically a Dunne biplane fitted with a large central float – underwent water trials in January 1914, during the course of which it was damaged. After being modified as an open 2-seater (originally a nacelle with a single seat had been fitted), it made a successful first flight in March 1914. The American services both expressed a close interest, and in the autumn two were ordered by the Navy and one by the Signal Corps. Two other machines were already under construction by that time, and the first delivery of a Burgess-Dunne floatplane was made in the early autumn to the Canadian government. The US Navy's first example (designated AH-7) was delivered in October, and that for the Signal Corps in December. The Navy had meanwhile ordered three more machines, with 140 hp Sturtevant engines, shorter-span wings and a torpedo-shaped crew nacelle. Only one of these (A-54) was completed; it proved unstable in a dive, was returned to Burgess for redesign and the other two were apparently not delivered. The second of the Navy's original pair (AH-10), with a 100 hp Curtiss engine and side-by-side seating, was accepted in April 1915. This, and all subsequent Burgess-Dunne machines, had wings of uniform camber, instead of the variable-camber surfaces designed by Dunne. The total number of Burgess-Dunne machines built cannot be established for certain, but at least three others are known to have been completed during 1915 and three more in 1916. One, with unequal-span wings, was built in 1915 for sale to Russia, though its delivery has not been confirmed. Two others were built for private owners Vincent Astor and H. P. Whitney, the former's machine having dual-sweep wings. The 2-seat Burgess-Dunne Model BD, basically similar to the Whitney machine and powered by a 100 hp Curtiss OXX-2 engine, was advertised in mid-1916 as a 'Sportsman's Seaplane', and that autumn Burgess announced a military counterpart, for reconnaissance

purposes, the 140 hp Model BDH. Perhaps the most interesting specimen of all, however, was the 3-seat Model BDF, which combined the sweptback Dunne wing configuration with the hull of a Curtiss flying-boat. Powered by a single OXX-2 engine, it appeared in the summer of 1916, but only one example is known.

On 10 February 1916 the Burgess Company became a division of the Curtiss Aeroplane and Motor Co. It continued to manufacture aircraft of its own design (as well as components for Curtiss types), but these were conventional straight-winged, float-fitted tractor biplanes and had no connection with the Dunne types. Six examples were built for the USN of the 2-seat Model 2 twin-float trainer, these being fitted with 120 hp Hall-Scott engines after being found to be under-powered with the original 85 hp Curtiss powerplant. In 1917, Burgess delivered to the US Navy six U-2 trainers, based on the single Model U of 1916 but with 100 hp Hall-Scotts replacing the original OXX-2 installation. Eight 'Speed Scouts' (two HT-B's and six HT-2's) were also built for the Navy during 1917: these were single-seat floatplanes with two 100 hp OXX-2 engines, the HT-2 being a somewhat more refined version of the HT-B. Delivery of the HT-2's – probably the last Burgess types to be built – was completed in September 1917. In the previous month the Army had accepted the sole example of the Burgess 'Twin Hydro', a large (72 ft = 21·95 m span) floatplane with two 150 hp Sturtevant 5A engines. It had originally ordered thirty-two of these aircraft, but cancelled the order after America's entry into World War 1. The activities of the Burgess Company were brought to an end by a serious fire which destroyed one of its main factories only a few days before the Armistice.

6 **Pemberton-Billing (Supermarine) P.B.1**

Noel Pemberton-Billing had already sown the seeds of an eventful career before he took up aeronautics as a serious interest. By 1904 he had been a seaman, mounted policeman, boxer, garage-owner and editor of a motoring journal – all by the age of 23. In 1904 he designed a kite-shaped glider which nearly caused his death when he jumped with it from the roof of his home in Sussex, and in 1908–09 built powered aeroplanes in which, eventually, he was able to make short hop-flights. He opened a flying ground at Fambridge, in Essex, where he endeavoured – again unsuccessfully – to create an 'Imperial Flying Squadron' and publish an aviation magazine. He gained his Aviator's Certificate on a Farman machine in September 1913, bought himself another biplane later in the same month and acquired premises on a wharf at Woolston, near Southampton. Here 'P-B' adopted as his telegraphic address the word 'Supermarine', a name destined to become world-famous for its association with marine aircraft in subsequent years.

The first design produced at Woolston, the P.B.1, was exhibited in March 1914 at the Olympia Aero Show in London, where it excited a considerable amount of comment. A single-seat biplane flying-boat, the remarkably clean lines of its fuselage-hull and the nacelle of its 50 hp Gnome rotary engine (probably the engine from his Farman biplane) were in marked contrast to most of the other aircraft on display. However, initial flight tests were not outstandingly successful, and a number of modifications were introduced before these were resumed in June 1914. The cockpit was located forward, instead of aft, of the wings and the engine had been transferred from its original between-the-wings position to one in

the hull, aft of the cockpit, from where it was connected to a pair of pusher propellers by means of a chain drive. Unfortunately the new configuration was no more satisfactory than the original one, and the P.B.1 was eventually wrecked during a test-flight.

Undaunted, Pemberton-Billing continued with the development of other marine aircraft designs, including the P.B.2, P.B.3 and P.B.5 flying-boats. The two last-mentioned types were designed so that their wings and tails could be removed to allow the hulls, by themselves, to be used as cabin cruisers. The designs were probably more ingenious than practical, though the hulls of two P.B.7 flying-boats were used in this way.

With the outbreak of World War 1 Pemberton-Billing turned to the design of landplanes for the RNAS, in which he took a commission, although the only type to go into wartime production was the P.B.25 Scout. Twenty of these were ordered, though it is probable that not all of these were built, nor do they appear to have entered operational service. The next seaplane design was the P.B.27, or Supermarine S.S.1, but this remained a paper aeroplane only.

Ever a vigorous militant – his was the brain behind the famous Avro 504 raid on the Zeppelin works at Friedrichshafen in November 1914 – Pemberton-Billing resigned his RNAS commission and entered Parliament in 1917. During that year he wrote a book, *Air War, How To Wage It*, and was a leading figure in the contumacious (and quite unjustified) campaign against the Royal Aircraft Factory and its aircraft designs. For the rest of his life (he died in 1948), Pemberton-Billing continued to be an ardent follower and vociferous critic of aviation matters, and his 'design studies' are known to have reached at least up to the P.B.55. But it is as the founder of the Supermarine Aviation Works that he deserves the greatest credit. After he left there to join the RNAS in 1914 they came under the charge of Hubert Scott-Paine, who guided the company towards its successful career during the post-war years.

7 **Fairey Campania**

Although it cannot claim any outstanding operational achievements, the Campania has its place in aviation history as the first-ever aeroplane to be designed for operation from an aircraft carrier. In October 1914 the Admiralty bought the former Cunard liner *Campania*, which it refitted as a warship with a flying-off deck. Eventually a 200 ft (60·9 m) deck was fitted, and in June 1916 the first fly-off by a 2-seat seaplane was made. Shortly after this the Admiralty issued a specification for a 2-seat patrol and reconnaissance aircraft to be operated from other ships of this kind. The first Fairey aircraft was allocated to HMS *Campania*, from which it derived its name.

The first of two prototypes had the Fairey works designation F.16 and serial number N1000; it made its first flight on 16 February 1917. It was powered by a 250 hp Rolls-Royce IV (later called Eagle IV) engine, had a Scarff ring mounting for a Lewis gun in the rear cockpit, and under-fuselage racks for two 100 lb (45 kg) bombs. The wings folded backward for stowage; in addition to twin landing floats there were flush-mounted balancer floats beneath each lower wing near the tip and another under the rear of the fuselage. A second prototype (Fairey F.17, serial N1001) flew on 3 June 1917. This had a 275 hp Rolls-Royce I (later Eagle VIII) in a slightly longer nose with a frontal radiator. Other changes included strut-mounted wing floats, kingpost bracing over the top wing and a slightly larger fin.

These two machines were later used

at the RNAS station at Scapa Flow. Fairey built a further eight Campanias to the original order, two of these being F.22's with 260 hp Sunbeam Maori II engines and larger radiators. Fifteen more F.17's and twenty-five F.22's were built by Fairey and delivered from November 1917. From March 1918 Barclay, Curle & Co began delivery of an order for fifty Eagle-powered F.17's, but only twelve were completed. In general, the F.17 Campanias were allocated to the seaplane carriers *Campania*, *Nairana* and *Pegasus*, while the Maori-engined F.22's served at Naval air stations in Scotland and southern England; one F.17 served at Cherbourg. The Campanias could take off from the deck of HMS *Campania* by using a jettisonable trolley gear, but those serving aboard the other two carriers had to be hoisted over the side to take off from the water. The Campanias performed useful ship-spotter service during the final year of the war without achieving particular operational eminence. On 31 October 1918 there were forty-two Campanias on RAF charge, twenty-six of them with Eagle engines (some having the lower-rated Eagle IV or VII). They remained in service for a short time after the war, carrying out mine-detection patrols in British coastal waters. Some of *Nairana*'s aircraft, operating from Archangel, were in action against the Bolsheviks in 1919; but in August 1919 the Campania was officially declared obsolete.

8 & 9 **Curtiss H and Felixstowe types**

In 1914 John C. Porte, a former British Naval pilot, helped to complete the Curtiss flying-boat *America* in which he hoped to fly the North Atlantic later that year. The outbreak of World War I prevented the attempt from being made, and Porte returned to Britain to rejoin the Royal Navy. Here he persuaded the Admiralty to purchase the two Atlantic-attempt Curtiss machines that had been completed, and these were delivered to Britain in November 1914. Twelve more H.4 Americas were ordered early in 1915; four of these were assembled in Britain by S. E. Saunders and the Aircraft Manufacturing Company, and all were refitted with Anzani, Beardmore, Clerget and Sunbeam engines of greater output than the 100 hp Curtiss engines which had powered the original *America*. Two of these machines were later based on Gibraltar for local patrol duties. Later in 1915 the RNAS ordered another fifty H.4's, which were supplied with American engines but refitted on arrival at Felixstowe with 100 hp Anzanis. Even in their re-engined form, however, the H.4's were underpowered for operational work and the majority were employed in a training role. In June 1918 there were few Curtiss H.4's left in RNAS service; two months later the type was officially declared obsolete, and the three aircraft which still survived at the Armistice disappeared shortly afterwards. Apart from the lack of power, the main disadvantage of the H.4 lay in its none-too-seaworthy hull. A great deal of thorough research into improving both the strength and the hydrodynamic shape of the Curtiss hull was undertaken by John Porte at Felixstowe, and it was an H.4 from the main RNAS batch that became the F.1 prototype for the subsequent series of highly successful Felixstowe flying-boats.

In July 1916 Curtiss completed an H.8 prototype with two 160 hp Curtiss engines. This was a larger aeroplane than the H.4, but the increase in power did not compensate adequately for the increase in size. The production version, the H.12, was therefore built for the US Navy with 330 hp Liberty engines and for the Royal Navy with 250 hp Rolls-Royce Eagle I's. The H.12

carried a crew of four men, one gunner occupying the bow position with two Lewis machine-guns and another gunner occupying the rear defensive position with a single gun; the underwing bomb load could consist of two 230 lb (104 kg) or four 100 lb (45 kg) weapons. Fifty H.12's were supplied to the RNAS and nineteen (together with the H.8) to the US Navy. The H.12 still exhibited the weakness in hull design that had characterised the H.4, but in the air it was an excellent flying machine and established a fine operational record. A British H.12 scored the very first victory against an enemy aircraft by an American-built warplane; H.12's shot down their first Zeppelin on 14 May 1917, and sank their first U-boat six days later. To distinguish them from the H.4's, the H.12's were known familiarly as Large Americas, their smaller brethren accordingly being dubbed Small Americas. Twelve H.12's were still on RAF charge at 31 October 1918. From January 1918 the RNAS began to receive twenty one H.12B's, an improved version; these were assembled in the United Kingdom. They subsequently underwent further modification and strengthening of their hulls, and in this form became known as Large America Converts. Six of these aircraft remained on RAF charge when the war ended, some of which may have been fitted with later and more powerful engines. Aircraft of the H.12 type were the first to operate the so-called 'spider's web' system of maritime patrol, in which the patrol area was divided into geometrical divisions and covered systematically sector by sector.

The largest and most efficient America type was the H.16, whose prototype appeared at the end of 1917. This employed a new and more efficient hull similar to the Porte design; it also had a balanced rudder and greater-span wings. Defensive armament was increased to one or two guns in the front cockpit, two in the rear-upper position and a beam gun on either side; war-load was increased to four 230 lb (104 kg) bombs. One hundred and fifty H.16's (including the prototype) were built by the Naval Aircraft Factory at Philadelphia, seventy-four of them for the US Navy with 400 hp Liberty 12 engines. The RNAS ordered one hundred and twenty-five H.16's, but fifty of these were later cancelled and another fifty put straight into store on arrival in the United Kingdom. The remaining twenty-five, delivered from March 1918, were fitted with 375 hp Rolls-Royce Eagle VIII engines. Due to various other modifications required before they could become operational, only fifteen H.16's were in RAF service by the end of the war, but the type remained in service until 1921. Those that did operate from naval bases around the British coast were supplemented by about fifty of the US Navy's H.16's.

The Felixstowe flying-boats, so named after the Royal Naval Air Station where they were evolved, originated as adaptations of the America series with more efficient and seaworthy hulls designed by Squadron Commander John Porte. The first was the F.1 (originally called the Porte 1), which was built from Curtiss H.4 serial number 3580. Only the wings and tail assembly were retained, the F.1 being given Hispano-Suiza engines and fitted with an entirely new hull. The successful evaluation of this machine having proved the soundness of Porte's design, the next stage was to scale up the new hull to match the size of the Curtiss H.12 Large America, and the prototype F.2 (8560) was a Curtiss H.12 with a Porte-type hull. This aircraft went into production as the F.2A, powered by 345 hp Rolls-Royce Eagle VIII engines, and the first F.2A was delivered in

November 1917. By March 1918 orders for the F.2A had reached nearly one hundred and seventy; in fact, just over one hundred were completed by Saunders and a further ten by the Aircraft Manufacturing Company, remaining contracts being amended to specify the later F.5.

The Felixstowe F.2A was a first-class flying machine, capable of long patrols. It carried two pilots and an armament varying from four to seven Lewis machine-guns: single or twin guns in each of the front and rear cockpits, another above the pilot's seats and sometimes a beam gun on either side. Two 230 lb (104 kg) bombs could be carried beneath the lower wings. The Felixstowe inherited the 'spider's web' patrolling of the North Sea from the Curtiss H.12, and scored numerous successes over enemy submarines and airships. Despite its size and weight, the F.2A could manoeuvre quite well, and was an opponent treated with a healthy respect by enemy seaplane fighters. By various improvisations some Felixstowe F.2A's could carry enough fuel for more than nine hours' flying, but in the spring of 1918 an alternative attempt was made to increase the combat radius, by towing the aircraft on a lighter behind a Royal Navy destroyer into the scene of action. However, so far as is known, little operational use was made of this procedure. The Felixstowe's major weakness lay in the fuel supply system, which often obliged the crew to bring it down on the sea. In order to prevent it from being attacked as an enemy aircraft, in summer 1918 the so-called 'dazzle painting' was introduced on F.2A's operating over the North Sea, and different schemes were evolved to identify individual aircraft. The F.2A's wartime activities were confined to British home waters, and at 31 October 1918 there were fifty-three of these aircraft on RAF charge. One example (N65) was completed of the F.2C, with a lightweight hull and modified nose turret. This was later used operationally from RNAS Felixstowe and was concerned in the destruction of the submarine U.C.1 in July 1917.

A prototype F.3 (N64), with 320 hp Sunbeam Cossack engines, was flown in February 1917. It was a slightly larger aircraft than the F.2A, with a longer range and twice the bomb load, and substantial orders were placed for it. By March 1918 more than two hundred and sixty F.3's had been ordered. Production aircraft were powered, like the F.2A, with the excellent Eagle VIII engine, but only about a hundred F.3's were in fact completed, ninety-six being on RAF charge on 31 October 1918. Eighteen of them had been built locally in Malta Dockyards, for the F.3 was employed in the Mediterranean as well as in the North Sea area. In many respects the F.3's performance was inferior to that of the F.2A, and it was officially declared obsolete in 1921. Some were then refurbished by Fairey for the Portuguese Navy. Thus the F.3 was survived by the F.2A which, with the F.5 (whose prototype, N90, underwent acceptance trials in May 1918), was a standard RAF type during the early 1920s and set a pattern for British flying-boat design that was not superseded until at least a decade later.

10 Franco-British Aviation

The Franco-British Aviation Company, despite its name, was almost entirely French both in outlook and in operation: its only tangible claim to a dual nationality was an office in London, and even this tenuous connection had been severed by 1917. From 1913–15 the company built flying-boats of Lévêque design; none of these were purchased by the French government, but small numbers were exported to Austro-Hungary and Denmark. In 1915 the

2-seat FBA Type B appeared, a development of the basic Lévêque design by Louis Schreck which had an upswept rear hull with an oblong rudder and a 100 hp Gnome Monosoupape rotary engine driving a pusher propeller. This was built in some numbers for the *Marine Nationale* and the Royal Naval Air Service. In addition to forty-four complete Type B's (three of which it later transfered to the RFC), the RNAS had twenty more of these aircraft completed by the Norman Thompson Flight Company from French-built hulls, and a further sixty built entirely in England by the Gosport Aviation Company. None of the French-built machines survived the war, but twenty-four of the Gosport batch were still in existence in January 1919.

In April 1916 the FBA Type B was followed by the Type C, generally similar except for a 130 hp Clerget rotary engine. This was built for the French, Italian and Russian Navies, initially for coastal patrol and later, like the Type B, used for training.

The most widely built FBA flying-boat, and possibly the most widely built and used flying-boat of any participant in World War 1, was the 3-seat Type H. This had a less swept-up rear hull, a high, strut-mounted tailplane and approximately oval rudder. It was not much bigger dimensionally than the Type C, but it had greater load-carrying capabilities and a Vee-type engine instead of the latter aircraft's rotary. Powerplants were Hispano-Suizas of various ratings or 160 hp Lorraine-Dietrichs. The Type H was built under licence in Italy by six manufacturers, following the supply of an initial batch from France. It says much for the merits of the FBA that, despite the preeminence in Italy at that time of the Macchi range of flying-boats, nine hundred and eighty-two examples of the French design were built there. Most of them were powered by 160 hp Isotta-Fraschini V-4B's and sported a small vertical fin. Armament consisted of a single machine-gun in the front cockpit. Four Italian-built Type H's were presented to the RNAS and based at Otranto. The Type H served with the *Marine Nationale*, including the celebrated *Escadrille de Dunkerque*, and with the Belgian and Russian Navies. Some were still in service with Italian *Squadriglie della Marina* in Tripoli in 1922.

A development of the Type H, the FBA Type S, had a 200 hp Hispano-Suiza, and an increased bomb load of two 35 kg (77 lb) or 50 kg (110 lb) weapons. It featured an enlarged tail assembly, including a triangular vertical fin, and carried a crew of two or three men. The Type S was in production for the final twelve months of World War 1 and saw widespread service with the *Marine Nationale* in the North Sea, English Channel and Mediterranean; a few also served with the Belgian Navy. One prototype was completed in 1918 of a Type S development: this retained the hull and powerplant of the Type S, allied to completely new wing and tail assemblies. Despite their widespread employment and undoubted usefulness as coastal patrol and anti-submarine aircraft, no record appears to have survived of French production figures for the individual types of FBA flying-boat.

11 Curtiss (early seaplanes)

Second only to the Wrights in his work to pioneer powered flight in the United States, Glenn Hammond Curtiss was until 1910 associated with the design, construction and piloting of land-based aeroplanes, first with the Aerial Experiment Association and later in partnership with Augustus M. Herring. On 14 November 1910 Eugene Ely, piloting a modified Curtiss Golden Flyer

landplane, took off from USS *Birmingham* in Hampton Roads, Virginia. On 18 January 1911 Ely completed the sequence by making a landing on the USS *Pennsylvania* in San Francisco Bay, and thus began the association of Curtiss with the early development of waterborne aircraft. His first seaplane, flown at San Diego on 26 January 1911, was little more than a modified Golden Flyer type, mounted on a single central float, with small stabilising skid-floats under the lower wing-tips. A later version had twin parallel main floats. By the end of February 1911, Curtiss had flown one of his seaplanes with a passenger on board, had developed an amphibious wheel-and-float seaplane, and had demonstrated (again on the *Pennsylvania*) how a seaplane could be lowered to the water from a warship, take off for a mission, land alongside and be winched back on board. Curtiss's demonstrations convinced the US Navy, which in July 1911 gave him an order for an amphibious seaplane; it was eventually designated A.1 (US Navy Airplane No. 1), and was later named Triad after the addition of retractable wheels to the main float. On 21 June 1912 it set up a seaplane altitude record of 900 ft (274 m). About a dozen single-float seaplanes, later given AH (Airplane, Hydro) designations, were acquired by the US Navy. In 1911 Curtiss also delivered three 60 hp Type E biplanes to the US Army Signal Corps, and one of these also was fitted with floats.

The next major advance in marine aircraft design came with the first Curtiss hull-type flying-boat, which made its maiden flight on 10 January 1912. It still bore the outdated frontal elevator of Curtiss's earlier aeroplanes, but this feature quickly disappeared and the standard 100 hp Curtiss-engined 'pusher' flying-boat of 1912–13 was a first-class aeroplane. The Model F was adopted by the US Navy, originally with C-for-Curtiss designation numbers and in 1912 a similar aircraft was the first to fly with the newly invented Sperry gyroscopic automatic pilot. A British licence to build the Curtiss flying-boat was acquired by White and Thompson Ltd, the hulls of which were built by S. E. Saunders at Cowes. The original five US Navy aircraft were redesignated in March 1914 with AB prefix letters, and played an important part in the evolution of catapult launching before being relegated to a training role. One hundred and forty-four additional Curtiss Model F's, perhaps more, were ordered from Curtiss specifically for training purposes, and one Curtiss F-boat was built by the Burgess Company.

In 1918 there appeared the Model MF (Modified F), a replacement for the ageing Model F that was, in fact, an almost complete redesign. Twenty-two were built by Curtiss during World War 1, and a further eighty post-war by the Naval Aircraft Factory; one of the latter was converted experimentally as an amphibian. Curtiss also built a few flying-boat and amphibious examples of a civil equivalent known as the Seagull. This was not particularly successful, but several ex-Navy MF's were converted for civil use after their Service careers had ended.

Roughly contemporary with the MF was another single-pusher-engined Curtiss flying-boat, the HS-1. This was a much larger aircraft, powered originally by a 200 hp Curtiss VXX engine and carrying a 2/3-man crew for general patrol duties. It was, however, not so much a scaled-up Model F as a scaled-down Model H, the designation letters in fact signifying 'H, Single-engine'. The HS-1 first appeared early in 1917; in October of that year it was flown with a 375 hp Liberty engine, and this, in its 400/420 hp production form,

became the standard powerplant. During production of the HS-1L, as the Liberty-engined version was known, a new HS-2L version was introduced with a 12 ft (3·66 m) greater wing span and increased bomb load. The type saw war service in Europe from May 1918, and remained in US Navy service until 1926. Production of the HS-1L/HS-2L was undertaken by the Curtiss Aeroplane and Motor Company (six hundred and seventy-five), Standard Aircraft Corporation (eighty), Lowe, Willard & Fowler (two hundred and fifty), Gallaudet Aircraft Corporation (sixty), Boeing Airplane Company (twenty-five) and Loughead Aircraft Corporation (two). A further two dozen or so HS-2L's were assembled from spares after the war, and six examples (four by Curtiss and two by the NAF) were built of an HS-3 model with a modified hull.

12 & 13 **Lohner/Macchi flying-boats**

The first flying-boats produced by the Jakob Lohner Werke of Vienna were the general-purpose E types, built in 1913. They were 2-seaters, with 85 hp Hiero engines, and one of these aircraft (E18) made the first operational sortie by an Austrian aircraft in August 1914. The later S types were unarmed training versions of the Type E. About two hundred, some of them converted E's, were in service during 1914–18; most of them had 85 hp Hiero engines, but some were fitted with 80 hp Oberursel rotaries.

In size and general configuration the Lohner Type L resembled the Type E, but was powered either by a 140 hp Hiero or by an Austro-Daimler engine of 140 or 180 hp. A slender, elegant aeroplane with sweptback sesquiplane wings, the Lohner Type L seated a crew of two side by side, the observer occupying the right-hand seat and manning a Schwarzlose machine-gun on a rotatable mounting. Up to 200 kg (441 lb) of bombs and/or depth charges could be carried. The Type L entered service in the second half of 1915, and it is thought that one hundred and sixty were completed by the parent company. To these may be added nine or ten similar machines built as Type M's by the Naval Dockyard at Pola. About thirty-six examples were also completed of the Type R, a 3-seat reconnaissance variant of the Type L with photographic equipment instead of a bomb load.

The Lohner L's were the most widely used flying-boats of the Austro-Hungarian Navy during World War 1, and operated exclusively in the Adriatic area against Allied shipping and targets on the Italian mainland. It was an aircraft of this type (L40) that fell into Italian hands on 27 May 1915 and eventually gave rise to the long and successful range of Macchi-developed flying-boats. The Austrian Navy's most celebrated pilot, Lieutenant Gottfried Banfield, scored the first of his many aerial victories on 1 June 1916 while flying a Lohner L, and the general effectiveness of the type can be judged from the fact that only thirty of these aircraft were lost during the war, and only one each of the Types E, R and S.

The aircraft L40, when it fell into Italian hands, was delivered to SA Nieuport-Macchi with the request that a copy be produced for the Italian Navy. Designated L.1 to signify its Lohner origin, the first example was completed by June 1915. It was similar to the Austrian design except for its 150 hp Isotta-Fraschini engine and forward-firing Revelli machine-gun. One hundred and thirty-nine L.1's were built, serving from late 1915 until autumn 1916, when they were replaced by FBA flying-boats. A lighter-weight development, the L.2, with a 160 hp Isotta-Fraschini V-4B, had a much

better performance, but only ten were completed. Further development introduced so many new features that the L.3 could justifiably be regarded as a Macchi design, and it was renamed M.3 on its adoption by the Italian Navy. One M.3 established a height record of 5,400 m (17,716·5 ft) in 1916; and just over two hundred M.3's were built for the *Regia Aeronautica Italiana*. These were employed throughout the Adriatic on reconnaissance, bomber escort and ground support duties; in the bombing role they carried four 100 kg (220 lb) bombs.

Macchi's first flying-boat fighter was the M.5, designed by Buzio and Calzavara. This was a single-seater (the earlier types having been 2/3-seaters), with two 6·5 mm Revelli machine-guns in the nose. The usual powerplant was the V-4B, though some later aircraft had the 250 hp V-6B. Two hundred and forty M.5's were built, being delivered to the 260a, 261a, 286a, 287a and 288a *Squadriglie della Marina* from early 1918 and serving until the Armistice. The M.5 was extremely manoeuvrable, had sufficient range to perform escort duty, and could climb to 4,000 m (13,123 ft) in 20 minutes.

However, it was not quite fast enough to compete with the Austrian Navy's Phönix D.I, and so Macchi developed the M.7, powered by the V-6B engine, to match or exceed the speed of the Austrian fighter. In this it was successful, for the smaller M.7, despite a higher gross weight, was faster and better than its predecessor, and could climb to 5,000 m (16,404 ft) in 22 minutes. Unfortunately, of two hundred ordered only seventeen were delivered before the Armistice and only three of these had become operational. Production continued after the war, but it has not been established whether the full two hundred were completed. Post-war variants included the M.7*bis* (one of which won the 1921 Schneider Trophy), M.7*ter* AR, M.7*ter* A and M.7*ter* B. The latest versions, with 475 hp Lorraine engines, were still in service in 1923.

A patrol development of the M.3 appeared late in 1917 as the 2-seat M.8. This retained the V-4B powerplant in a bigger and stronger airframe, and was armed with a movable gun in the prow. It carried a similar warload to the M.3, plus photographic and radio equipment. Fifty-seven were built by the Armistice, primarily for coastal patrol and anti-shipping duties. They remained in service post-war as trainers. The M.9 was an enlarged development with a 300 hp Fiat A-12*bis* engine. Plans were made in 1918 to build several hundred, but only thirty were completed, of which sixteen were delivered, before the Armistice. They remained in service until the mid-1920s. Another wartime model was the M.12, a 3-seat development of the M.9 with a 450 hp Ansaldo-San Giorgio 4E 28 engine. This had fore and aft gun positions, connected by a tunnel in the fuselage so that both could be manned by one gunner. The M-12's broad front hull and twin tailbooms afforded the rear gun an excellent field of fire. Like the M.9, the M.12 was too late for war service, but a few were delivered to the Italian Navy; they figured in trans-Mediterranean flights and Schneider events in later years. Demilitarised versions used commercially after the war included M.3's in service with a Swiss operator and the M.9*bis* and M.9*ter*.

14 Navy-Curtiss NC flying-boats

Once the accomplishment of powered flight became a reality, the urge was inevitable to improve upon the speeds, altitudes and distances of which aeroplanes were capable. From the earliest days a crossing of the North Atlantic by air had been a cherished ambition, and

only the outbreak of war in 1914 prevented competition during that year for the *Daily Mail* prize of £10,000 offered in 1913 to the first aviators to accomplish a direct (i.e. non-stop) crossing. As recorded elsewhere in the series, the prize was ultimately won in June by Alcock and Brown for their flight in a modified Vickers Vimy, but in the month preceding this another Atlantic crossing, with stops en route, had been made by an American flying-boat, the NC-4. That this aircraft should have been of Curtiss manufacture was particularly appropriate, for Glenn Curtiss was a pioneer of seaplane design (see *Pioneer Aircraft* 1903–14) and his company's flying-boat *America* was designed originally as a 1914 contestant in the trans-Atlantic competition.

The NC-4 was one of four NC (Navy-Curtiss) flying-boats, built during World War 1 originally to provide patrol cover for American shipping in the Atlantic against the attentions of German U-boats. The requirement was drawn up, and the aircraft designed, by the Navy in September 1917. It featured a short hull (45 ft = 13·72 m in length) of advanced hydrodynamic design, and was intended to be powered by three engines. The first four aircraft were numbered separately NC-1 to NC-4, but the war was ending even as flight testing began. The NC-1 (three 400 hp Liberty engines) flew for the first time on 4 October 1918, and on 25 November gave striking proof of its load-lifting abilities by carrying 51 people on a single flight – a world record. Nevertheless, the three-engined installation was considered inadequate for trans-Atlantic flying, and completion of the second, third and fourth aircraft was delayed while a fourth engine was included in the design. First flights were made on 12 April (NC-2), 23 April (NC-3) and 30 April (NC-4), NC-2 having its four engines mounted back-to-back in tandem pairs while the other two aircraft retained the between-wings separate tractor layout of three engines and had the fourth mounted, as a pusher, at the rear of the hull. It was decided to enter the Navy-Curtiss machines for the trans-Atlantic attempt, for which they were redesignated NC-TA. Before the attempt NC-1, whose wings had sustained storm damage, was given the wings from NC-2, whose engine layout had proved unsatisfactory. The three 'boats took off from Trepassy Bay, Newfoundland, on 16 May 1919, their first intended stop being Horta in the Azores, some 1,400 miles (2,253 km) away. The NC-4, captained by Lt Cdr Albert C. Read, arrived safely on the following day, but NC-1 came down in the water 100 miles (160 km) west of Flores and sank after being damaged by heavy seas. The crew was rescued by one of the ships stationed along the route. The flagship of this trio, NC-3 commanded by Cdr John H. Towers, leader of the trans-Atlantic team, was also forced down, some 45 miles (72 km) south-east of Fayal. It taxied the next 200 miles (362 km), finally limping into Horta harbour 52 hours after leaving Newfoundland, but was unable to continue. Read in the NC-4 therefore continued alone, leaving on 20 May for Ponta Delgada, where weather delayed him until 27 May when he flew on to Lisbon to complete the crossing of the North Atlantic. He subsequently continued his journey to arrive at Plymouth on 31 May, and was escorted into the harbour there by three Felixstowe F.2A flying-boats of the Royal Air Force. The NC-4 made a triumphal return to the USA later, ending a celebratory tour of the eastern and southern seaboard by flying up the Mississippi to St Louis. Here it was handed over to the Smithsonian Institution, in whose possession it remains today.

After the Armistice the Naval Aircraft Factory at Philadelphia built six more NC-type flying-boats. These were built initially as tri-motors, but four were later converted to an NC-4-type four-engined layout, the other two meanwhile having been lost. The converted aircraft served during 1920–22 with the US Navy's East Coast Squadron before being retired.

15 **Friedrichshafen FF33, FF39, FF49 and FF59**

Serving from the spring of 1915 until the closing stages of World War 1, the Friedrichshafen range of 2-seat patrol floatplanes were probably the most extensively employed German seaplanes of the war period; nearly five hundred examples of the four models listed above were completed. Most of them were armed, and their major duties included coastal and ocean patrol, fleet observation and co-operation, and anti-submarine work. Some were based at coastal stations, operating in the North Sea and English Channel areas; others served aboard German seaplane carriers. The best-known example was the FF33E christened *Wölfchen* (Little Wolf), which was carried by the merchant raider *Wolf* in the Indian and Pacific Oceans and helped the German warship to account for twenty-eight Allied vessels.

Approximately five hundred FF33's were built, details of which are given in the *Bombers* 1914–1919 volume in this series. The FF39 was an interim model, which appeared in 1917 with a strengthened and refined fuselage, 200 hp Benz Bz.IV engine and rear-firing Parabellum machine-gun; fourteen were built. The principal Bz.IV-powered version, however, was the FF49, of which twenty-two FF49B's and two hundred and eighteen FF49C's were completed by Friedrichshafen, LFG and Sablatnig. The former version was unarmed, but most FF49C's had a rear-firing Parabellum gun; at least thirty of the late-production machines built in 1918 had two guns. Apart from its more powerful engine, the FF49 broadly resembled the FF33J except that it had balanced control surfaces. Before the war ended, twenty examples were ordered of the FF59C, another Bz.IV-engined floatplane with a more compact fuselage and a greater range than preceding models. The only wartime 'in service' figures known are those for FF33 variants in May 1917: these included one hundred and twenty-one FF33E's, twenty-five FF33H's, thirty FF33J's and one hundred and fourteen FF33L's.

After the war, in 1918–19, the Flugzeugbau Friedrichshafen GmbH built a further forty-four seaplanes of unknown type(s). In addition, a number of FF49's were converted at about the same time to serve in an interim capacity as transport aircraft. These were of somewhat hybrid design, having a forward pilot's cockpit like the FF49C, a new enclosed cabin structure to the rear, and the larger-area rudder of the FF49B. Two cabin sizes are known, the aircraft being designated V1 with a 3-seat cabin and V11 with a 5-seat cabin. Transport conversions of the FF49 were built by LFG and Sablatnig as well as by the parent company; most of them had Bz.IV engines initially, but the LFG-built V11 is said to have had a 260 hp Mercedes D.IVa and some were subsequently re-engined with Junkers L-2 or L-5 powerplants. Operators of passenger/mail-carrying FF49s during the early post-war years included DDL (Det Danske Luftfartselskab) of Denmark, and the German companies DLR (Deutsche Luft-Reederei), LFG (Luft-Fahrzeug GmbH), LLS (Lloyd-Luftverkehr Sablatnig) and Luftdienst GmbH.

16 **Supermarine Sea Eagle**

During 1919–21 the Supermarine Aviation Works at Woolston, Southampton, produced a number of small biplane flying-boats. These included the Lion-engined Sea Lion I (G-EALP), a single-seat aircraft entered for the 1919 Schneider Trophy competition and flown by Cdr. B. D. Hobbs. It had a short and unlucky career, for the 1919 race was declared void because of bad weather, and the aircraft was later damaged during a take-off. In 1921 Supermarine built another racer, an amphibian, originally powered by a 300 hp engine and named Sea King II. Registered G-EBAH, it flew for the first time in March 1922, but later that year the amphibious landing gear was removed, the wing area reduced and a 450 hp Napier Lion engine substituted for the original powerplant. In this form, renamed Sea Lion II, it was flown in the 1922 Schneider race at Naples by H. C. Biard, winning the contest at an average speed of 145·62 mph (234·37 km/hr). With modified wing bracing and an enlarged rudder, it was entered (as the Sea Lion III) for the 1923 contest at Cowes, but although Biard averaged 151·56 mph (243·91 km/hr) over the course this was sufficient only to earn him third place. At the end of the year the Sea Lion III was handed over to the RAF.

By this time Supermarine had acquired the services, as chief designer, of a young and talented engineer, R. J. Mitchell, later to achieve world-wide fame as the designer of the S.4/S.5/S.6/S.6B series of Schneider Trophy seaplanes (see pp. 116–118) and eventually of the Spitfire fighter. One of Mitchell's first designs, however, was concerned not with speed but with the transportation of passengers. This was the Sea Eagle, an equal-span three-bay amphibious biplane with a single Rolls-Royce Eagle engine driving a pusher propeller. It carried a one-man crew and had a fully-enclosed cabin seating six passengers. Three Sea Eagles (G-EBFK, G-EBGR and G-EBGS) were built, the first of which was flown during the early part of 1923. They were produced to the order of the British Marine Air Navigation Co Ltd, a new company set up late in 1922 with a £10,000 government subsidy to operate passenger-carrying flying-boat services between Southampton, the Channel Islands and Le Havre. Prior to the start of these services, late in 1923, G-EBFK was a competitor in the 1923 King's Cup air race, but its career with BMAN was a short one, for it crashed in May 1924. The other two Sea Eagles were handed over to the newly formed Imperial Airways in June of that year, whereafter G-EBGS was sunk in January 1927 after being holed by a ship in Guernsey harbour and G-EBGR was withdrawn from service in 1929.

17 **Curtiss F-5L**

With the production of the F-5L the cycle of Curtiss/Porte/Felixstowe flying-boat development completed its full circle, returning to the USA via Canada for good measure. In 1913 the London *Daily Mail* had offered a £10,000 prize for the first direct crossing of the North Atlantic by air, and a number of widely different aeroplanes was sponsored to make the attempt during 1914. Among these were two Curtiss *America* flying-boats, in one of which a former British Naval pilot, John C. Porte, hoped to compete for the prize. Prevented from doing so by the outbreak of World War 1, Porte returned to Britain to rejoin the Royal Navy, and persuaded the Admiralty to buy the two *America* machines. In the USA, the *America* design gave rise to the later Curtiss H.4, H.12 and H.16 series of flying-boats, while in Britain the Royal Navy, disappointed with the

seaworthiness of its H.4's, appointed Sqn Cdr Porte (as he then was) to conduct a thorough investigation at Felixstowe Naval Air Station into both the strength and the hydrodynamic shape of the Curtiss-designed hull. The immediate result was the Felixstowe F.1, a converted H.4, with Hispano-Suiza engines and an entirely new and fully-seaworthy hull designed by Porte. Extending the same approach to the Curtiss H.12, Porte evolved the Felixstowe F.2A (*q.v.*), which became one of the most successful maritime aircraft of World War 1. It survived its supposed replacement, the F.3, and was in due course followed by the F.5, whose prototype (N90) underwent acceptance trials in May 1918. Plans had been made to place the latter type in production as the F.5L, powered by two 400 hp Liberty engines, but the advent of peace caused these to be abandoned and the aircraft in fact entered service powered, like the F.2A before it, with Rolls-Royce Eagle engines.

Meanwhile, however, the US Navy had also decided to adopt a Liberty-engined version of the F.5, ordering four hundred and eighty from the Naval Aircraft Factory at Philadelphia, fifty from Canadian Aeroplanes Ltd of Toronto and sixty from Curtiss. Construction of these began in April 1918, and the first (a Canadian-built machine) was delivered in the following July. After the Armistice the Canadian order was reduced to thirty, and the NAF completed only one hundred and thirty-seven. The typical Curtiss/Felixstowe triangular-pattern fin and rudder were replaced during the early post-war period by larger-area surfaces comprising a quadrant-shaped fin and balanced rudder. These surfaces had first appeared on two NAF-built F-6L's, ordered originally as part of the F-5L contract. In 1922, when a new designation system for USN aircraft was introduced, the flying-boats were allocated PN (Patrol-Navy) designations PN-5 and PN-6 respectively, though in practice they continued to be known by their original designations until their withdrawal from service in 1928.

Development was, however, continued by the Naval Aircraft Factory, still using the Porte-developed hull as a basis. This produced two PN-7's (525 hp Wright engines and new wing design), one PN-8 (475 hp Packard engines and all-metal structure), one PN-9 (as PN-8 but with redesigned nacelles and tail surfaces), two PN-10's (V-12 engines), one Hornet-engined prototype and three Cyclone-engined PN-11's (new, wider hull), and two PN-12's (as PN-10 but one with Cyclone and one with Hornet engines). Production of PN-12 variants was undertaken by Douglas (twenty-five PD-1), Keystone (eighteen PK-1) and Martin (thirty PM-1 and twenty-five PM-2). The PK-1 and PM-2 versions were fitted with twin fins and rudders.

18, 19 & 20 **Curtiss Navy racers**

In 1918 Curtiss built for the US Navy two examples of the Model 18-T Wasp, a 2-seat triplane fighter powered by a 400 hp Curtiss K-12, forerunner of the D-12 series of engines. The Model 18-T, a landplane, was remarkable for its extremely clean fuselage, the exterior of which exhibited an extremely smooth finish due to its outer skin of cross-laminated veneer strips and helped it to set a world speed record of 163 mph (262 km/hr) on 19 August 1918. In modified form the two aircraft were entered for several post-war races, and much of the experience gained with them was built into two new racing biplanes which were completed in 1921.

These were ordered as official Navy competitors in the Pulitzer Trophy race of September 1921, but were flown instead by company pilots when the USN withdrew from participation. Known initially as Curtiss Navy racers, the aircraft were each powered by a 405 hp Curtiss CD-12 direct-drive engine, a development of the geared C-12 installed in two earlier Curtiss-financed competitors built for the 1920 Gordon Bennett Trophy race. The second Navy racer won the 1921 Pulitzer, at Omaha, Nebraska, at a speed of 176·7 mph (284·4 km/hr), and on 3 November that year the same aircraft set a new world speed record of 197·8 mph (318·3 km/hr). In 1922 the two aircraft were repurchased by the Navy, which in that year also introduced a new system of aircraft designation. Under this system the Curtiss biplanes were known initially as CF-1's and then, separately, as the CR-1 and CR-2. Both were refitted with new CD-12 engines and enlarged fin and rudder surfaces; the CR-2 was in addition given new wings, with surface radiators instead of the external Lamblin type fitted previously. Curtiss aeroplanes swept the board in the 1922 Pulitzer race, held near Detroit, for the first two places were taken by a pair of Army R-6 racers, developed from the Navy design, while the third and fourth places went, respectively, to the CR-2 and CR-1.

Up to this point the two Navy racers had been flown as landplanes, but when the USN decided to enter them for the 1923 Schneider Trophy race at Cowes, Isle of Wight, both were converted to twin-float landing gear and redesignated CR-3. Both aircraft were provided with wing surface radiators, and the vertical tail surfaces were further enlarged. They captured the first two places in the race, though at speeds lower than their Pulitzer-winning performances of the year before. The 1924 Schneider competition was postponed by the US after all European entries had withdrawn, and the two racers were considered unlikely to win in 1925. Nevertheless, during those two years the second CR-3 (refitted with a later D-12 engine and redesignated CR-4) established a new closed-circuit speed record for seaplanes of 188·078 mph (302·681 km/hr), and was later used in the training programme for the 1925 US Schneider Trophy team.

Meanwhile, the CR-1/R-6 design had been developed a stage further to produce a new Navy biplane racer, the R2C-1, to compete in the 1923 Pulitzer race. Again, two examples were built, both at first having a wheeled landing gear. They were powered by 488 hp D-12A engines, with surface radiators on both sets of wings, and took first and second places, the winner having a speed of 243·68 mph (452·16 km/hr). This machine, the second of the pair, was also converted to float gear (as R2C-2) in preparation for the 1924 Schneider race, while the other was sold to the US Army as the R-8. Both were lost in crashes, the R-8 in 1924 and the R2C-2 in 1926.

For the 1925 National Air Races, the US Army and Navy combined their efforts and ordered three R3C-1 racers from Curtiss. Although externally similar to the R2C design, these had wings of improved aerofoil section and 610 hp V-1400 engines, a development of the D-12. In October 1925 the Army-piloted R3C-1 set up the best Pulitzer performance, with a speed of 248·99 mph (400·71 km/hr). The three aircraft became R3C-2's when fitted with floats for the Schneider Trophy race later that month, and this event too was won by the Army R3C-2, flown on this occasion by Lt 'Jimmy' Doolittle at 232·57 mph (374·29 km/hr). In the following year two of the trio, both flown by Navy pilots, were entered for the Schneider Trophy. These were by then known as R3C-3 and R3C-4, having been re-engined respectively with a 700 hp Packard

2A-1500 and a 700 hp Curtiss V-1550. Unfortunately, the R3C-3 sank after an accident during a practice flight, and its place in the competition was taken by the reserve aircraft, the modified R3C-2, which was placed second after the R3C-4 had to withdraw. The R3C-2 is preserved today by the Smithsonian Institution in the National Air Museum in Washington, DC.

21, 22 & 23 **Supermarine Schneider Trophy seaplanes**

When Jacques Schneider, a member of the famous armaments family, offered his 25,000-franc trophy* for 'hydro-aeroplanes' – plus a cash prize of corresponding value – to the Fédération Aéronautique Internationale in 1912, it is debatable whether he could have foreseen the extent of the international feeling and technological advancement that its existence would generate in later years. From 1923, when the US Navy sponsored a team of Curtiss racers to compete for the Trophy, the chances of success by wealthy private competitors were virtually nil, and government participation became the order of the day. Britain had won the war-interrupted contest in 1914 and 1922, respectively with the Sopwith Schneider and the Supermarine Sea Lion, but in the early post-war years the honours had gone first to Italy and then the USA. Two British challenges had been conceived for the 1924 event, but the Gloster-Napier II sank during tests and the Condor-engined Supermarine entry was not completed in time. With three wins in any five-year period sufficient for any nation to win the Trophy outright it was clear that America, with a win in 1923 and a moral victory in the 1924 'no contest', stood a strong chance of victory in the 1925 race. Three aircraft made up the British team entry for that year: two Gloster-Napier III seaplanes, with 700 hp Lion VII engines, and the similarly-powered Supermarine-Napier S.4, the latter to be flown by the 1922 race winner, Captain H. C. Biard. All three were designed to Air Ministry Specification 2/25. The Supermarine aircraft was the progeny of Reginald J. Mitchell, chief designer and technical director of the Supermarine Aviation Works, and embodied a special high-speed wing section developed at the Royal Aircraft Establishment at Farnborough. The S.4 made its first flight at Southampton on 25 August 1925, some months before the Schneider Trophy race was due to take place at Chesapeake Bay, Baltimore. On 13 September, piloted by Biard, it set up a new world seaplane speed record of 226·6 mph (364·6 km/hr), and with further engine tuning and a more efficient Fairey-Reed propeller its chances for the race appeared good. Unfortunately for British hopes it was lost in America, in a crash believed to have been due to wing flutter, the day before the race. The Curtiss R3C-2 secured America's second victory in the event, but British disappointment was mitigated somewhat by the achievement of second place by one of the Gloster-Napier machines.

Further development of both British racers took place, in the form of the Gloster-Napier IV and Supermarine-Napier S.5, but due to delays in the receipt of their new 875 hp Lion engines they were not entered for the 1926 contest, which was won by the Italian Macchi M.39. The year 1927 was however marked by the formation of a special High Speed Flight at Felixstowe and a government order for three S.5's to Specification 6/26. Mitchell's new design differed from the S.4 dimensionally, and in having low-mounted wings with surface radiators, a repositioned cockpit and all-metal construction. Two S.5's were entered for the 1927 race at Venice, whither they were shipped in the aircraft carrier *Eagle*. Of these, N219, flown by Flt Lt O. E. Worsley, had a direct-drive Lion VIIB engine, while N220 (Flt Lt S. N. Webster) was fitted with a geared version of the same engine. The two aircraft were designated S.5/21 and S.5/25 respectively; the latter machine won the race, with the former taking second place, and they were the only two competitors to complete the course. During the contest Webster also established a new world seaplane speed record over a 100 km (62·1 mile) closed circuit of 283·66 mph (456·506 km/hr).

After some initial dissension, the participating countries agreed that the competition was becoming prohibitive in terms of cost and of time needed to develop new machines, and it was decided to hold the event at two-yearly intervals. During 1928, the S.5 continued to enhance its reputation by setting up a new British seaplane speed record of 319·57 mph (514·296 km/hr), flown by Flt Lt D. D'Arcy Greig. But two new machines, known as the S.6, were being developed for participation in the 1929 contest. Ordered to Specification 8/28, they were slightly larger than the S.5, and each was powered by a new racing engine, the Rolls-Royce 'R', developing 1,900 hp. The 1929 race, held at Spithead, attracted a strong British contingent comprising two Gloster-Napier VI seaplanes, now with 1,400 hp Lion VIID engines, two S.6's and one S.5. The two Glosters, however, were withdrawn before the race and one of the S.6's was disqualified. The other, flown by Fg Off H. R. D. Waghorn, was declared the winner with a speed of 328·63 mph (528·88 km/hr); D'Arcy Greig in the S.5 was placed third, the two British victors being 'split' by Tomaso Dal Molin flying a Macchi M.52*bis*. Waghorn's S.6, flown by Sqn Ldr A. H. Orlebar, raised the world speed record for seaplanes to 357·7 mph (575·7 km/hr) on 12 September 1929. Tragically, at the peak of the excitement and expense which now characterised this world-famous contest, Jacques Schneider died in 1929, in extreme poverty.

The rapidly deteriorating economic situation in Britain led the government to announce, early in 1931, that it would not after all participate in that year's competition, despite the prospect of winning the Trophy outright. However, following the generous donation of £100,000 by Lady Houston, it later agreed to allow the High Speed Flight to compete. Hurriedly, Mitchell refined the S.6's and fitted them with larger floats – they then became known as S.6A's – and set about building two new machines to be designated S.6B. These were basically similar to the S.6A, but were powered by much-improved Rolls-Royce 'R' engines offering 2,350 hp. America had not entered a team in 1931, and neither France nor Italy could produce one in time, so that Britain remained the only competing nation. Unlike America in 1924, however, she had no scruples in allowing the event to take place, the 'race' consisting simply of a completion of the course by one S.6B. Flown by Flt Lt J. N. Boothman, at an average speed of 340·08 mph (547·31 km/hr), it was sufficient to secure the Schneider Trophy outright for Britain when no challenger had appeared during the ensuing five years. The same S.6B, its engine developed to produce an outstanding 2,550 hp, was flown by Flt Lt G. H. Stainforth on 29 September 1931 to a new world absolute speed record of

* The Trophy is often, but inaccurately, referred to in English as the Schneider Cup– probably from too literal a translation of its correct French name, *La Coupe d'Aviation Maritime Jacques Schneider*. In fact, it is not a cup but a bronze and marble statuette. It is now in custody of the Royal Aero Club in London.

407·5 mph (655·8 km/hr) – the first time the record had exceeded 400 mph (644 km/hr). Both S.6B's survive, the record-breaking machine (S1595) being displayed in the Science Museum, London, and the other (S1596) at Southampton.

24, 25 & 26 **Macchi Schneider Trophy seaplanes**

In each of the first three Schneider Trophy races to be held after World War 1, Italy established a firm place, honours going in 1919 and 1920 to SIAI (Savoia) flying-boats and in 1921 to the Macchi M.7 flying-boat which, piloted by Lt Giovanni de Briganti, won at Venice with a speed of 110·99 mph (178·63 km/hr). In 1922 the M.7 competed again, this time coming only second behind Britain's Supermarine Sea Lion II, and the next Italian success was not until the 1925 contest, when the M.33 (with de Briganti once more the pilot) achieved third position with an average speed of 168·44 mph (271·08 km/hr). This was some 64 mph (103 km/hr) slower than the winner's time, due to the fact that de Briganti mistook one of the turning points on the course which caused him to fly some 4 miles (6½ km) extra on each of the seven laps.

The M.33, a monoplane flying-boat with a 450 hp Curtiss D-12 engine, was however an augury for future Italian successes, for it was the first Trophy competitor to be evolved by Macchi's able designer, Ing Mario Castoldi. For his second design, for the 1926 race, Castoldi designed the M.39, a beautifully proportioned twin-float seaplane powered by an 850 hp Fiat AS.2 Vee-type engine. Three M.39's were entered, two of them gaining first and third positions flown by Major Mario de Bernardi and Lt Adriano Bacula of the *Regia Aeronautica*. The third M.39 was obliged to retire in the fourth lap. Four examples of a developed version, the M.52, were entered for the 1927 contest, one being a reserve. The M.52 featured a longer fuselage than the M.39, together with shorter floats and shorter-span wings. Powerplant was the 1,030 hp Fiat AS.3, and it was troubles engendered by this engine that caused the retirement of all three 1927 Italian competitors at various stages of the race. However, these troubles were vindicated on 4 November 1927 when Major de Bernardi piloted an M.52 to a new seaplane speed record (which was also a world absolute speed record) of 297·78 mph (479·23 km/hr). A modified version, the M.52*bis*, had shorter-span wings and revised float bracing. This aircraft raised the world speed record again on 30 March 1928, when de Bernardi flew it at an average of 318·623 (512·776 km/hr).

The M.52*bis* was entered as Italy's reserve aircraft in the 1929 Schneider Trophy contest at Cowes, and did in fact compete, gaining second place. The main Italian hopes that year, however, were centred upon a new Castoldi machine, the M.67, two of which were entered for the race. The M.67 was, in essence, a re-engined M.52*bis* with the larger-area wings of the original M.52, and was powered by a 1,400 hp Isotta-Fraschini Asso W-type engine. Two examples, flown by Lts Remo Cadringher and Giovanni Monti, took off for the race, but both were forced to retire.

As it turned out, this was the last Schneider Trophy event in which Italian aircraft competed, for Macchi's 1931 entry could not be got ready in time. In retrospect, however, it is at least arguable that this machine was the best of all the racing seaplanes designed to compete for the Trophy. It was the M.C.72, the C in its designation giving credit at last to the man who had designed the entire series of successful Macchi seaplanes for the competition.

Although larger and – chiefly because of its unorthodox powerplant – heavier than Castoldi's earlier competitors, the M.C.72 had a considerably better power-weight ratio and a much-enhanced performance. It was because of development difficulties with the powerplant that the M.C.72 was not ready in time for the 1931 race, which it might well have won had it been able to compete. Its twenty-four-cylinder Fiat AS.6 engine, which initially developed 2,600 hp, was in fact a pair of twelve-cylinder AS.5's mounted one behind the other in the front fuselage, each driving its own two-blade propeller independently of the other, in opposing directions to cancel out the tremendous torque developed by the combined power of the engines. (This problem was one which beset all designers of racers for the later Schneider contests; more speed required more power, and more power created more torque. The reaction against this tended to make one float 'dig into' the water, the aircraft thus planing round in a huge circle on the water, unable to get up enough speed to take off. It was not until the M.C.72 appeared, with its contra-rotating propellers, that this problem was satisfactorily overcome.) Four M.C.72's were built, the first of them flying in June 1931, and it cost the loss of three of them, with their pilots, before all the aerodynamic problems were overcome. This was achieved in the spring of 1932, and at once the M.C.72 began to show its true capabilities. On 10 April 1933, piloted by Warrant Officer Francesco Agello, it clocked a new world speed record of 423·822 mph (682·078 km/hr). Eighteen months later, on 23 October 1934 – by which time the engine was developing some 3,100 hp – Agello put up a new world and seaplane speed record of 440·68 mph (709·209 km/hr). As an outright world record this lasted until 1939, but it remained unbeaten in the seaplane class until August 1961, when a new record was set by the Soviet twin-turboprop M-10 (Beriev Be-10) jet flying-boat.

27 **Dornier Do X**

Although it is only in comparatively recent times that plane-loads of 150 or more passengers have become an accepted standard, one aircraft with such a capacity was flown more than forty years ago, and the fact that it was not an unqualified success cannot detract from the engineering feat which it represented. Design of the Do X, which began in 1916 under the leadership of Professor Claude Dornier (1884–1969), was aimed at producing a transport aircraft capable of carrying large payloads over trans-oceanic distances. The project was the subject of considerable scepticism, but Prof Dornier and his team remained undaunted, completing a full-size mock-up of the giant aeroplane and carrying out static testing of the proposed engine installation. This, in its original form, comprised twelve 525 hp Siemens-built Bristol Jupiter air-cooled radial engines, mounted in back-to-back pairs in six nacelles and driving four-blade propellers. The entire installation rested on an auxiliary 'over-wing' supported on six faired-in pylons. The Do X (a stopgap designation, later retained officially and signifying 'unknown quantity'), was primarily of metal construction, though large areas of wing and the wing and tail control surfaces were fabric-covered. Small metal auxiliary balancing surfaces were mounted above the ailerons and elevators.

The first Do X (sometimes referred to as the Do-X1) was completed in mid-1929 and made its first flight on 25 July of that year. At this time it was by far the largest aeroplane in the world, and its load-carrying ability was amply

demonstrated on 21 October 1929 when it made a 1-hour flight with 169 people on board – a 10-man crew, 150 passengers and 9 stowaways. This flight, although excellent for publicity purposes, gave a somewhat exaggerated picture of the Do X's intended operational capacity, for the standard interior layout was for 66–72 passengers. The maximum fuel load of 3,520 Imp gallons (16,000 litres) was an indication of the aircraft's potential range. The passengers, accommodated on the main deck of the three-deck hull, were offered the travelling luxury of a bar, smoking and writing rooms, lounge and sleeping quarters in addition to the normal seating facilities. Early test flights of the Do X soon revealed a serious engine problem: the inadequate cooling of the six rear-facing Jupiters. A solution was found by substituting a completely new installation of twelve liquid-cooled Curtiss Conqueror engines; at the same time, replacement of the over-wing and 'solid' pylons by an open, strutted structure reduced the total wing area by 32·2 sq m (346·6 sq ft). On 2 November 1930 the flying-boat left Friedrichshafen for a world-wide demonstration tour which took it by way of Amsterdam, Calshot, Bordeaux, Lisbon, the Canary Islands, Bolama, the Cape Verde Islands, Fernando de Noronha, Natal (Brazil), Rio de Janeiro, Antigua and Miami to New York, where it arrived on 27 August 1931. Some of the time during the 10-month trip was taken up with repairs, after fire had burnt part of the wing at Lisbon and the hull had sustained damage when taking off from the Canaries. After its return to Germany the Do-X1 was owned briefly by Deutsche Luft Hansa before being transferred to the DVL (Deutsche Versuchsanstalt für Luftfahrt) for experimental work. Eventually it went on display in the Aircraft Museum in Berlin, where it was destroyed in an Allied air attack during World War 2.

While the Do-X1 was making its world tour, two examples of the Do-X2 were being completed for Italy. These were basically identical to the first aircraft, but were powered by 550 hp Fiat A.22R liquid-cooled engines, mounted on 'solid' pylons but retaining the horizontal tubular support struts. Identified as I-REDI *Umberto Maddalena* and I-ABBN *Alessandro Guidoni*, they had been ordered originally by SA Navigazione Aerea for operation in the Mediterranean area, but were not after all so used. They were, however, used for a time by the *Regia Aeronautica* for experimental flying before being broken up.

28 **Blackburn Iris and Perth**

Although the majority of flying-boats employed by the Royal Air Force between the two World Wars were of Short or Supermarine design, the Blackburn Aeroplane and Motor Co produced small quantities of two three-engined types, each of which was, in its time, the largest flying-boat to serve with the RAF. The first of these, the Iris, was indeed the first large aircraft of this type to be built by Blackburn, whose only other venture into this area of aircraft design had been the small, single-seat N1B and Pellet. The latter was an unsuccessful civil design, built for the 1923 Schneider Trophy race, which crashed on its first attempted take-off. The design of the Iris, to Air Ministry Specification 14/24, began in 1924. The prototype (N185) was powered by three 650 hp Rolls-Royce Condor IIIA engines, had a wooden hull and was flown for the first time in 1927. In this form it was designated Iris I, but was rebuilt as the Iris II with a metal hull, taking part (as the flagship) in an RAF 'Baltic Cruise' of various flying-boat types later in the

same year. The next machine to be built (N238) was the prototype Iris III, in which the wings and tail also were of metal construction (though still fabric-covered), and modifications were made to the engine mountings and the interior layout. This aircraft was delivered to the RAF in November 1929, and in January 1930 No 209 Squadron – the only unit to operate the Iris – was formed at Mount Batten, Plymouth. Only three more Irises were built, originally as Iris III's with Condor engines. These carried a five-man crew, and standard armament consisted of three 0·303 in Lewis machine-guns, one each in open positions in the bow, amidships and at the tail. A 2,000 lb (907 kg) bomb load could be carried. The last Iris III had an enlarged cockpit in the bow, in which was mounted a 37 mm C.O.W. gun instead of the standard 0·303 in weapon. All three production Iris III aircraft were later fitted with 825 hp Rolls-Royce Buzzard IIMS Vee-type engines, in which form S1263 and S1264 were redesignated Iris V and S1593 became the Iris VI. (The Iris IV was the original prototype, N185, with an experimental installation of three 700 hp Armstrong Siddeley Leopard radial engines, the centre one driving a pusher propeller.)

The Iris VI paved the way for a slightly larger version, known as the Perth, which was produced as an Iris replacement in response to Air Ministry Specification 20/23. Four Perths were built, of which the first example (K3580) was flown in 1933. Powered by Buzzard engines, the Perth had a superior performance to the Iris III which included a maximum speed of 132 mph (212 km/hr) at sea level, a ceiling of 11,500 ft (3,505 m) and a maximum range of 1,300 miles (2,092 km). Crew complement and bomb load remained unchanged, as did the dorsal and tail armament, but fully-enclosed accommodation was provided for the two pilots in a redesigned hull. The bow station mounted both a 37 mm and a 0·303 in gun, the former being an automatic weapon firing a hundred 1½-pounder shells a minute. The fourth machine differed slightly, in having the centre one of the three upper-wing fuel tanks deleted. The Perth – the largest biplane flying-boat to serve with the RAF – replaced the Iris in service with No 209 Squadron in 1934, and when that unit re-equipped with Short Singapores two years later was transferred to No 204 Squadron until 1937.

29 **Dornier Do J Wal (Whale) and Do R Super Wal**

When World War 1 ended in 1918 the German Zeppelin-Werke at Lindau, headed by Prof Claude Dornier, had under construction a twin-engined all-metal flying-boat known as the Gs I. After the Armistice the design was modified for commercial operation, and it first flew on 31 July 1919, but the terms of the Armistice prohibited German manufacture and the Gs I was sunk at the Allies' request in April 1920. Similarly the completion of two 9-seater Gs II developments was banned, but between them the two designs provided the basis for a subsequent German flying-boat that was to become widely known.

This was the Do J, or Wal, whose prototype flew for the first time on 6 November 1922. Restrictions on German production of such an aircraft were still in force, but Dornier had circumvented these in 1922 by establishing an Italian company, Società di Costruzioni Meccaniche di Pisa, at Marina di Pisa, to build its products under licence. (This company became a Fiat subsidiary in 1929, and changed its title in 1930 to Costruzioni Meccaniche Aeronautiche SA (CMASA.) More than 150 Wals were built in Italy, including a number by Piaggio. First

customer for the Wal was the Spanish Navy, whose initial order, for six with 300 hp Hispano-Suiza engines, was completed in 1923. Overall production of the Wal totalled about three hundred aircraft, produced in a multiplicity of variants with a score or more of alternative powerplants and wing spans ranging from 73 ft 10 in (22·50 m) to 89 ft 2¾ in (27·20 m), which makes a detailed record virtually impossible. The Dornier company itself began Wal production in 1932, at Friedrichshafen, and other manufacturers included CASA in Spain (forty), Aviolanda in Holland (about the same number) and Kawasaki in Japan (three).

In 1933 CMASA built a version known as the Marina Fiat MF.5; those built by Dornier were designated Do JII and known as 8 ton or 10 ton Wals according to their metric gross weight. The latter version had a fully-enclosed crew cabin. The *Luftwaffe* designation Do 15 was applied to a military version of the 8 ton Wal ordered in 1933. Other military users of the Wal included the *Regia Aeronautica* and the Spanish and Netherlands navies. Commercial Wals were operated for many years, on passenger or mail-carrying services, by European and other airlines, among them Deutsche Luft Hansa and Aero Lloyd in Germany, Aero Espresso and SANA in Italy, Condor and Varig in Brazil, SCADTA in Colombia and Nihon Koku in Japan. Standard accommodation was 8–10 passengers and a crew of two. After a number of trial flights, DLH employed the Wal on its regular South Atlantic mail services from February 1934. The aircraft were launched by catapult from the depot ships *Westfalen* and *Schwabenland*, and a total of 328 crossings were made before the service was withdrawn.

A number of Wals featured in other noteworthy flights during the inter-war period. Two CMASA-built aircraft (N24 and N25) were purchased by Norway in 1925 for Roald Amundsen's attempt to reach the North Pole by air. The former aircraft had to be abandoned after reaching 87° 43′ N, the farthest north then reached by aeroplane, on 21 May 1925; N25 was later purchased by Englishman F. T. Courtney, re-registered G-EBQO and refitted at Pisa with 450 hp Napier Lion engines for an attempted trans-Atlantic flight. After two failures it was resold to Germany where, as D-1422 *Amundsen Wal* and fitted with 600 hp BMW VI engines, it was successfully flown to Chicago via Iceland, Greenland and New York by Wolfgang von Grunau between 20–26 August 1930. This was the first east-west crossing of the Atlantic by a flying-boat. This remarkable airman made a similar trip in 1931 in the *Grönland Wal* (D-2053), and a round-the-world flight in 1932. Between 22 January–10 February 1926 Major Franco of Spain, flying a Spanish-built Wal (M-MWAL *Plus Ultra*) with Napier Lion engines, made a spectacular crossing of the South Atlantic to Buenos Aires. He left from Palos de Moguer, near Huelva – the port from which Columbus had sailed for America – and completed the 6,258 mile (10,072 km) journey in 59½ flying hours.

On 30 September 1926 the prototype was flown of an enlarged development, the Do R Super Wal, which was powered by two 650 hp Rolls-Royce Condor engines. Comparatively few twin-engined Super Wals were built, however, the majority of production aircraft having four engines (two tandem pairs) mounted above the wing. First flight of the four-engined version was made on 15 September 1928. Normal seating was for up to 19 passengers, though at least one version seated 29 people. Sixteen Super Wals are known

to have been built at Friedrichshafen, of which six were delivered to Deutsche Luft Hansa: one twin-Condor-engined machine, one with four 450 hp Lions and four with licence-built Jupiter engines. Six other Jupiter-engined aircraft went to the Italian operator SANA; two to Severa Gmbh (the prototype and one with two 800 hp Packard engines); and two to Stout D & C Air Lines with four 525 hp Pratt & Whitney Hornet radial engines. A military version, with four inline engines, was placed in production by CASA in Spain in 1928, but it is not known how many of this version were built.

30 CRDA Cant Z.501 and Z.506

After acquiring the services of Ing Filippo Zappata, the former Cantiere Navale Triestino changed its name in 1931 to Cantieri Riuniti dell' Adriatico, subsequently producing a number of seaplanes and flying-boats for both civil and military purposes. First product of the new CRDA organisation was the Z.501 Gabbiano (Seagull) flying-boat, a single-engined aircraft which flew for the first time at Monfalcone, Trieste, in 1934. This aircraft (I-AGIL) established a world distance record for seaplanes in October of that year, when it flew 2,560 miles (4,120 km) non-stop from Monfalcone to Massawa in Eritrea. It lost the record to a French aircraft shortly afterwards, but recaptured it in July 1935 with a 3,080 mile (4,957 km) flight from the same starting-point to Berbera in Somaliland. The Gabbiano had been designed, however, as a maritime reconnaissance-bomber, and it was in this role that it entered service with the *Regia Aeronautica* in 1936. Of wooden construction, with fabric-covered wings and tail, it originally carried a single 7·7 mm Breda-SAFAT machine-gun in each of three positions: an open position in the bow and semi-enclosed positions in the mid-upper fuselage and in the rear of the over-wing engine nacelle. On racks attached to the inner wing bracing struts a variety of small bombs, up to a maximum load of 1,410 lb (640 kg), could be carried. Some Z.501's saw action in the Spanish Civil War of 1936–39, and a small number was purchased by Rumania in 1937–38. When Italy entered World War 2 in June 1940 there were two hundred and two Gabbianos serving with the *Regia Aeronautica*, equipping seventeen maritime reconnaissance squadrons and a number of other units. The type was still in service at the Italian armistice in September 1943, and continued to operate in limited fashion thereafter with both factions of the divided Italian air force. Armament was reduced during the war, with the removal of the nose gun and enclosing of the observer's station in this position.

The next known Zappata flying-boat design, the Z.504 of 1935, was an unsuccessful 2-seat biplane fighter, but during the first half of the following year the prototype was flown of a more significant aeroplane, the Z.506 twin-float commercial seaplane. This aircraft (registered, appropriately, I-CANT), was powered by three Pratt & Whitney Hornet radial engines, but for commercial operation the aircraft was produced as the Z.506A (760 hp Wright Cyclone engines) and Z.506C (750 or 800 hp Alfa Romeo 126 engines). The Italian airline Ala Littoria operated both models, and the Z.506C was responsible for setting up several international seaplane records for distance-with-payload and speed.

The Z.506B, named Airone (Heron), was a military model which entered production in 1937 for a reconnaissance-bomber role with the *Regia Aeronautica*. Powered by three 750 hp Alfa Romeo 126 RC 34 radial engines, it differed from the civil versions chiefly in having

a long ventral gondola and a dorsal gun turret. The former incorporated a weapons bay for a 1,764 lb (800 kg) torpedo or up to 2,204 lb (1,000 kg) of bombs, to the rear of which was a ventral 7·7 mm Breda-SAFAT machine-gun position. The Breda M.1 dorsal turret mounted a 12·7 mm weapon. Thirty-two of this version – the Serie I – were built, some of which were operational in Spain towards the end of the Civil War; manufacture of subsequent series, with detail differences, had raised to ninety-five the number built by the time of Italy's entry into World War 2, some of these being produced by Piaggio. Included in this total were twenty-nine of an order for thirty placed by Poland in 1938. Only one had been delivered before the German invasion, and the rest were diverted to the *Regia Marina*. The Airone's initial wartime role was that of bomber, but during the latter half of 1941 it began to be transferred to maritime patrol and convoy escort duties. Some, converted for air/sea rescue duties, were redesignated Z.506S; five of these, together with twenty-three Z.506B's, were operated by the Co-Belligerent Air Force after the Italian Armistice in September 1943, the latter type being used as a transport aircraft. Overall production figures for the Airone are not known, but it was produced in several versions, of which the major one was the Serie XII, with an improved form of dorsal turret, two 'midships 7·7 mm guns firing laterally, and the maximum bomb load increased to 2,645 lb (1,200 kg). The Airone continued in service with the post-war Italian Air Force, on transport and air/sea rescue duties, until 1959.

Other known civil variants included the Z.505, a long-range model with a lengthened fuselage and 830 hp Isotta-Fraschini Asso XI-R Vee-type engines; one landplane example of the Z.506; and the Z.509, with 1,000 hp Fiat A.80 RC 41 radial engines. None of these is known to have entered production.

31 & 32 Short Calcutta, Kent and Singapore

During the years between the two World Wars, Short Brothers were responsible for a considerable variety of water-borne aircraft, many of which became famous in RAF or commercial service. The tiny Cockle and the celebrated 'C' class 'Empire' flying-boats of Imperial Airways are dealt with elsewhere in this volume, as are the wartime Sunderland and its post-war derivatives; the Calcutta and Singapore have been chosen to illustrate typical examples of the company's multi-engined biplane flying-boats during the inter-war years.

The S.8 Calcutta, flown for the first time on 14 February 1928, was built to the requirements of Imperial Airways' Mediterranean sector of its England-India service, and was designed as a three-engined development of the Singapore I. G-EBVG, later named *City of Alexandria*, was the first of two originally ordered by the airline, the other being G-EBVH *City of Athens*. The Calcutta, which had standard seating accommodation for 15 passengers, is important historically as the first flying-boat with a metal-skinned hull to go into regular commercial operation. Imperial Airways ultimately bought five of these aircraft; it lost one in 1929, but the remaining four gave yeoman service until the second half of the 1930s. One other was built for the French government, after which four were built under licence by Breguet, from which the French company developed its own Bre 521 Bizerte flying-boat (*q.v.*). A sixth British machine, the S.8/8 Rangoon, was flown on 24 September 1930 in RAF markings as S1433, equipped with two 0·303 in Lewis guns amidships, a third on a Scarff ring mounting in the nose, and provision for carrying a 1,000 lb (454 kg) bomb load. This aircraft was built in response to Air Ministry Specification R.18/29, and was followed by five other Rangoons. They served initially, from 1931, with No 203 Squadron in Iraq, returning to the UK in August 1935 for service with No 210 Squadron at Pembroke Dock.

An account of Short flying-boats in Imperial Airways service would be incomplete without mention of the three S17 Kent 'boats, generally considered the ultimate in airline flying-boat comfort for their time. First to fly, on 24 February 1931, was G-ABFA *Scipio*, followed by G-ABFB *Sylvanus* and G-ABFC *Satyrus*. Basically an enlarged, four-engined development (555 hp Jupiter X FMB radials) of the Calcutta, the Kent entered service in mid-1931. By August 1932 the three 'boats had between them flown 266,319 miles (428,600 km) without one breakdown from mechanical failure.

Design of the Singapore began, as its S.5 designation indicates, before that of the Calcutta. This designation applied to the Singapore I (N179), which was ordered in 1925 to Specification 13/24 and first flew on 17 August 1926. It was powered by two 650 hp Rolls-Royce Condor IIIA engines, had unequal-span wings, a single main fin and rudder and twin auxiliary rudders. The Singapore I did not go into production, but during 1927–28 the Air Ministry loaned N179 to Sir Alan Cobham, and it was in this aircraft (re-registered G-EBUP) that he made his remarkable 23,000 mile (37,015 km) round-Africa flight which did much to pave the way for subsequent Imperial Airways services across the continent. A four-engined development, the S.12 Singapore II (N246), was flown on 27 March 1930. This aircraft retained the unequal-span wings of its predecessor, but had – at first – a single fin and rudder. Four Vee-type engines were installed as tandem pairs, back-to-back in twin nacelles mid-mounted on sturdy struts between the upper and lower wings. A triple-fin-and-rudder tail assembly was introduced later, and with Specification R.3/33 the Air Ministry ordered four pre-production aircraft developed from this which became known as S.19 Singapore III's. The first Singapore III (K3592) was flown on 15 June 1934, and subsequent small batches brought the total number of this version built to thirty-seven, all of which were delivered by mid-1937. Early production machines, which had 640 hp Kestrel IIIMS/IIMS engines, went into service in April 1935 with No 230 Squadron; Singapore III's ultimately served with Nos 203, 205, 209, 210 and 240 Squadrons in various parts of the world, some remaining in use for a time after the outbreak of World War 2. They carried a crew of six and a bomb load of 2,000 lb (907 kg).

33 Supermarine Southampton, Scapa and Stranraer

Between them, these three biplane flying-boats for the RAF bridged the entire period between the two World Wars, the Southampton succeeding the Felixstowe F.5 and the Stranraer serving until replaced by the Short Sunderland in 1939. Indeed, only the Sunderland served longer than the Southampton, which first entered service in September 1925 and remained in use for more than ten years. The Southampton prototype (N218) was developed, from the Swan civil flying-boat, to meet the requirements of Air Ministry Specification R.18/24, and was the first post-war-designed flying-boat to join the RAF. A small batch of Southampton Mk I's was built, resembling the prototype in having wooden hulls, and the first of these were

delivered to No 480 (Coastal Reconnaissance) Flight at Calshot; in January 1929 this unit was re-formed as No 201 Squadron. Principal RAF version was the Mk II, which introduced an anodised duralumin hull that lessened the structural weight by 540 lb (245 kg) and permitted an additional substantial weight saving by eliminating the absorption of water. Seventy-eight Southamptons in all were built, including a few Mk III's, and the type served with Nos 201, 203, 204, 205 and 210 Squadrons in the UK, Iraq and Singapore. During their service they made many noteworthy long-distance flights, of which the best-known was a 27,000 mile (43,450 km) tour by the RAF's Far East Flight (later No 205 Squadron) between October 1927 and December 1928.

The name Southampton IV was applied at first to a developed version which appeared in 1932 with a much-refined structural design (by R. J. Mitchell) and 525 hp Rolls-Royce Kestrel IIIMS engines in place of the Southampton's two 500 hp Napier Lions. This aircraft, which was renamed Scapa in October 1933, had fabric-covered wings as well as an all-metal hull, and twin fins and rudders of similar contours to the triple assembly of the Southampton. The earlier type's tandem open cockpits gave way to an enclosed cabin with side-by-side seating for the two pilots. Three other crew members were carried, and armament, as in the Southampton, consisted of one 0·303 in Lewis gun in the bow and two amidships. Bomb load was 1,000 lb (454 kg), compared with the Southampton's 1,100 lb (499 kg). Maximum weight went up from 15,200 lb (6,895 kg) to 16,040 lb (7,275 kg), but speed was increased from 108 mph (174 km/hr) to 141·5 mph 227·7 km/hr) and range from 770 miles (1,239 km) to 1,100 miles (1,770 km). The prototype (S1648) was followed by fifteen production Scapas, built to Specification 19/33 all of which had been delivered by the end of 1935. They served initially with No 202 Squadron in Malta, and later with Nos 204 and 240 in the UK.

The Southampton name was also perpetuated briefly for a further prototype (K3973) which appeared in 1935; although renamed Stranraer in August of that year, it was originally known as the Southampton V and was evolved in response to Air Ministry Specification R.24/31. Though much larger than the Scapa, it retained a substantially similar hull form, had sweptback wings with extended-span upper planes, and a redesigned twin-fin-and-rudder tail unit. Powerplant of the prototype was a pair of Bristol Pegasus IIIM radial engines driving two-blade wooden propellers, but production Stranraers (of which seventeen were built in Britain) had the more powerful Pegasus X engine with three-blade metal propellers. Forty more Stranraers were built in Montreal by Canadian Vickers Ltd for operation by the RCAF. First RAF deliveries were to No 228 Squadron in December 1936; later squadrons to use the type included Nos 201, 209 and 240, all based in the UK. Some continued in RAF service until mid-1940; those of the RCAF were withdrawn in 1943. Bomb load of the Stranraer was similar to that of the Scapa, but the crew complement was increased to six men, necessitated by the rearrangement of the three defensive guns singly in bow, dorsal and tail positions. One of the Canadian-built Stranraers, re-engined post-war with Wright Cyclone engines, still survived (though no longer in flying condition) in 1970.

34 & 35 **Savoia-Marchetti S.55 and S.66**

Ing Alessandro Marchetti became chief designer and technical director of the

Società Idrovolanti Alta Italia (S.I.A.I.) in 1922, three years after an S.13 flying-boat produced by the Savoia company had (morally) won the race for the Schneider Trophy. During his first eight years he was responsible for a series of flying-boat and amphibian designs, large and small, of which undoubtedly the most famous were the twin-hulled S.55 and S.66.

Design of the S.55 began in 1923, as a twin-engined torpedo-bomber and minelaying aircraft for the *Regia Marina*, and the prototype flew for the first time in August 1924. The powerplant consisted of two 400 hp Lorraine-Dietrich Vee-type engines (licence-built by Isotta-Fraschini). These were mounted back-to-back on a pylon structure above the wing centre-section, driving one tractor and one pusher propeller. The entire wing was extremely thick, and the centre-section, which bridged the gap between the two hulls, accommodated the pilots' open cockpit in its leading-edge. The weapon load of bombs, mines or torpedoes was suspended beneath the centre-section. In the rear of each hull was an observer's cockpit with a Scarff ring mounting for a 7·7 mm machine-gun, and each hull supported an open-work rear boom structure carrying the twin fin and triple rudder tail assembly. Construction of the S.55 was of wood, with plywood and fabric covering. The military version, of which about two hundred were built, was designated S.55M. Late in 1925 Savoia-Marchetti produced the first example of a commercial counterpart, the S.55C; about half a dozen of this version were built for Aero Espresso Italiana, which inaugurated a Brindisi-Constantinople service with the S.55C in August 1926. The powerplant was similar to that of the S.55M, and provision was made to accommodate up to 5 passengers in each hull. An improved version, the S.55P, appeared in 1928, with 500 hp Isotta-Fraschini Asso engines and deeper hulls with accommodation for 4–6 passengers in each. About fifteen of this version were built for Società Aerea Mediterranea, some with Asso engines and some with 750 hp Fiat A.24R's. Two S.55's (version unknown) were delivered to the USA, where one other example was built under licence by the American Aeronautical Corporation.

It was, however, the military S.55's which captured the headlines. No less than fourteen world records were set up by the type in 1926 for speed, altitude and distance attained with various payloads, and in 1927–28 other S.55's made memorable trans-oceanic flights to both North and South America. In 1930 there appeared the S.55A (750 hp Fiat A.24R or 800 hp Asso engines), with which the first of the now-famous mass flights across the Atlantic were made. Twelve S.55A's, led by General Italo Balbo, the Italian Air Minister, made a 6,500 mile (10,460 km) formation flight from Rome to Rio de Janeiro during the year. Three years later Balbo led an even more impressive flight by four squadrons (twenty-four aircraft, plus one reserve) from Rome to Chicago for the World's Fair, the outward journey of 6,065 miles (9,760 km) being made in 48¾ hours. The aircraft flown on this occasion were of the S.55X model with a more streamlined structure and 750 hp Asso engines driving three-blade metal propellers. A trans-Siberian flight of some 14,000 miles (22,530 km) was made by other aircraft of the S.55 type in 1932. The military versions remained in service until the end of the decade, thirteen still being owned by the *Regia Marina* in 1939. By then, however, they had become obsolete, and none is known to have seen wartime service.

The S.66, in essence, was an enlarged

development of the S.55, with three separately-mounted engines and a greater carrying capacity. It was built only as a commercial flying-boat, the prototype (I-ABRA) flying in 1932 with 550 hp Fiat A.22R Vee-type engines. These were later replaced by more powerful A.24R engines, which became the standard powerplant for production aircraft. At least twenty-three S.66's are known to have been built, which operated variously with Aero Espresso, SAM and Ala Littoria. Accommodation was for 14/18 passengers. Sixteen were still in airline service early in 1939, and after Italy's entry into World War 2 in 1940 a small number were reportedly employed for a while as air/sea rescue aircraft.

36 **Breguet Bizerte and Saïgon**

The Bizerte and Saïgon were, respectively, military and civil developments by Breguet of the Short Calcutta, four of which were built by the French company in 1931–32. First to appear was the Bizerte, whose Bre 521-01 prototype was flown for the first time at Le Havre on 11 September 1933, powered by three uncowled 845 hp Gnome-Rhône 14 Kdrs radial engines. Flight testing continued throughout most of the following year, and in April 1935 the aircraft began operational service tests with *Escadrille* E1 of the French Navy at Cherbourg. Meanwhile three pre-production aircraft had been ordered, the second of which differed from its two predecessors in having the cockpit enclosure extended forward to the tip of the nose, with gun blisters to either side at the rear of the cabin instead of the original open gun position in the bow. Each blister housed a forward-firing 7·5 mm Darne machine-gun, two similar weapons being installed aft of the wings (to fire laterally through sliding hatches) and a fifth in the extreme tail. A crew of eight was normally carried. Production Bizertes were ordered a few at a time, the first examples entering service with *Escadrilles* E2 and E3 late in 1935. Twelve had been built by the end of 1936. The last of these (designated Bre 522) was fitted experimentally with Hispano-Suiza 14AA radial engines, but the standard powerplant for production Bizertes was three Gnome-Rhône 14 Kirs 1 engines. Deliveries had reached twenty-eight aircraft by the end of 1938, by which time Breguet's Le Havre factory had been acquired by the SNCA du Nord. Shortly after the outbreak of World War 2 an additional twelve Bizertes were ordered, for which 900 hp Gnome-Rhône 14 N series and minor detail improvements were specified, but in the event only three of this version were completed. During the early part of the war the Bizertes served over the Atlantic and Mediterranean with *Escadrilles* E1, E2, E6 and E9 (order of the designation letters and numerals was reversed in 1941), mainly on reconnaissance duties, although they were capable of carrying four 165 lb (75 kg) bombs beneath the lower wings. Only 1E and 9E were kept in being to serve with the Vichy Navy after the French surrender, and those of *Escadrille* 9E (plus four others from store) were subsequently taken over and used by the *Luftwaffe* as air/sea rescue aircraft.

The commercial counterpart of the Bizerte, the Bre 530 Saïgon, was built to the order of the French airline Air Union, which had become a part of Air France by the time that it entered service. Only two Saïgons were completed, the first of these (F-AMSV *Algérie*) making its maiden flight in May 1934. Accommodation was for a crew of two and 19 or 20 passengers in three cabins: two or three in the 'de luxe' rear cabin, six first-class amidships and eleven second-class in the forward cabin, with a toilet and baggage hold at the rear of

the hull. Powerplant was three 785 hp Hispano-Suiza 12 Ybr twelve-cylinder Vee-type engines. Services across the Mediterranean, by *Algérie* and her sister 'boat F-AMSX *Tunisie*, began on 2 January 1935. Plans were made for a long-range development, to be called the Dakar, for trans-Atlantic mail and freight transport, but this version was not built.

37 **Sikorsky S-40 and S-42**

Seemingly unaffected by the prevailing economic depression, the air transport business continued to grow during the closing years of the 1920s. One of the most thriving airlines at that time was Pan American Airways, which at the end of 1929 boasted a total fleet of forty-four aircraft. A large proportion of its route network was spread over water, and to meet the growing need for greater size, speed and range PAA contracted with Sikorsky Aircraft for an amphibious aircraft with a range of 950 miles (1,530 km) or a maximum capacity for 40 passengers and a ton of baggage or freight over shorter distances. This resulted in the S-40, three of which were built for Pan American. The first of these was flown in August 1931, christened *American Clipper* two months later, and the S-40 went into regular operation the following year on the airline's Caribbean routes. The era of luxurious trans-oceanic air travel had begun.

At the time of its construction the S.40 was the largest aeroplane to be built in the USA, and was powered by four 575 hp Pratt & Whitney Hornet radial engines mounted on the wing-bearing struts. A wheel landing gear was fitted to provide against possible forced landings over land areas, such as Cuba, en route.

The S-40 had not been in service for long before Pan American announced a further requirement, for an even larger, faster and longer-range seaplane – one with a 2,500 mile (4,025 km) non-stop range carrying 12 passengers. Both Sikorsky and Martin submitted designs to meet this requirement, the S-42 and M-130 respectively. The S-42 was the first to be completed, and the prototype was flown on 29 March 1934. The PanAm specification had necessitated the evolution of a much more modern design than the S-40, and the S-42 represented a considerable advance over its predecessor. Apart from small areas of the wings and tail it was of all-metal construction, with a flush-riveted skin, two-step hull, wing-mounted Hornet engines with three-blade variable-pitch propellers, and split trailing-edge wing flaps. The wings were carried above the hull on a faired superstructure and braced by two struts on each side; stabilising floats beneath the outer wings were preferred to the more fashionable hull-mounted 'sea wings' or sponsons. During its development programme the S-42 set up ten payload-to-height records, and ten were ordered (three S–42's, four S–42A's and three S–42B's. From April 1935 the S-42's went into service with Pan American, initially between San Francisco and Hawaii and subsequently on the New York–Bermuda, Miami–South America and Manila–Hong Kong routes of the PAA system. Normal seating accommodation was for 32 daytime passengers and a crew of five, the former divided equally between four cabins. A 14-passenger 'sleeper' configuration was evolved, but seldom if ever used. On short stages the S-42A could carry up to 40 passengers by adapting the forward baggage/freight compartment as an additional cabin. But, even with the payload reduced to 12 passengers, the S-42A's range was still well below that required, and in due course the Martin M-130 operated over the longer stages, the Sikorsky

serving on the Manila–Hong Kong sector of the China route.

The designation S-42B was applied to three aircraft equipped with additional fuel tanks (total load 2,414 US gallons = 9,137 litres) to carry out survey flights over both the Atlantic and Pacific. One S-42B was used during 1935 to survey the trans-Pacific routes to Manila to be flown later by the airline's M-130 'China Clipper' flying-boats. Another, NC 16736 *Pan American Clipper III*, made three out-and-back survey flights across the North Atlantic in the summer of 1937. (The generic name 'Clipper' was applied by PAA to all types of flying-boat – and there were several – in service on its world-wide network. At one time it had no fewer than fourteen types of water-borne aircraft in its fleet, with passenger seating capacities ranging from 6 to 40, and several of these were flying-boats or amphibians of Sikorsky design.) Pan American began regular trans-Atlantic services, with Boeing 314 flying-boats, on 23 May 1939.

38 **Short Cockle**

The first all-metal-hull flying-boat ever built, and at the time the smallest also, the tiny Cockle was a single-seat monoplane which brought to the realm of the seaplane a new form of construction first heralded by the Short Silver Streak landplane four years earlier – a circular-framed fuselage covered with a stressed skin of duralumin sheet. This constructional approach was to receive its first operational application only a few years later in the much larger Singapore and Calcutta flying-boats.

Apart from the obvious advantage of metal over wood in durability, it also eliminated one of the major drawbacks of the wooden-hulled flying-boat – its natural tendency to soak up large quantities of water, which not only affected performance by adding to the weight of the aeroplane but contributed to its eventual deterioration. Credit for the evolution of the experimental Cockle goes chiefly to Oswald Short, who encouraged it, and to Francis Webber, with whom he designed it. Originally known as the Stellite, the aircraft was also the first Short Brothers design to bear a manufacturer's designation, S.1. The name was subsequently changed at the request of the Air Ministry, to avoid confusion with another Short design, the Satellite. It was launched at Rochester on 18 September 1924, and for more than half an hour tried unsuccessfully to take off. Eventually, after alterations to the wing's angle of incidence, it was able to make its first flight on 7 November 1924, but was really too heavy for the available power – only half that of the two 32 hp Bristol Cherub engines which it had originally been intended to install. At the beginning of 1925, to improve directional control, the Cockle was given a much-enlarged fin and rudder of a new and taller shape and horizontal tail surfaces of increased chord. Six months later, having failed in two attempts to obtain a civil Certificate of Airworthiness, the Cockle was handed over to the Air Ministry on loan for trials at the Marine Aircraft Experimental Establishment at Felixstowe, replacing its civil identity (G-EBKA) with the RAF serial N193. The MAEE was appreciative of the anti-corrosion qualities of the hull, but take-off difficulties were still being encountered and it was returned to Rochester in August 1926. Here a pair of Cherub II engines were installed, but again the Cockle was unlucky, for one of them misfired during the first attempted take-off on 14 June 1927. A successful flight was, however, achieved three days later, and in subsequent tests the Cockle clocked 73 mph (117·5 km/hr). But this was almost its last flight, for the Air Ministry then purchased the machine outright for use by the MAEE in research into the question of salt-water corrosion. It made its last flight on 3 October 1927.

39 **Short 'C' class and 'G' class**

Almost 38 million miles – equivalent in distance to more than 150 journeys to the Moon and back – were flown by the forty-two 'C' class flying-boats of Imperial Airways/BOAC in more than a decade of service, from 1936–47; *Canopus* alone flew some 2,800,000 miles (4,506,200 km) during her career. Seldom in commercial aviation history has such an airline gamble paid off so well. The Short 'C' class flying-boat's *raison d'être* lay in the British government's Empire Air Mail Scheme, approved in 1935, whereby all mail between countries in the British Empire would be carried without a surcharge. To implement this policy, Imperial Airways required a new fleet of aircraft capable of carrying large payloads at high cruising speeds between the countries concerned. The airline's Technical Adviser, Major R. H. Mayo, drew up a specification for such an aeroplane, and Short Brothers Ltd at Rochester were asked to build it. Demand for the aeroplane left no time for a normal prototype development programme, but Imperial Airways' faith in the design by Arthur Gouge's team was such that it ordered a fleet of twenty-eight aircraft, at a total cost of £1¾ million, 'off the drawing-board'. Many of the essential features (including the Gouge flaps which, when extended, increased the wing area by 30 per cent) were scale-tested on the Scion and Scion Senior or in test tank and wind tunnel, but nevertheless the S.23 flying-boat was the largest passenger-carrying British monoplane at that time to have been put into wide-scale production, and some of its design features could only be evaluated when the aircraft itself was flown. The first flight was made on 4 July 1936 by G-ADHL *Canopus*, which later became the flagship of the fleet; it received its Certificate of Airworthiness on 20 October 1936 and went into airline service on the last day of the month. Subsequent deliveries were made at an average rate of two per month, and through services to Australia and South Africa were inaugurated during 1937. The 'C' class (so called because individual aircraft each received a fleet name beginning with that letter) had a two-deck hull layout, the upper deck being designed to accommodate a 3,000 lb (1,361 kg) mail and freight payload and the lower deck furnished to seat 24 daytime passengers or 19 in a sleeper layout. However, so successful was the Empire Air Mail Scheme that the passenger maximum was reduced to 17, enabling an additional half a ton of mail to be carried. Altogether, thirty-one of the S.23 version were built, three additional aircraft being built and delivered early in 1938 to join three others which were transferred to Qantas in Australia. The operational success of the 'C' class, however, was not achieved without setbacks, for during their first two and a half years of operation no fewer than eight were lost in fatal crashes – though in most cases the aircraft's design was not at fault. Nine examples of a 'heavyweight' version, the S.30, were built, eight of these having 890 hp Bristol Perseus XIIC engines and a gross weight of 48,000 lb (21,772 kg) or 53,000 lb (24,040 kg). The four of the latter weight, equipped for in-flight refuelling, were intended for trans-Atlantic operation. This followed experimental long-distance flights in 1936–37 by the S.23 'boat *Caledonia* (G-ADHM), equipped with additional fuel tanks; aerial refuelling tests were conducted with *Cabot* (the only Pegasus-engined S.30) and *Caribou*

in spring 1939, and these two 'boats inaugurated a regular trans-Atlantic service on 8 August, making eight return flights in the four weeks before the outbreak of World War 2. Production of the 'C' class was completed with two designated S.33, which were essentially similar to the S.23; completion of a third S.33 was abandoned in 1940. The 'Empire Boats' had an eventful wartime career, flying much of the time on sectors of BOAC's 'Horseshoe Route' via East Africa and India to Australia. Two S.30's and two S.23M's (for Military) operated with No 119 Squadron of the RAF, three being lost during the war. Many of the BOAC machines, including three on loan to the RAAF, were lost during war service, but thirteen of the class survived the war. By then they had been refitted with with 1,010 hp Pegasus 22 engines. They continued, in diminishing numbers, to serve for a further two years, but all had been withdrawn by the end of 1947.

One additional flying-boat, the S.21 *Maia*, was built to essentially the same design as the 'C' class. This formed the lower component of the Short-Mayo composite aircraft, which is described separately.

Three examples were also built of the larger S.26 'G' class (G-AFCL *Golden Hind*, G-AFCJ *Golden Fleece* and G-AFCK *Golden Horn*). With four 1,380 hp Bristol Hercules IV engines and a gross weight of 73,500 lb (33,339 kg), they were ordered for non-stop services across the Atlantic but were instead impressed for RAF service as armed VIP transports. Two were lost during the war, but *Golden Hind* survived until 1954, when it was wrecked in harbour by a storm.

40 **Martin M-130**

Second of the huge trans-oceanic flying-boats used by Pan American Airways System between the wars, the Martin Model 130 resulted from the same specification to which Sikorsky had evolved the S-42. Unlike the Sikorsky design, however, the Martin 'China Clipper', as it was to become known, truly possessed the long overwater capability that the airline required. PanAm's planned trans-Pacific route to the Philippines was San Francisco–Honolulu–Midway Island–Wake Island–Guam–Manila, the five stage lengths being, respectively, 2,410, 1,380, 1,260, 1,450 and 1,550 miles (3,880, 2,220, 2,030, 2,335 and 3,220 km). To accomplish this it required an aircraft with a non-stop range of 2,500 miles (4,025 km) carrying 12 passengers, which even by mid-1930s standards was hardly an economic payload/weight ratio. While the routes were being surveyed in 1935 by S-42B, Martin was building three M-130's, which in service were named *China Clipper* (NC14716), *Philippine Clipper* and *Hawaii Clipper*. Of all-metal construction, the M-130 had a two-step hull, the upper portions of which were clad in corrugated duralumin sheet, and sponsons (sometimes called 'sea wings') were fitted to the hull sides at cabin floor level. These aerofoil-shaped surfaces fulfilled a dual function: they helped to stabilise the aeroplane while resting or manoeuvring on the water, and served also as storage areas for nearly half of the flying boat's 3,800 US gallon (14,383 litre) fuel load. Retractable platforms were built into the leading-edge of each wing on either side of each engine nacelle, to provide access for servicing the engines, two of which were completely changed every three trips. The flight crew of five comprised captain, first officer, radio officer, flight engineer and steward. Aft of the flight deck, in order, were the forward passenger compartment, lounge and two rear passenger compartments. Each passenger compartment could accommodate 8

seats or 6 sleeping berths, and the lounge seated 12. Since the long-distance payload was only 12 passengers altogether, one can appreciate the declaration by one American observer that passengers 'rattled around in the vast expanse of hull in a degree of comfort never known before'.

Proving flights were made in late 1935 and early 1936, *China Clipper* making the first-ever commercial double crossing of the Pacific between 22 November and 6 December 1935. The full, regular trans-Pacific M-130 service opened on 21 October 1936, the flight spanning five days and occupying a total of 60 hours actual flying. By 1940 (*Hawaii Clipper* having been lost at sea) the surviving pair of M-130's had accumulated some 10,000 flying hours each – equal to an average daily utilisation of 5½ hours – and had flown 12,718,200 passenger miles (20,467,930 passenger-km) in addition to express and mail flights. In 1942 they were impressed for war service as US Navy transports, though not given a Naval designation. *China Clipper* was wrecked early in 1945, shortly after the tenth anniversary of its first flight, when it struck an unlit boat during a night landing.

An even larger flying-boat than the M-130 was built by Martin in 1937. This was the Model 156, whose design followed closely that of its predecessor except for the provision of twin fins and rudders. Powered by four 1,000 hp Wright Cyclone engines, it could accomodate 33–53 passengers (compared with a maximum of 52 in the M-130) and had a gross weight of 63,000 lb (28,576 kg).

41 **Short-Mayo composite**

This remarkable experiment was inspired by Major R. H. Mayo, Technical Adviser to Imperial Airways, as a solution to the airline operator's perennial problem of increasing the range and payload of its aircraft without a corresponding sacrifice in performance. Reasoning on the basis that a large proportion of an aircraft's gross weight is taken up by the fuel load necessary for taking off and climbing to its cruising altitude, he conceived the idea of a composite – one aircraft, carrying the payload, mounted pick-a-back fashion on top of a second machine which would contribute the fuel and most of the necessary power for the take-off and initial climb. His ideas, with Air Ministry approval, were put to Short Brothers Ltd for implementation, and design work on this project began prior to that for the S.23 'C' class flying-boats. The composite designs were designated S.20 and S.21, the former being a comparatively small, four-engined, twin-float seaplane (G-ADHJ *Mercury*) and the latter a large four-engined flying-boat (G-ADHK *Maia*). *Maia* was essentially similar in design and construction to the subsequent S.23 'boats, the most noticeable differences being a broader hull beam, with a wider flare at the bow, more widely-spaced outer engines and increased wing and vertical tail area. Above the wing centre-section a trapeze-like structure was attached, on to which the *Mercury* seaplane was lowered by a hoist. When flown separately, *Mercury* had a gross weight of 15,500 lb (7,031 kg), but when air-launched from *Maia* this could be increased by 5,300 lb (2,404 kg) – a dramatic indication of its potential for carrying heavier payloads. The two aircraft were first flown separately, *Maia* for the first time on 27 July 1937 and *Mercury* on 5 September. The first flight as a composite was made on 20 January 1938, and the first air launching of *Mercury* from *Maia* on 6 February. On 21 July 1938 the composite made its first commercial flight, *Mercury* separating

over Foynes in Ireland and flying non-stop to Montreal in 20 hr 20 min with a nominal payload of 600 lb (272 kg). For take-off and flight together, all four engines in each aircraft were used, but *Mercury*'s control surfaces were locked until it separated from *Maia*. On 6 October 1938, refitted with 370 hp Rapier VI engines, *Mercury* was air-launched after a take-off from Dundee and made a 6,045 mile (9,728 km) non-stop flight to the head of the Orange River in South Africa which established a new international distance record for seaplanes. Pilot of *Maia* during the July 1938 trans-Atlantic flight was Captain A. S. Wilcockson, one of Imperial Airways' senior officers, who had also commanded the 'C' class flying-boat *Caledonia* on the first Atlantic crossing by an aircraft of that type on 5–6 July 1937. In command of *Mercury* on its trans-Atlantic and South African flights was Captain D. C. T. Bennett, later to achieve even greater fame during World War 2 as the RAF officer in charge of Bomber Command's 'Pathfinder' Force and as the post-war head of British South American Airways.

Although there was no serious doubt about the success of the Short-Mayo pick-a-back experiments, the advent of flight refuelling techniques and the intervention of war, which spurred the evolution of long-range aircraft independent of such assistance, rendered further exploration of the concept unnecessary from a commercial viewpoint. Nevertheless, the idea did reappear during World War 2. Shorts and Hawker prepared plans for a Liberator/Hurricane composite for Atlantic convoy protection, which were not put into effect, but in Germany the *Luftwaffe* made limited use of Fw 190 and Bf 109 fighters mounted pick-a-back on unmanned Ju 88 bombers packed with explosive for release as *Mistel* (Mistletoe) pilotless missiles.

42 **Heinkel He 59**

Intended originally for the torpedo-bomber/reconnaissance role, and designed at a time when the secretly-forming *Luftwaffe* was still very much in an embryo state, the Heinkel He 59 stayed in service, performing a variety of duties, for more than ten years. All production He 59's were floatplanes, although when designed by Reinhold Mewes in 1930 provision had been made for the aircraft to operate from either wheels or floats and the second of the two prototypes was indeed completed as a landplane. This aircraft (D-2215) was the first of the type to fly, in September 1931; it was followed by the twin-float prototype, D-2214, in the following January. In the spring of 1932 production was initiated with an evaluation batch of fourteen He 59A floatplanes and a generally similar batch of sixteen He 59B's, all of which were unarmed and carried a crew of two.

The first armed version was the He 59B-1, in which a single 7·9 mm ring-mounted MG 15 machine-gun was installed in an open cockpit in the nose; similar guns were installed in dorsal and ventral positions in the four-seat He 59B-2, in which glazed positions were introduced in the nose and ventral step for bombardier and gunner. Weapon load comprised a single torpedo or up to 2,204 lb (1,000 kg) of bombs. Large orders were placed for the B-2, which went into operational service in the Spanish Civil War from 1936, and a proportion of these were undertaken by the Arado company. (One Arado-built B-2 was used in 1937 to flight-test the nose section of a new and larger twin-float seaplane, the He 115. A description of the He 115 appears in the *Bombers 1939–45* volume in this series.) The He 59 was first used in Spain for night bombing, but a later application was in the role of anti-shipping aircraft, for which some B-2's were given a reinforced nose mounting a movable 20 mm MG FF cannon.

Subsequent production versions included the He 59B-3 (a long-range reconnaissance model, built by the Walter Bachmann company and omitting one of the 7·9 mm guns); the He 59C-1 with a 'solid', rounded nose, also employed for reconnaissance or training; the unarmed air/sea rescue He 59C-2, which carried six dinghies and additional radio; the He 59D aircrew trainer and He 59E-1 torpedo trainer; and the He 59E-2 photographic reconnaissance version, of which six were completed. Some He 59D's, fitted out with special radio equipment as navigation trainers, were designated He 59N in this form. During World War 2, until their replacement by Dornier flying-boats in 1943, He 59's remained active on a variety of duties which included those of convoy shadowing, mine-laying, coastal reconnaissance and transport as well as in a training capacity.

43 **Blohm und Voss Ha 139**

In so far as it is possible for a large, four-engined aeroplane to look attractive, when it has plank-like gull wings, a strut-braced tailplane with twin fins and rudders, and is mounted on two large floats, the Ha 139 probably represented the best compromise possible in the late 1930s between operational considerations and aerodynamic cleanliness. Deutsche Luft Hansa made known in 1935 a requirement for a new commercial floatplane, capable of flying across the North and South Atlantic after being launched by catapult from German depot ships, but capable also of taking off from and landing on rough water if necessary. Two years earlier the Blohm und Voss shipbuilding company had set up an associate company, Hamburger Flugzeugbau GmbH, for aircraft manufacture, and under the design leadership of Dr Ing Richard Vogt this company prepared a design, the Ha 139, to meet the DLH requirement. The first of these, the Ha 139V1 (D-AMIE, named *Nordmeer* = North Sea), was completed in 1936 and delivered to the airline in March of the following year, together with the Ha 139V2 (D-AJEY *Nordwind* North Wind). Between mid-August and the end of November 1937 these two aircraft, operating from the MSS *Schwabenland* off the Azores and *Friesenland* off Long Island, made seven experimental return crossings of the North Atlantic between Horta and New York. They carried a four-man crew and a 1,058 lb (480 kg) payload.

The North Atlantic trials revealed a few shortcomings in the design, notably in the cooling of the engines and in directional stability. Modifications to rectify these faults were made during the winter of 1937–38, from which the aircraft emerged with the original circular fins and rudders replaced by new surfaces of different shape and greater area. A third prototype (D-ASTA *Nordstern* = North Star) was delivered to DLH in 1938, this being somewhat larger overall and having the restyled tail surfaces and such other improvements as lower-mounted engines and much smaller attachment fairings between the floats and the wings. Luft Hansa gave the designation Ha 139A to the first two aircraft, referring to the Ha 139V3 as the Ha 139B.

All three floatplanes were in operation before the end of 1938, at first on further experimental flights over the Horta-New York route and later on regular South Atlantic services between Bathurst, Natal (Brazil) and Recife. The one hundredth crossing (forty over the North Atlantic and sixty over the South Atlantic) was made in June 1939. A projected maritime reconnaissance-bomber development was not proceeded

with, but upon the outbreak of World War 2 the three DLH floatplanes and their crews were impressed for military service and the Ha 139V3 underwent extensive conversion for the reconnaissance role. The principal alterations involved the provision of a glazed observation station in a lengthened nose, the substitution of larger, roughly-triangular fin and rudder surfaces, and the fitting of an unwieldy external structure for de-gaussing magnetic mines. In this form, in which it was first flown on 19 January 1940, it was redesignated Ha 139V3/U1. All three aircraft were pressed into emergency use as transports during the invasion of Norway later in 1940.

44 Chetverikov ARK-3

Although he was concerned for nearly two decades with the design of waterborne aircraft in the Soviet Union, the work of Igor Chetverikov remains comparatively little known even today. In 1930 he joined the TsKB (Central Design Bureau of the Aviatrust), for whom his first design was the ambitious but unsuccessful four-engined MDR-3 flying-boat. Flight trials of this machine took place during the second half of 1932. It underwent extensive redesign (not by Chetverikov, who had by then left the TsKB) to re-emerge in 1934 as the three-engined MDR-4. Two prototypes (which both crashed) and fifteen production examples were completed, but were scarcely more successful than the original design. His next effort, developed and built by the civil aviation experimental organisation OSGA, where he was then employed, was the OSGA-101 submarine-borne flying-boat, a small single-engined (100 hp) aircraft first flown in July 1934. A slightly smaller machine, known as the SPL, was then built as a production prototype, but although it performed quite well in the air its characteristics on the water were below expectations, and no additional machines were built.

Through one of the quirks of ill-founded intelligence information the name of Chetverikov became more widely known during World War 2 as the designer of a twin-engined flying-boat called ARK-3. He was indeed its designer, but, contrary to the Allies' belief that it was in wartime service with the Soviet Navy, only two prototypes were built, both of which had been lost more than a year before the war began. Intended for weather reconnaissance and supply duties in the Russian Arctic, the ARK-3-1 first prototype flew at Sebastopol during 1936, powered by two 710 hp M-25 radial engines. Later, after some minor structural improvements, it set a world altitude record for seaplanes by reaching 30,151 ft (9,190 m) on 25 April 1937. The ARK-3-1 had a maximum range of 1,865 miles (3,000 km), a factor which undoubtedly helped to influence the Soviet Navy in placing an order for five pre-production aircraft adapted for maritime reconnaissance duties. These requirements were reflected in the second aircraft, the ARK-3-2, flown in May 1938, which had M-25A engines of greater power and turrets instead of open positions for the 7·62 mm guns in the bow (two) and dorsal positions (one). Provision was made for an underwing bomb load of up to 2,204 lb (1,000 kg). Unfortunately for the ARK-3's prospects, however, structural failure caused the loss of the first prototype on 14 July 1937 and the second exactly a year later, and the order for five pre-production aircraft was cancelled.

Chetverikov did, however, design at least one successful flying-boat, one which, incidentally, *did* serve during World War 2. This was the MDR-6, powered by two 730 hp M-25E radial engines, which flew in mid-1937. First

and only production model was the MDR-6A (960 hp M-63 engines), of which fifty were built between 1939–41 for the Soviet Navy; they were redesignated Che-2 during their wartime service. Of pleasing but conventional appearance, the MDR-6A was an all-metal flying-boat with a two-step hull, single fin and rudder, sharp-dihedral cantilever wings with over-mounted engines and non-retractable stabilising floats at slightly less than mid-span. It was armed with bow and dorsal turrets, the former mounting a 7·62 mm ShKAS machine-gun and the latter a 12·7 mm UBT gun. Maximum speed at 16,400 ft (5,000 m) was 224 mph (360 km/hr). Chetverikov later evolved a number of twin-finned prototype developments with MDR-6B designations, some of which were improved so much in their hull design as to be virtually new aeroplanes; but he seemed to have concentrated on their aerodynamics to such an extent as to neglect their hydrodynamic characteristics, and their poor water performance brought about their rejection by the Soviet Navy. Before its closure in 1948 the Chetverikov design bureau produced three prototypes of a final design, the TA-1 amphibious commercial transport. Designed to carry 8 passengers, it was powered by two 700 hp ASh-21 radial engines which gave it a maximum speed of 199 mph (320 km/hr), and was first flown in July 1947. However, this design also exhibited poor handling qualities and no orders were received.

45 Consolidated PB2Y Coronado

The Coronado resulted from a requirement drawn up by the US Navy in 1936 for a long-range maritime reconnaissance flying-boat, powered by four engines and having a performance and load-carrying capability even greater than that of the twin-engined PBY which was then in production. Two American manufacturers, Consolidated and Sikorsky, submitted prototype designs (XPB2Y-1 and XPBS-1 respectively) to meet this requirement, of which the former made its first flight on 17 December 1937. Powered by 1,050 hp Pratt & Whitney XR-1830-72 Twin Wasp engines, the XPB2Y-1 incorporated a number of PBY design features, notably its all-metal construction and retractable wing-tip floats. The deep, capacious two-step hull could accommodate a 10-man crew, and a maximum bomb load of 12,000 lb (5,443 kg) could be carried. Defensive armament comprised single 0·50 in guns in the bow turret and tail, and a pair of 0·30 in guns firing laterally from hatches amidships. Development flying was somewhat prolonged, mainly due to the pronounced lateral instability of the original design. Attempts to rectify this resulted first in oval auxiliary fins to supplement the original single fin and rudder, then in the adoption of twin endplate fins and rudders of circular shape. Other modifications to the prototype included doubling the distance between the first and second steps of the hull. By the time that the US Navy ordered six PB2Y-2 production aircraft in March 1939 Consolidated had made further extensive redesigns. The circular fins and rudders were replaced by broad-oval units similar to those of the B-24 Liberator, the hull had been made considerably deeper and the original step beneath the bow turret had been eliminated in a new, smoothly-contoured nose design incorporating a ball-type turret. The number of crew members was decreased by one, despite an increase in the armament to a total of six 0·50 in guns. Deliveries of the PB2Y-2, to Squadron VP-13, began on 31 December 1940, these aircraft being used primarily for experimental work. In November 1940 an initial order was

placed for the PB2Y-3 model, for which the sixth PB2Y-2 was modified to serve as prototype. Principal changes were the substitution of 1,200 hp R-1830-38 engines, addition of two more 0·50 in guns, and the provision of self-sealing fuel tanks and armour protection for the crew which raised the gross weight to 68,000 lb (30,844 kg). The PB2Y-3 remained in production until the autumn of 1943, by which time two hundred and ten of this model had been built. Ten of these, designated PB2Y-3B, were supplied under Lend-Lease to the RAF; intended originally for use by Coastal Command, they were actually employed as freighters by No 231 Squadron of Transport Command. The USN designation PB2Y-3R was applied to thirty-one other Coronados converted in the USA as 44-seat unarmed transports with 1,200 hp R-1830-92 'low altitude' engines. Some PB2Y-3's in service as maritime reconnaissance-bombers were equipped with ASV radar in a fairing just behind the pilots' cabin, but during 1944 the Coronado began to be replaced in the patrol role by Navy Liberator landplanes. A conversion similar to that resulting in the PB2Y-3R was applied to a number of other PB2Y-3's, resulting in their redesignation as PB2Y-5, -5R patrol bomber or -5H ambulance aircraft. They were fitted with R-1930-92 engines, and a substantial increase in fuel tankage enabled the -5 and -5R models to carry an 8,000 lb (3,629 kg) bomb load over a range of 1,640 miles (2,639 km). The designation XPB2Y-4 was applied to a PB2Y-2 fitted experimentally with Wright Cyclone engines.

46 & 47 **Consolidated PBY Catalina**

The Consolidated XP3Y-1, or Model 28, was one of two prototypes (the other being the Douglas XP3D-1) commissioned by the US Navy in October 1933 for comparative evaluation as patrol flying-boats. Isaac M. Laddon's design for the Consolidated Aircraft Corporation showed extremely clean lines, particularly in its near-cantilever wings, which were mounted on a pylon above the hull and had stabilising floats which retracted to form the wingtips when in flight. The XP3Y-1 (serial number 9459) flew for the first time on 21 March 1935, powered by two 825 hp R-1830-54 Wasp engines, and later that year (after a change to the 'Patrol Bomber' designation XPBY-1) sixty production PBY-1's were ordered. These could carry up to 2,000 lb (907 kg) of bombs, and were armed with four 0·30 in machine-guns. Delivery of the XPBY-1 was made to Squadron VP-11F in October 1936, and was followed shortly afterwards by the first production aircraft. Fifty PBY-2's followed in 1937–38, and in the latter year three PBY-3's and a manufacturing licence were sold to the USSR. The Soviet version, designated GST, was powered by M-62 engines. Orders for the US Navy continued with sixty-six PBY-3's (R-1830-66 engines) and thirty-three PBY-4's (1,050 hp R-1830-72's), the latter introducing the prominent waist blisters that characterised most subsequent versions. The RAF received one Model 28–5 for evaluation in July 1939, resulting in an order for fifty aircraft similar to the US Navy's PBY-5, which had 1,200 hp R-1830-82 or -92 engines and a redesigned rudder. The RAF name Catalina was subsequently adopted for the PBY's in USN service. During 1940 the RAF doubled its original order, and other Catalinas were ordered by Australia (eighteen), Canada (fifty), France (thirty) and the Netherlands East Indies (thirty-six). Of the US Navy's original order for two hundred PBY-5's the final thirty-three were

completed as PBY-5A amphibians, and an additional one hundred and thirty-four were ordered to PBY-5A standard. Twelve later became RAF Catalina III's, and twelve more were included in the Dutch contract. Seven hundred and fifty-three PBY-5's were built and seven hundred and ninety-four PBY-5A's, fifty-six of the latter being completed as OA-10's for the USAAF. Lend-Lease supplies to Britain included two hundred and twenty-five PBY-5B's (Catalina IA) and ninety-seven Catalina IVA's with ASV radar. Production continued with the tall-finned Naval Aircraft Factory PBN-1 Nomad (one hundred and fifty-six, most of which went to the USSR) and the similar PBY-6A amphibian (two hundred and thirty-five, including seventy-five USAAF OA-10B's and forty-eight for the USSR). Canadian Vickers-built amphibians went to the USAAF (two hundred and thirty OA-10A's) and Royal Canadian Air Force (one hundred and forty-nine, named Canso). Boeing-Canada production included two hundred and forty PB2B-1's (mostly as RAF Catalina IVB's), seventeen RCAF Catalinas, fifty tall-finned PB2B-2's (RAF Catalina VI) and fifty-five RCAF Cansos. Total US/Canadian production of PBY models was three thousand two hundred and ninety, to which must be added several hundred GST's built in the Soviet Union.

A prominent ocean-going patrol and reconnaissance type during World War 2, the Catalina possessed a performance that enabled it to maintain its viability with the military and naval air arms of many countries, as well as in a commercial transport role, for many years after the war, particularly in South America. Among those still operating Catalinas for maritime reconnaissance up to the mid-1960s were Argentina, Brazil, Chile, Ecuador and Mexico, at which time Nationalist China, Dominica, Indonesia and Peru still used the type for search and rescue, and France and Israel retained a few for miscellaneous duties. Although the Catalina was clearly not an especially economic type for commercial services, its other advantages led to its use in such areas as the Amazon basin and among the island groups of south-east Asia and Australasia. As an example, the six owned by Panair do Brasil until its dissolution in February 1965 were operated very successfully as 22-passenger transports along the Amazon river. By 1970, however, very few military or civil Catalinas remained in service.

48 **Latécoère 300, 301 and 302**

The Laté 300 flying-boat, intended for commercial mail-carrying across the South Atlantic between Dakar and Natal (Brazil), was designed as one of three prototype competitors to meet a French Air Ministry specification issued in 1928. Registered F-AKCU, the sole example made its first flight during 1931, but in December of the same year sank in the Etang de Berre near Marseilles. Early in 1932 it was salvaged, and was then rebuilt, re-registered (as F-AKGF), re-flown (on 7 October 1932) and given the name *Croix du Sud*. The name was soon to become famous, for on 31 December 1933, piloted by Capitaine de Corvette Bonnot, the flying-boat took off from the lake at Berre to fly non-stop to St Louis (Senegal) in 23 hours 6 minutes – a distance of 2,286 miles (3,679 km). On 3–4 January it crossed the South Atlantic to Natal, and later that year made a further six crossings while participating in Air France's Dakar–Natal mail service. It continued on these operations during 1935–36, but on 7 December 1936 was lost in mid-ocean while under the command of the celebrated French pilot Jean Mermoz;

neither the aircraft nor its crew were ever traced.

Attracted by the long-range capabilities of the Laté 300, the *Ministère de l'Air* ordered six examples of a developed version, three as Latécoère 301 commercial flying-boats for Air France and three as Latécoère 302 maritime reconnaissance aircraft for the *Aéronavale*. These incorporated modifications made in 1934–35 to the *Croix du Sud*, including increases in wing dihedral and vertical tail area. The Laté 301's, like the Laté 300, were powered by four 650 hp Hispano-Suiza 12 Nbr Vee-type engines mounted back-to-back in tandem pairs above the wing. They were registered and named (originally) as F-AOIK *Orion*, F-AOIL *Eridan* and F-AOIM *Nadir*, the first aircraft making its maiden flight on 7 September 1935. Before entering service early in 1936, their names were changed to *Ville de Buenos Aires*, *Ville de Rio de Janeiro* and *Ville de Santiago du Chile* respectively; F-AOIL, however, was an early casualty, being lost during a Natal–Dakar flight on 10 February 1936.

The Laté 302 military version, carrying a crew of eight compared with the four of its commercial counterpart, had more powerful engines, an extended cockpit enclosure reaching to the extreme nose, and the greater wing dihedral and tail area of the earlier machine. The three aircraft were christened *Guilbaud*, *Cavellier de Cuverville* and *Mouneyres*, the first of these flying for the first time on 22 February 1936. Initially, a retractable gun turret was mounted in each wing, outboard of the engine nacelle, but these were subsequently removed, the aircraft when in service having two 7·5 mm Darne machine-guns firing laterally from hatches in the hull sides aft of the wings and a third mounted in the bow. Four 165 lb (75 kg) bombs could be carried on racks attached to the wing bracing struts. Delivery was made to *Escadrille* E4 at Berre late in 1936. By September 1939 this unit was based at Dakar, and its three 302's were then joined by the Laté 301 F-AOIM, which was re-christened *de l'Orza*.

The last of the Latécoère flying-boats was withdrawn from service with E4 in December 1941.

49 **Supermarine Walrus**

Originally in the Fleet reconnaissance role, and later as an air/sea rescue aeroplane, the Walrus amphibious flying-boat was one of the best-known sights in the wartime skies, especially those over British home waters. The Walrus could trace its lineage back to the Seagull amphibians of the 1920s, and when the prototype (K4797) first appeared it was indeed known as the Seagull V. It first flew on 21 June 1933, powered by a 635 hp Bristol Pegasus IIM.2 radial engine driving a pusher propeller. Twenty-four Seagull V's were ordered by the Australian government, and a further twelve, to Specification 2/35, by the Fleet Air Arm, by whom it was given the name Walrus. In the following year Specification 37/36 was issued to cover the production of another two hundred and four Walrus I's, and additional contracts followed later. Three aircraft from FAA orders were diverted to the Irish Army Air Corps in 1939. The metal-hulled Walrus I was delivered to Fleet Air Arm units from July 1936, initial allocations being made to Royal Navy battleships, cruisers and other warships equipped with catapults. These units were combined in January 1940 to form No 700 Squadron, whose total aircraft strength included forty-two Walruses. Other Fleet-spotter squadrons to employ the Walrus included Nos 711, 712 and 714. The Walrus carried a defensive armament of two 0·303 in Vickers K guns, one each in the bow and mid-upper fuselage, and provision also existed for a light load of small bombs or depth charges beneath the lower wings. From 1941 onward the Walrus was also employed increasingly by the Royal Air Force as an air/sea rescue amphibian, a task which it performed with distinction until the end of World War 2. Seven RAF squadrons in Britain and four in the Middle East operated the Walrus in this role. From the two hundred and eighty-eighth machine onward, production was undertaken by Saunders-Roe at Cowes. The Saro-built aircraft, which were designated Walrus II, had wooden hulls and Pegasus VI engines, and most of the ASR squadrons were equipped with this version. Despite its somewhat archaic appearance, the Walrus was a far more rugged aeroplane than it seemed, and operated with an outstanding record for reliability in a variety of sharply-contrasted climates: some, flying in the Argentine, were not retired until as recently as 1966. When Walrus production ended in January 1944 a total of seven hundred and forty-one had been built (including the prototype), of which four hundred and fifty-three were completed by Saunders-Roe.

50 **Boeing 314**

If for no other reason, the Boeing 314 would take its place in aviation history as the aeroplane with which regular scheduled passenger services were first flown across the North Atlantic. These began on 28 June 1939, following the inauguration of a trans-Atlantic mail service on 20 May 1939, and were flown by Boeing 314 aircraft of Pan American World Airways. The service was brought to an end by the outbreak of war in Europe later that year, but hostilities did not prevent the American flying-boats from continuing to give useful service.

Design of the Model 314 resulted from discussions between Boeing and Pan American in 1935, and received the airline's approval in the spring of 1936. Based upon the wings and horizontal tail surfaces of the huge Boeing XB-15 long-range bomber, the Model 314 was powered by four 1,500 hp Wright Double Cyclone engines and provided accommodation inside the capacious hull for a crew of up to 10 persons, a daytime payload of up to 74 passengers or, with sleeping facilities, up to 40. Part of the 4,200 US gallon (15,898 litre) fuel load was accommodated in the large sponsons, which provided stability on the water and also served as loading or boarding platforms.

Six Boeing 314's were ordered by Pan American in July 1936, and the first of these (there being no separate prototype) was flown on 7 June 1938. In its original form, with a single fin and rudder, this aircraft suffered from inadequate directional control. This was overcome, first by substituting twin outrigged oval fins and rudders and subsequently by adding to these a central fin similar in shape and size to the original single fin and rudder. All six aircraft were delivered to the airline during the first half of 1939, and went into service with 'Clipper' fleet names (a fact which has occasionally led to the incorrect assumption that the Model 314 was officially known as the Boeing Clipper). Pan American followed its original order with one for a further six aircraft with improved range and performance. These were designated Boeing Model 314A, having higher-powered Double Cyclone engines, an additional 1,200 US gallons (4,542 litres) of fuel and daytime seating for up to 77 passengers; the first 314A was flown on 20 March 1941. In the following year, five of the original 314's were brought up to 314A standard and redesignated accordingly. Three of the 314A's intended for PanAm

had meanwhile been diverted, before delivery, to BOAC for wartime transport service. As G-AGBZ *Bristol*, G-AGCA *Berwick* and G-AGCB *Bangor*, they were operated mostly across the Atlantic, after brief service on the Foynes–Lagos sector of BOAC's 'Horseshoe' route to Australasia in 1941. In January 1942, while bringing Winston Churchill home from Bermuda, *Berwick* was met by Hurricane fighters sent up to intercept the unannounced 'hostile'! All three survived the war, being returned to the USA in the spring of 1948.

The wartime career of the American-operated Boeings included a narrow escape for PanAm's *Anzac Clipper* on 7 December 1941: en route for Singapore, its captain received news of the Pearl Harbor attack when only an hour's flying time from Hawaii. The airline's three 314A's and one 314/314A were acquired by the USAAF in 1942, receiving the designation C-98; one 314A was returned at the end of the year, and in late 1943 the other three were transferred to the US Navy, which acquired two others direct from Pan American. All five, retaining their civilian identities, were flown by airline crews on Navy transport duties for the remainder of the war. *Dixie Clipper* flew President Roosevelt to Casablanca in January 1943 for his famous wartime conference with Winston Churchill, escorted out by *Atlantic Clipper* and back to the US by *American Clipper*. The only wartime loss was that of *Yankee Clipper*, which was destroyed not by enemy action but by a landing accident at Lisbon in February 1943.

Two of the flying-boats were lost after the war, one in November 1945 and the other in October 1947, in strangely similar circumstances. Each, following a safe and successful forced landing on the sea, had subsequently been struck and severely damaged by one of the ships sent out to secure it, and had to be sunk by gunfire. It was no small tribute to the aircraft's general seaworthiness that 1,300 rounds of 20 mm shells were needed to send *Honolulu Clipper* to the bottom. Pan American ceased operating the type in April 1946, but the survivors (apart from two aircraft cannibalised to provide spares for the others) were operated by charter companies for a few more years. Six of them were finally scrapped in 1950, and the seventh was destroyed in harbour by a storm a year later.

51 **Martin Mars**

The largest flying-boat in the world for its time, the Martin Model 170 Mars was designed originally to serve with the US Navy as a long-range maritime patrol bomber. An XPB2M-1 prototype was ordered in August 1938, and this aircraft (serial number 1520) was launched on 5 November 1941, making its first flight (delayed because the aircraft ran aground after an accidental fire in one engine) on 3 July 1942. The huge hull accommodated a two-deck internal layout for a crew of eleven, but as a pre-war design no provision had been made to afford them armour protection, and the only defensive armament comprised power-operated gun turrets in the nose and tail. The conversion and production effort that would have been necessary to bring the aircraft up to wartime combat standards were evidently considered prohibitive, and so its adoption for its intended role was never achieved. Instead, during 1943 the gun turrets were removed and faired over, and the airframe of the prototype was modified and strengthened to enable it to serve as a cargo transport. In this form, redesignated XPB2M-1R, it began operating with the US Naval Air Transport Service in December 1943. On its first cargo mission it flew 4,375 miles (7,041 km) non-stop from the Naval Air Station at

Patuxent River, Maryland, to Natal, Brazil, with a 13,000 lb (5,897 kg) payload. On the return trip it carried, over a 1,216 mile (1,957 km) stage length, a record payload (then) of 35,000 lb (15,876 kg), and early in the following year it transported a payload of 20,500 lb (9,299 kg) over an even longer distance of 4,700 miles (7,564 km) on a trip to Hawaii and back.

In January 1945 the US Navy ordered twenty examples of a much-modified version, the JRM-1, exclusively for the cargo transport role. The prototype of this model made its first flight in the summer of 1945, but foundered after an early test flight and the order was subsequently reduced to only five aircraft, which served with Squadron VR-2. The JRM-1 Mars, with a modified hull design and single fin and rudder, was powered by four 2,300 hp R-3350-8 engines, had a gross weight of 145,000 lb (65,770 kg) and a maximum speed of 225 mph (362 km/hr). Duty and reserve crews, each of four men, could be carried. Plans were made for several commercial passenger-carrying developments, but none of these was realised. For cargo carrying, internal equipment included tie-down rings and a 5,000 lb (2,268 kg) capacity hoist, and the loading hatches were redesigned and enlarged. Provision was made for the JRM-1 to be converted, if required, to an ambulance aircraft carrying 84 stretcher cases and 25 medical attendants, or to an assault transport carrying 132 fully-equipped troops, seven Jeeps or other military equipment. The fourth and last JRM-1 was delivered in the summer of 1946. On 19 May 1946 the JRM-1 *Marshall Mars* set up an unofficial world record for the number of people carried in a single flight, when it flew from Alameda to San Diego with a crew of seven and 301 passengers. One final Mars, the JRM-2, was built, and was delivered in the autumn of 1947. This had an improved engine installation and was cleared for operation at an all-up weight of 165,000 lb (74,843 kg); the JRM-1's were in due course brought up to the same standard and redesignated JRM-3. Retired from US Navy service in the mid-1950's, the four flying-boats were purchased by Forest Industries Flying Tankers Ltd. They were modified by Fairey Aviation of Canada for operation in that country by their new owners as forest-fire water-bombers, each aircraft having two hull scoops capable of filling four glass-fibre internal tanks with a total water load of 7,000 US gallons (26,500 litres).

52 **Fokker T.VIII-W**

In the years before World War 2 the Dutch Fokker company was responsible for a number of military aircraft, some of distinctly handsome appearance and a few that, equally distinctly, could scarcely be called attractive by any stretch of the imagination. Among the former category, however, was a twin-float torpedo-bomber/reconnaissance seaplane designed in 1937 for the *Marine Luchtvaartdienst* (Naval Air Service) and designated T.VIII-W. Evolved as a replacement for the earlier T.IVa, it first flew early in 1939, the maiden flight being made by one of five aircraft ordered by the MLD for evaluation. The T.VIII-W carried a crew of three, had an armament of two 7·9 mm FN-Browning machine-guns (one in the rear cockpit and one in the port side of the nose) and could carry a single torpedo or a 1,334 lb (606 kg) bomb load. Power was provided by two 450 hp Wright Whirlwind radial engines. An additional fourteen examples were built of this version, which was designated T.VIII-W/G, the suffix letter standing for the Dutch word *gemengd* (mixed) and indicating a mixed

construction of wood, metal and fabric covering. Eight survivors were commandeered by the *Luftwaffe* after the occupation of Holland in May 1940, and employed over the North Sea and Mediterranean for anti-shipping, reconnaissance and air/sea rescue duties. By the time of the invasion, production was well under way of a later version, the all-metal T.VIII-W/M, twelve of which, on the assembly line, were also completed and put into service by the *Luftwaffe*. At the beginning of 1939 the Finnish government had placed an order for a larger version, powered by 890 hp Bristol Mercury XI engines and with a span and length of 65 ft 7½ in (20·00 m) and 48 ft 7¾ in (14·83 m) respectively. Maximum speed of this version was 222 mph (357 km/hr), despite an increase in the gross weight to 15,432 lb (7,000 kg). Five of this model were actually completed, four being floatplanes designated T.VIII-W/C and the fifth, designated T.VIII-W/L, being completed with a non-retractable wheel landing gear.

Those T.VIII-W/G aircraft in Dutch service which survived the German onslaught were ordered to evacuate to France on 14 May 1940, where for a few days they operated along the French Channel coast from Cherbourg. On 22 May they left for Britain, eight going into service with the RAF as the equipment of No. 320 (Dutch) Squadron of Coastal Command. By September 1940, however, two of these had been lost and the remainder were grounded due to the lack of spares. For these few months they belonged to the comparatively small group of aircraft that, through force of circumstances, found themselves fighting both for and against the Allied cause.

53 **Latécoère 298**

This 2/4-seat torpedo-bomber/reconnaissance floatplane, as its somewhat utilitarian appearance suggested, was a sturdily-built aircraft, being of all-metal construction except for its fabric-covered control surfaces. It enjoyed some brief moments of glory during the early part of World War 2, but by that time was obsolescent, having been designed in 1934–35. The Laté 298–01 prototype was flown for the first time on 8 May 1936, and was sent to St Raphaël in the following September for official French Navy trials. As a result of these an order was placed in 1937 for thirty-six generally similar production aircraft. Powerplant of the prototype was an 880 hp Hispano-Suiza 12 Ycrs 1 *moteur-canon* engine, with provision for mounting a 20 mm cannon between the engine cylinder banks to fire through the propeller spinner, but this option was rejected in the production models in favour of a 7·5 mm Darne machine-gun mounted in each wing, with a third similar gun on a movable mounting in the rear cockpit. The first production aircraft, a 298A, was flown for the first time on 29 October 1938. Twenty-four of the initial production batch were completed, for shore-based operation, with fixed outer wing panels, and were designated Laté 298A. They entered service with *Escadrilles* T1 at Berre and T2 at Cherbourg at the end of 1938. The remaining twelve, delivered for operation with *Escadrilles* HB1 and HB2 aboard the seaplane carrier *Commandant Teste*, were designated Laté 298B and had folding wing and tailplane tips, two-section wing flaps and dual controls. They carried a crew of four. Both models were equipped to carry a semi-recessed Type 1926 DA torpedo beneath the fuselage, with provision for alternative mission loads including one 1,102 lb (500 kg) bomb, two 331 lb (150 kg) or 110 lb (50 kg) bombs, an auxiliary fuel tank observation flares or smoke-laying equipment. Fifteen more 298B's were ordered in

April 1938, together with five 298D's. (The 298C remained a project only.) The Laté 298D was essentially similar to the B model, but without wing-folding provision. After the outbreak of World War 2, two additional Laté 298 *escadrilles* were formed: T3 at Berre in mid-September 1939 and T4 on the French Mediterranean coast in mid-January 1940. By that time orders had been placed for a further ninety Laté 298D's, and a total of sixty-eight A, B and D models had been delivered. In March 1940 Latécoère began, at French Navy request, to convert the 80th production machine (a Laté 298D) into a prototype observation and coastal patrol version designated 298E. Modifications included a lengthening of the cockpit enclosure and removal of the torpedo/bomb crutch, a large ventral fairing taking the place of the latter in which an observer's station was accommodated. This version did not go into production, since it was found that the observation windows became unusable after being sprayed with salt water during take-off. In any case its development would have been overtaken by the German advance across France in May 1940, at which time sixty Laté 298s were operational, ten with each of the six *escadrilles* listed above. Through operational necessity, all six units became involved in dive-bombing or ground-attack missions in the all-out French effort to stem the advance, and it is no small tribute to their rugged construction that they were able to do so with some degree of success. Deliveries continued, new squadrons were equipped with the type, and by mid-August 1940 seventy-five Laté 298's were on strength distributed between eight *escadrilles*. Four of these were disbanded after the French Armistice, but two new ones were created by the Vichy government and in March 1942 a resumption of production was authorised with an order for thirty Laté 298F's, a slightly simplified version of the D model. One *escadrille* (2S) later operated with RAF Coastal Command on anti-submarine activities, and a second Allied unit, 3S, was formed in April 1945. Both the latter units were disbanded in 1946, and the Laté 298 was then used in a training capacity until withdrawn in 1950–51.

54 & 55 **Dornier Do 18, Do 24 and Do 26**

Continuing in the same basic configuration as the Wal, from which it was developed, the Dornier Do 18 originated in a DLH requirement of 1934 for a replacement for the former type on the German airline's mail routes across the Atlantic. The first of three prototypes (D-AHIS *Monsun*, D-AANE *Zyklon* and D-ABYM *Aeolus*) made its initial flight on 15 March 1935; all three, with two other essentially similar aircraft (D-AROZ *Pampero* and D-ARUN *Zephir*), were delivered to the airline under the collective designation Do 18E. The standard powerplant comprised two tandem-mounted 600 hp Junkers Jumo 205C engines, although the Do 18V1 had been fitted originally with 540 hp Jumo 5's. The Do 18E's entered service with Deutsche Luft Hansa in the autumn of 1936 over the North Atlantic route to New York, but were later switched to the South Atlantic service to Brazil, on which they continued until the outbreak of World War 2 (except for *Pampero*, lost in October 1938). A sixth civil machine was also delivered. This was the unnamed D-ANHR, first flown in June 1937 and intended for experimental rather than scheduled flights. It was designated Do 18F, and had enlarged wings with a span of 86 ft 3½ in (26·30 m) and area of 1,196·95 sq ft (111·2 sq m). On 27–29 March 1938 the Do 18F set a new sea-

plane record for distance flown in a straight line, when it flew 5,215 miles (8,392 km) from the English Channel to Caravellas in Brazil. It was later re-engined, making its first flight on 21 November 1939 as the Do 18L with a pair of 880 hp BMW 132N radial engines.

Major production of the Do 18, however, was for the *Luftwaffe*, for whom the first model was the Do 18D, which entered service in 1938. In dimensions and powerplant this was essentially similar to the E model, but carried a four-man crew and a defensive armament of two 7·9 mm machine-guns, one each in open positions in the bow and mid-upper fuselage. Four 110 lb (50 kg) bombs could be carried beneath the outer wing panels. It was built in Do 18 D-0 (pre-production), D-1 and D-2 versions, which were superseded in production in 1939 by the Do 18G-1. The G model, though dimensionally similar to the D, had more powerful (880 hp) Jumo 205D engines, a 13 mm MG 131 gun in the bow, and the dorsal gun replaced by an enclosed turret mounting a 20 mm MG 151 cannon. Some G-1's were later converted (as Do 18N-1's) for air/sea rescue, and an unarmed training version was produced as the Do 18H-1. Overall Do 18 production, including prototypes and civil examples, totalled slightly more than one hundred.

A broadly similar structural layout was followed in the Do 24, designed in 1935 to the requirements of the Royal Netherlands Naval Air Service for use in the East Indies. The major design changes were apparent in the power installation and tail assembly, the Do 24 having three radial engines mounted separately in the wing leading-edge, and twin fins and rudders. Three prototypes were completed, of which the first to fly, on 3 July 1937, was the Do 24V3, powered by 890 hp Wright Cyclone radial engines. The Do 24V1 and V2 had 600 hp Jumo 205C diesel engines, but the Cyclone was chosen for the eleven initial production aircraft. These, designated Do 24K, were delivered to the Dutch government from 1938, joining the Do 24V3 which had been handed over in the previous year. The Aviolanda and de Schelde factories in Holland then continued to build the type under licence, twenty-five (of forty-eight ordered) having been completed before Holland was overrun by the Nazis in 1940. Several were early casualties during the early months of the war in the Pacific, but others escaped to Australia and were employed by the RAAF. Those Do 24K's unfinished when Holland was invaded were completed in Germany and operated by the *Luftwaffe* as Do 24N-1 air/sea rescue flying-boats. After the occupation of Holland and France production continued with Do 24T-1 reconnaissance and Do 24T-2 transport models (1,000 hp Bramo 323R-2 radial engines), mostly for the *Luftwaffe*; one hundred and fifty-four were built in Holland and forty-eight at the CAMS plant in Occupied France. After the German withdrawal twenty-two of the latter aircraft were delivered to the *Aéronavale* and operated by *Flottille* 9F (later renamed *Escadrille* 30S). One Do 24T, interned during the war, was operated under the designation Tp 24 by the Royal Swedish Air Force until 1951, when it was claimed by the USSR as spoils of war. The Spanish government purchased twelve Do 24T's in 1944, and in 1953 acquired a further number after their retirement from service with the French Navy. Armament of the Do 24T-1 consisted of a 20 mm MG 151 cannon in a dorsal turret and single 7·9 mm MG 15 guns in the nose and tail; up to twelve 110 lb (50 kg) bombs could be carried externally.

The Dornier Do 26, which combined many advanced structural and aerodynamic features with the best aspects of the Do 18 and Do 24, did not reach the production stage, and its six prototypes proved to be the last flying-boats manufactured by the German company. Like the Do 18, the Do 26 was evolved originally as a trans-Atlantic mail carrier for DLH. It had cantilever gull wings, with four 600 hp Jumo 205E engines in tandem pairs, and the extension shafts which drove the two pusher propellers could be elevated 10 degrees during take-off to raise the propeller blades clear of spray. Retractable stabilising floats were located approximately at mid-span, replacing the hull sponsons which had performed this function in earlier designs. Three civil-registered prototypes were completed (D-AGNT *Seeadler*, D-AWDS *Seefalke* and D-ASRA *Seemöwe*), and the first of these made its maiden flight on 21 May 1938. The first two aircraft, which carried a mail payload only, were operated by the airline across the South Atlantic under the collective designation Do 26A; the third, which seated four passengers, was intended as a Do 26B production prototype. The outbreak of war, however, caused it instead to be converted for the *Luftwaffe* as a transport/reconnaissance aircraft with an armament of three 7·9 mm MG 15 guns (two in waist blisters and one in the rear floor of the hull) and one 20 mm MG 151 cannon in a bow turret. The Do 26V4 to V6, which had 700 hp Jumo 205Ea engines and were intended as Do 26C prototypes, underwent similar conversion as 10/12-seat transports. All six Do 26's (as well as the Do 24V1 and V2) were employed operationally during the German invasion of Norway, during which two of them were destroyed; the survivors continued in service for as long as spares were available and then withdrawn.

56 **Blohm und Voss Bv 222 Wiking (Viking)**

The aptly-named Wiking, whose design was evolved under the leadership of Dr Ing Richard Vogt, was originally conceived as a trans-Atlantic passenger-carrying flying-boat for Deutsche Luft Hansa, which placed an order for three in the autumn of 1937. Planned gross weight was 99,208 lb (45,000 kg) and maximum range in excess of 4,350 miles (7,000 km). The intended accommodation was for 24 day or 16 night-time passengers, but the aircraft never went into commercial service, for war had broken out before the Bv 222V1 first prototype (D-ANTE) made its first flight on 7 September 1940, some twenty months after construction had begun. Instead the prototype was used, beginning in July 1941, as an unarmed freight transport on behalf of the *Luftwaffe*, but by the following winter it had become obvious that a defensive armament was necessary. This took the form of a 13 mm MG 131 machine-gun in each of two dorsal turrets and five 7·9 mm MG 81 guns, four amidships firing to left and right and a fifth in the nose, and in this form the aircraft became operational with LTS (*Luft-transportstaffel*) *See* 222 in the following spring. In August 1942 it was joined by the second prototype (Bv 222V2), which had first flown a year previously and had incorporated armament from the outset. It had originally had two additional MG 131 guns in fairings under the inboard wing sections, but these were removed and a deeper keel fitted before the V2 entered service. The V3 (first flight 28 November 1941) was essentially similar except that the armament, consisting originally of only a single nose-mounted MG 81, was later increased to three 20 mm MG 151 cannon, one MG 131 and two MG 81 in three dorsal and two wing turrets, with no gun at all in the nose.

Subsequently the V2, V4 and V5 prototypes were brought up to a similar standard, prior to being employed by the *Fliegerführer Atlantik* in a maritime reconnaissance role from the spring of 1943. By this time the V1, V6 and V8 had been lost, the V1 in a landing accident and the other two shot down; and in June 1943 the V3 and V5 also were destroyed, while at moorings, by Allied air attack. All of these seven aircraft were powered by Bramo Fafnir 323R radial engines, and were designated Bv 222A by the *Luftwaffe*. The V7 machine, prototype for the Bv 222C, had meanwhile been flown on 1 April 1943 with a powerplant of six 1,000 hp Junkers Jumo 207C twelve-cylinder diesel engines. (The Bv 222B was an unbuilt project for a Jumo 208-powered commercial transport.) Armament in the V7 again varied, the three 20 mm guns being retained with one MG 131 in the nose and four more amidships. The ninth Wiking was the first true production example of the Bv 222C, and was placed in service together with three similar aircraft and the V7 aircraft in the summer of 1943. Only one other Wiking, the thirteenth aircraft, was subsequently completed. Originally to have been the first Bv 222D, with Jumo 205D diesel engines, it was in the event fitted with Jumo 205C's. The Bv 222D series, and a proposal to replace the six-engined layout with four of the more powerful BMW 801 radial engines, were both abandoned, and when work on the Bv 222 was halted in 1944 (to give priority to more urgently-needed combat aircraft) four additional C-series flying-boats were left uncompleted. The Wiking was the largest flying-boat in production and service during World War 2; only three Bv 222C's, of the thirteen Wikings built, survived the war; one was then brought to the UK for study and two sent to the USA.

Huge as the Bv 222 was for its time, an even larger flying-boat was built by Blohm und Voss during the war years. This was the Bv 238, intended as a replacement for the much smaller Bv 138 (see *Bombers 1939–45*), and was originally proposed early in 1941 with four Jumo 223 diesel engines. Later that year the design was adapted for six DB 603 or BMW 801 engines, and four prototypes were ordered. Only the Bv 238V1, with 1,750 hp DB 603V engines, was flown, and that not until 1944; by the end of the war in Europe the V2 and V3 were still incomplete, as was the first prototype of a land-based development, the Bv 250. The Bv 238V1 had a wing span of 197 ft 5 in (60·17 m), length of 142 ft 3 in (43·36 m), normal take-off weight of 154,324 lb (70,000 kg), maximum speed of 264 mph (425 km/hr) and range of 3,790 miles (6,100 km).

57 Grumman G-21A/JRF Goose

A general-purpose utility transport amphibian which is still giving plenty of useful service more than thirty years after its first appearance, the Goose originated in 1936 as the G-21, a 6/7-seat aircraft for both civil and military use. The prototype, powered by two 450 hp Pratt & Whitney R-985-SB Wasp Junior radial engines, was flown for the first time in June 1937, and about a score of the G-21A model (higher-powered R-985-SB2 engines and increased gross weight) were sold to civilian customers prior to the outbreak of World War 2. One G-21 was acquired by the US Navy in 1938, and evaluated as the XJ3F-1 for the 'general utility' role. It was, however, decided to order the type as a utility transport, in which capacity it was designated JRF-1. An initial order for twenty was placed, ten of these (delivered from late 1939) being JRF-1's and the other ten JRF-4's with provision for carrying

two 250 lb (113 kg) bombs or depth charges beneath the wings. Five of the JRF-1's were subsequently adapted for aerial photography and target-towing as JRF-1A's.

Prior to the Navy order the US Army Air Corps had also placed a contract in 1938 for twenty-six as utility aircraft; these were given the designation OA-9, as were five civil G-21's impressed for war service in 1942. During 1939–40 ten more were purchased by the USN (seven JRF-2's and three JRF-3's) for use by the US Coast Guard in an air/sea rescue capacity. The JRF-3 version, intended for use in northern waters, was fitted with anti-icing equipment and an autopilot.

Major production version of the Grumman design, of which one hundred and eighty-five were built, was the JRF-5. In its basic form this was fitted out with cameras and other equipment for aerial survey work, and fifty were ordered for the RAF by the British Purchasing Commission in 1940. These, however, were requisitioned by the US Navy, to whom deliveries began in 1941. Six, designated JRF-5G, were assigned to the US Coast Guard for rescue duties; another six were supplied to the RAF, which named them Goose I, a name which was later adopted for all G-21 models in service; twenty-nine were delivered to the Royal Canadian Air Force for use on navigation training and other duties; and a further number were supplied to the Portuguese Navy. Internal changes were the main features of the JRF-6 (new radio and electrical equipment) and JRF-6B (navigation training equipment). Of these versions, thirty-seven were supplied to the US Navy and fifty in 1943 to the RAF as the Goose IA. The latter were employed variously for transport duties with No 24 Squadron, for air/sea rescue, or for ferry duties with the Air Transport Auxiliary. Five other aircraft were employed by the USAAF; these comprised three commercial G-21A's, impressed in 1942 as OA-13A's, and two OA-13B's which were JRF-5's acquired from the US Navy.

Among post-war forces to employ ex-American G-21A's was France's *Aéronavale*, whose *Escadrille* 8S was equipped with JRF-5's for maritime reconnaissance until the end of the 1950s, and those of the Portuguese Navy were also still in service at that time. The majority of those built, however, found their way to the civil market after the war, where they have served on local-service passenger routes in such areas as the Caribbean or the lakelands of Canada, on patrol or survey activities, or as business executive aircraft. Their longevity has been enhanced by a number of available conversions to turboprop power, of which the best-known current example, in 1970, was the Turbo-Goose. This is available as the 9/13-seat G-21C and G-21D, with 579 ehp PT6A-20 turboprop engines, retractable wingtip floats, lengthened radar nose and other structural and equipment improvements; or the 8/12-seat G-21G, with 715 ehp PT6A-27 turboprops. Both versions have been granted FAA Type Approval.

58 Beriev MBR-2

In many respects the MBR-2 was to the Soviet Navy what the Supermarine Walrus was to the RAF and Fleet Air Arm, both types enjoying long production lives and service careers. The MBR-2 was designed by Georgi M. Beriev and first flown in 1931, the designation being a functional one whose initial letters signified *Morskoi Blizhnii Razvedechik*, or Naval Short Range Reconnaissance. The prototype was powered by an imported BMW VI.Z engine of 500 hp, and it was a licence-built development of this, the

680 hp M-17B, which powered the initial production version of the flying-boat in 1934. This version carried a crew of four or five, with the two pilots seated side by side in an open cockpit. It had open gun positions in the bow and mid-upper fuselage, each with a 7·62 mm PV-1 machine-gun on a movable mounting, and was characterised by a square-topped fin and rudder. It became a standard Soviet Naval Aviation type during 1935, and could be fitted with a non-retractable wheel or ski landing gear to enable it to operate from land or ice-covered waters. During 1934 an 8-passenger commercial version, the MP-1, was put into service by Aeroflot, and an MP-1T freighter counterpart appeared in 1936. In 1935, however, Beriev had undertaken an extensive redesign of the aircraft, based upon the installation of the more powerful Mikulin AM-34N engine. Other changes included the provision of a manually operated turret, mounting a 7·62 mm ShKAS machine-gun, an enclosed crew cabin and larger, redesigned vertical tail surfaces. Up to 661 lb (300 kg) of bombs, mines or depth charges could be carried beneath the wings. This version, sometimes referred to as the MBR-2*bis*, remained in production until 1941, and saw extensive service throughout World War 2. Many were still in service for fishery patrol and similar duties up to ten years later, and a few were possibly still flying in 1970. The AM-34N-powered civil version was designated MP-1*bis* and entered Aeroflot service in 1937, after the prototype had been used to establish several distance and payload-to-height records for women pilots.

59 **Blackburn B.20**

Two of the inherent problems faced by the designer of a propeller-driven flying-boat are those of keeping the propeller blades well clear of the water (including spray) during take-off and landing, and of enabling take-off to occur with the wings at an angle of incidence greater than that required by the aircraft for level flight. One ingenious attempt to overcome these problems resulted in the Blackburn B.20, designed to meet the requirements of Air Ministry Specification R.1/36 for a medium-range maritime reconnaissance aircraft. It took the form of a retractable planing bottom to the hull, which when extended gave the aircraft the effect of a conventional aeroplane mounted clear of the water on a separate central float. The basic concept had been evolved and patented some years earlier by Major J. D. Rennie, Blackburn's chief seaplane designer. Stability on the water was provided by retractable wingtip floats. In the air, the planing bottom retracted to a flush fit with the remainder of the fuselage, while the outrigger floats formed well-streamlined shapes at the wingtips. Only one B.20 (V8914) was completed, this flying for the first time early in 1940. Design work on a developed version was begun, but was abandoned due to pressure of more important wartime requirements, as was any further development of the concept after the loss of the only prototype during a test flight. Prior to that, however, the B.20 had revealed satisfactory handling qualities both on the water and in the air. No weapons were fitted during the flight trials that were undertaken, but the B.20's design provided for an eight-gun defensive armament (two 0·303 in machine-guns each in nose and dorsal turrets and four in a tail turret) and a warload of eight 250 lb (113 kg) bombs in the wings inboard of the engine nacelles. Accommodation was provided for a crew of seven – two pilots, navigator, wireless operator, bomb-aimer, an observer and engineer – and included sleeping quarters for six persons, a wardroom,

engineer's workroom, galley and toilet. Stowage space was provided for dinghies, flares and other equipment.

60 **Kawanishi H8K**

The 13-*Shi* (1938) specification to which Dr Kikuhara designed the first prototype H8K1 was an exacting one, and in its initial trials early in 1941 the flying-boat gave little indication of its future promise, having a marked lack of stability on the water and an unfortunate tendency to 'porpoise'. Various modifications were made to this aircraft, and to the three pre-production H8K1's of 1941, all of which were powered by 1,530 hp Mitsubishi Kasei 11 engines. As finally accepted for production in February 1942, the H8K1 Model 11 had a deeper hull, with a more efficient planing bottom, and enlarged vertical tail surfaces. Thirteen production H8K1's were built at Kohnan. They carried a crew of 10 and were armed, as were the pre-series machines, with a single 20 mm tail gun, one 20 mm and two 7·7 mm guns in the nose turret and a 7·7 mm gun in each of the beam blisters. The operational debut of 'Emily', as the H8K was known under the Allied wartime code-naming system, was made by the three pre-production H8K1's. These made an abortive attack on Pearl Harbor early in March 1942, flying from the Marshall Islands and refuelling from submarine tankers en route. The production H8K1 was an excellent design hydrodynamically, with a performance equal or superior to that of any other flying-boat in service during World War 2. In 1943 it was superseded by the H8K2 Model 12, with more powerful Kasei 22 engines and an augmented armament comprising two 20 mm cannon in each of the nose and tail turrets, another in the dorsal turret, and four 7·7 mm machine-guns in the beam blisters and on the flight deck. An internal weapon load comprising up to eight 551 lb (250 kg) bombs or two 1,764 lb (800 kg) torpedoes could be carried. The H8K2 was employed throughout the Pacific theatre of war, its maximum endurance of nearly 27 hours enabling it to carry out extremely long-range maritime patrol, bombing and reconnaissance duties. Late production H8K2's carried ASV (Air to Surface Vessel) radar in the bow, and the beam observation blisters were omitted. One hundred and twelve H8K2's were completed during 1943–45, plus thirty-six examples of a transport version known as the H8K2-L Sei-Ku (Clear Sky). This could carry up to 64 passengers, or a mixed load of passengers and cargo. It was recognisable by double rows of fuselage windows and had a much-reduced armament consisting of a single 13 mm gun in the nose and one 20 mm cannon in the tail position. The first H8K1 prototype, re-engined in 1943 with Kasei 22's and converted to a passenger layout, served as the trials aircraft for this version. Two H8K3 Model 22's were completed, these being essentially late-production H8K2's fitted experimentally with retractable wingtip floats (originally planned for the first prototype) and a retractable dorsal turret. Later they were re-engined with Kasei 25b's and were redesignated H8K4 Model 23. Neither the H8K3 nor the H8K4 went into production, and a projected H8K4-L Model 33 transport version was never completed.

61 & 62 **Short Sunderland, Sandringham and Solent**

The Sunderland, whose design was based upon the successful 'C' class 'Empire' flying-boats of Imperial Airways, was evolved to meet Air Ministry Specification R.2/33, and was destined to become the RAF's longest-serving operational aircraft. The prototype

(K4774) first flew on 16 October 1937, powered by 950 hp Bristol Pegasus X engines. The initial production version, the Sunderland Mk I, had 1,010 hp Pegasus XXII's and a revised armament comprising four 0·303 in Browning guns in the tail turret, one 0·303 in Vickers K or Lewis gun in the nose turret, and two Vickers K guns amidships. An internal bomb load of up to 2,000 lb (907 kg) could be carried. Production began in 1938, first deliveries being made in June of that year to No 230 Squadron in Singapore; by 3 September 1939, forty Sunderlands were in service with four RAF squadrons. Ninety Mk I's were eventually completed, including fifteen by Blackburn. This company also built five of the forty-three Mk II's which, from the end of 1941, began to replace the Mk I's in service. The Mk II introduced Pegasus XVIII engines, with two-stage superchargers, a twin-gun dorsal turret (similar to that fitted to the Blackburn Botha) in place of the 'midships gun ports, an improved tail turret, and ASV (Air to Surface Vessel) radar. Rising operating weights now necessitated a redesign of the hull planing bottom, and the Mk II on which this was tested thus became the prototype for the principal production model, the Sunderland Mk III. The first Short-built Mk III flew on 15 December 1941; the parent company eventually completed two hundred and eighty-six Mk III's, while a further one hundred and seventy were built by Blackburn. It was No 10 Squadron of the Royal Australian Air Force which first experimented with a group of four machine-guns in the nose of the Sunderland III. This proved so successful, both against enemy submarines and aircraft, that many Sunderlands were subsequently operated with this total armoury of ten guns, their bristling defence earning the respectful nickname *Stachelschwein* (porcupine) from their German adversaries. The designation Sunderland IV was given originally to a larger, heavier development with 1,700 hp Bristol Hercules engines, eight 0·50 in machine-guns and two 20 mm cannon. In the event, only two prototypes and eight production aircraft were built; they were given the new type name Seaford, but after a brief service appearance were later converted into Solent commercial transports for BOAC. Final Sunderland variant was the Mk V (one hundred built by Shorts and fifty by Blackburn), with 1,200 hp Pratt & Whitney R-1830-90 Twin Wasps as powerplant and improved ASV equipment. The Sunderland V entered service in February 1945, and was the last version to serve with the RAF, finally retiring in 1958. Sunderlands exported after World War 2 to the French *Aéronavale* (nineteen) and the RNZAF (sixteen) continued in service until 1960 and 1966 respectively.

The development of Sunderland derivatives for service with BOAC and Commonwealth airlines began as early as 1942, with the allocation of RAF Sunderland III's to BOAC for urgent wartime passenger and mail flights. With gun turrets removed and rudimentary seating installed, about thirty ex-Sunderland III's bore civil registrations for this purpose. With rather more extensive alteration to meet civilian standards, and with higher-rated Pegasus engines, twenty-two of these became BOAC's 'Hythe' class, beginning commercial operation in January 1946. One of them, G-AGKX *Himalaya*, had meanwhile been further converted in 1945 as the first – and only – Sandringham 1. Chief differences included revised nose and fin contours, and a new two-deck interior seating 16 or 24 passengers. Some ex-RAF Sunderland V's were converted to a similar standard, but the first true civil versions

were three 45-seat S.25/V Sandringham 2's built for Dodero of Argentina, and the 21-seat Sandringham 3, two of which were completed for another Argentine customer. Other Sandringhams included three Mk 4's for TEAL, nine Mk 5's and three Mk 7's (as BOAC's 'Plymouth' and 'Bermuda' classes). The BOAC Sandringhams were withdrawn in 1949 and sold to various operators in New Zealand, Norway and South America.

Outwardly resembling the Sandringham, the S.45 Solent was adapted from the RAF Seaford in much the same way as its predecessor had been converted from the Sunderland. The principal outward points of difference were the Solent's Bristol Hercules engines, large curving dorsal extension to the fin, and slightly wider hull. After borrowing an RAF Seaford (NJ201/G-AGWU) for study in 1946, BOAC ordered twelve Solent 2's based on the Seaford but with 1,690 hp Hercules 637 engines in place of the Seaford's Hercules 130's. The twelve Solent 2's were completed between November 1946 and April 1948, entering BOAC service as 30-seaters in May 1948. In 1950 five were converted to 39-seat Solent 3's, together with six other ex-RAF Seafords including the original NJ201. The last BOAC service by any kind of flying-boat was flown to South Africa on 10 November 1950 by Solent 2 G-AHIO *Somerset*, and several Sandringhams and Solents were sold after this, to operators in the United States and Australasia. Four Solents, 44-seat Mk 4's, were by then already flying between Australia and New Zealand with TEAL; these, and the Mk 3's, could be distinguished by an additional pair of cabin windows at the rear of the upper deck. The last British-operated flying-boats, those of Aquila Airways, were withdrawn in the autumn of 1958, and the TEAL Solents were withdrawn in 1960. At the end of 1966, two Sandringhams were still owned by Ansett and one by Reseau Aérien Interinsulaire in Tahiti.

63 **Martin PBM Mariner**

The Mariner (Martin Model 162) design for a maritime reconnaissance bomber was initiated in 1937, and to test its aerodynamic and hydrodynamic qualities Martin built a Model 162A quarter-scale single-seat 'prototype'. A full-size prototype, designated XPBM-1, was ordered in June 1937 by the US Navy, and in the following December a contract was placed for twenty PBM-1 production aircraft, differing principally in having dihedral tailplanes. First flight of the XPBM-1 (serial number 0796) was made on 18 February 1939, and delivery of production aircraft, mostly to Squadron VP-74, began in 1940. Powerplant of this initial model was two 1,600 hp Wright R-2600-6 Cyclone radial engines, and the PBM-1 carried a crew of seven, a bomb load of 2,000 lb (907 kg), including depth charges, and a defensive armament of one 0·30 in and five 0·50 in machine-guns in nose, tail, dorsal and waist positions. Shortly after this version entered service substantially larger orders were placed for improved models of the Mariner. These appeared from 1942, and were designated in the PBM-3 series, the XPBM-2 having been a prototype with additional fuel tankage and provision for catapult launching.

Whereas the PBM-1 had had retractable wingtip floats, those of the PBM-3 models were larger, non-retractable and braced by struts. Engine naccles were lengthened to accommodate depth charges or bombs. Variants included the PBM-3B (thirty-two built for Lend-Lease supply to the RAF); PBM-3C (two hundred and seventy-four for the US Navy); PBM-3D (two hundred and one for the USN); PBM-3R (fifty for

the US Naval Air Transport Service); and PBM-3S (one hundred and fifty-six for the USN). The PBM-3B, -3C, -3R and -3S were powered by 1,700 hp R-2600-12 Cyclones, the PBM-3D having uprated R-2600-22 engines of 1,900 hp each. Except for their powerplant the -3C and -3D combat models were essentially similar, having increased armour protection internally, power-operated nose and dorsal turrets and search radar in a large fairing above and behind the flight deck. Bomb load of the PBM-3D was 8,000 lb (3,629 kg). The PBM-3S, produced for a more specialised anti-submarine role, was structurally similar to the -3C but had less armour protection, a total armament of four hand-held guns and increased fuel capacity. All armament was deleted from the PBM-3R, which served as a transport accommodating 20 troops or an equivalent freight load. No examples were built of the PBM-4, a proposed version with R-3350-8 Cyclone engines.

In May 1943 there flew the first of two prototypes of the PBM-5, a more powerful version with 2,100 hp Pratt & Whitney R-2800-34 Double Wasp radial engines, eight 0·50 in guns and a smaller APS-15 search radar in a bullet-shaped fairing mounted on a pylon above and behind the flight deck. Deliveries began in September 1944. More than a thousand of this version were ordered, but after VJ-day cancellations the total number of PBM-5's built (including prototypes) was five hundred and ninety-one. Some of these, re-equipped after the war with more modern gear, were then redesignated PBM-5E. These were employed both by the US Navy in the ASW role, in which they were designated PBM-5S, and by the US Coast Guard for air/sea rescue duties with the designation PBM-5G. Production ended in April 1949, after delivery was completed of one XPBM-5A and thirty-six PBM-5A's, which were amphibious counterparts to the PBM-5 with a retractable tricycle landing gear and R-2800-34 engines.

64 **Grumman G-44/J4F Widgeon**
In many respects a smaller edition of the G-21 Goose, the Grumman G-44 was evolved in the first instance as a 4/5-seat commercial amphibian, the first prototype (NX 28633) making its maiden flight in July 1940. The first order to be placed, however, was that of the US Navy for twenty-five of a 2/3-seat anti-submarine patrol and general utility version, the J4F-1, for service with the US Coast Guard. Performance in the former role was poor, though one sinking of a U-boat, in 1942, was recorded – a creditable result considering that the aircraft was unarmed and could carry only a single 200 lb (91 kg) depth bomb. During 1942 delivery took place of sixteen OA-14's to the USAAF, by which time also the US Navy had begun to receive the first examples of the J4F-2, which it employed either as a utility transport, accommodating a crew of two and three passengers, or as an instrument trainer. Fifteen J4F-2's were supplied under Lend-Lease to the RAF (which at first named them Gosling I before adopting the name Widgeon) and were employed primarily as communications aircraft in the West Indies during 1943–45. One hundred and thirty-one J4F-2's were purchased by the US Navy, including those allocated to the RAF.

Military production of the Widgeon ended in 1945, but after World War 2 some redesign of the Widgeon's hull was undertaken, the modified aircraft being given the manufacturer's model number G-44A. About fifty were built by Grumman for the civil market; forty similar aircraft, manufactured under licence by the Société de Constructions

Aéro-Navales in France as the S.C.A.N.30, were later sold to the USA, where they became known as Gannet Super Widgeons after being fitted with 300 hp Lycoming R-680 radial engines. McKinnon Enterprises Inc has produced other Super Widgeons (and was still doing so in 1970) by converting existing Widgeons into executive aircraft with a powerplant of two 270 hp Lycoming GO-480 'flat-six' engines.

65 **Saunders-Roe Princess**
Lord Brabazon of Tara, writing in 1951, revealed that he 'always felt a little guilty' that his wartime committee on post-war British civil aviation did not recommend the building of any new flying-boats; but the committee's purpose was to reflect operators' requirements, and operators could not be persuaded to order them. This being so, it is remarkable that the Princess ever reached completion at all, but even this graceful giant was to become a victim of the general post-war apathy towards the flying-boat species. Design of the S.R.45 Princess was started in 1943, making use of experience gleaned from the little Saunders-Roe Shrimp which had been flown in 1939 as a small-scale prototype for an earlier civil flying-boat project. In July 1945 Saunders-Roe was invited to tender for a high-capacity trans-Atlantic flying-boat, and with BOAC expressing an interest in such an aircraft for its Southampton–New York service the Ministry of Supply ordered three prototypes from Saunders-Roe in May 1946. Details released by the company a month or two later revealed an aircraft weighing 260,000 lb (117,930 kg) for take-off and powered by twelve Rolls-Royce Tweed turboprop engines coupled in pairs. Cancellation of the Tweed delayed the development of the Princess while it was redesigned instead for a powerplant of ten Bristol Proteus turboprops – still in six nacelles – and by the time prototype construction began in 1947 the design had become a 105-seater intended to gross 315,000 lb (142,884 kg), some ten tons heavier than the Bristol Brabazon landplane. The Proteus engines were mounted as coupled pairs in each of the four inboard nacelles and single units in each of the outboard nacelles. The gigantic 'double-bubble' pressurised hull accommodated two decks, each with passenger seats and refreshment bars; there were two large freight holds in the lower deck and a galley on the upper deck. Provision was made for a flight crew of six. By early 1951 BOAC, which meanwhile had committed itself to an all-landplane fleet, had rescinded its plans to acquire the Princess, and the Ministry of Supply directed that the three prototypes should instead be delivered to the RAF, to be evaluated as long-range military transports carrying up to 200 troops. In March 1952 a further announcement stated that only the first prototype, G-ALUN, was to be completed, the other two airframes to be cocooned until the more powerful 3,650 shp Proteus 705 engine became available. On 19 August 1952 G-ALUN was launched at Cowes, and was taken up on its maiden flight by Geoffrey Tyson three days later. The second Princess, G-ALUO, was launched in its cocoon on 13 February 1953, but both this aircraft and G-ALUP, the third Princess, were then beached at Calshot – where they remained for many years, flanking Southampton Water and passed almost daily by the trans-Atlantic liners that they were meant to put out of business. G-ALUN was scrapped in 1967. With the Princesses also died Saunders-Roe's 1950 Duchess project, for a 74-seat medium-range commercial flying-boat powered by six 5,000 lb (2,268 kg) st de Havilland Ghost turbojet engines.

66 **Saunders-Roe SR/A1**
Designed at Cowes, Isle of Wight, by a team under the leadership of Henry Knowler, the single-seat SR/A1 was the world's first jet-powered flying-boat to fly. It had come into being as a result of Air Ministry Specification E.6/44, a wartime requirement for a high-speed fighter capable of operating from coastal waters in the Pacific theatre. Outwardly conventional in its appearance, the SR/A1 nevertheless embodied a number of features designed to result in an aerodynamically clean exterior with the minimum of drag-producing protrusions. The two Metrovick Beryl turbojets were mounted side by side in the hull, below and just aft of the cockpit, with a single common air intake in the nose and separate jet-pipes to the rear of the wing, on each side of the fuselage; the intake itself had an extendable 'snout' designed to prevent the entry of spray. Stabilising floats were mounted at approximately two-thirds span. These could be retracted inwards after take-off, the floats themselves rotating an additional 90° during the process so that the curved upper surface was outermost in the fully-retracted position. The pilot's compartment was built as a complete unit, fitted with a Martin-Baker ejection seat, and provision was made for the installation of four 20 mm Hispano Mk 5 cannon in the upper front portion of the hull, firing through ports above the nose intake. Internal fuel capacity could be increased by more than 60 per cent by the use of flush-fitting, jettisonable slipper tanks beneath the inboard wing panels.

Three prototypes of the SR/A1 were ordered (TG263, TG267 and TG271), and the first of these, piloted by Geoffrey Tyson, made its first flight at East Cowes on 15 July 1947. In this aircraft the Beryl turbojet engines were restricted to an initial thrust rating of 3,250 lb (1,474 kg); the second prototype, which flew in 1948, was fitted with 3,500 lb (1,588 kg) st MVB 2 engines, and in the third machine the F.2/4A Beryl Mk 1 reached its full design rating of 3,850 lb (1,746 kg) st. During 1948 also, a reinforced cockpit canopy replaced the original fully-transparent Perspex hood and a streamlined 'bullet' fairing was added at the tailplane/fin intersection to improve the airflow. Although flight trials were generally satisfactory, and the aircraft highly manoeuvrable, two of the prototypes were later involved in accidents, though not before one of them had demonstrated its ability to fly at speeds more than 70 mph (113 km/hr) in excess of the then-existing world speed record for seaplanes. But in any case the requirement for such a fighter had disappeared with the ending of the war, and no production orders were placed. Testing was resumed, but only briefly, in 1951 with the original prototype, and this machine is now preserved by the Skyfame Museum at Staverton, Gloucestershire.

67 **Martin P6M SeaMaster**
The eclipse of the military flying-boat after World War 2, in favour of shore-based aircraft for the maritime patrol function, was temporarily deferred by a few post-war designs in which much of the experience gained during the war from the operation of water-borne aircraft was put to good effect. In particular, this minor resurgence was made possible by a better knowledge of the hydrodynamic problems involved, resulting in the use of higher length/beam hull ratios which did much to close the performance gap between the flying-boat and its land-based counterparts. It led to the appearance in the USA in the late 1940s and early 1950s of such types as the Martin Model 237 Marlin, first flown on 30 May 1948 and built as the P5M-1 (one hundred and fourteen)

and P5M-2 (about one hundred) for the US and French Navies.

In 1952 the US Navy held a design competition for a new flying-boat, to carry out the role of mine-layer and to be powered by turbojet engines. Both Convair and Martin submitted proposals, and the latter company's Model 275 was selected as the winner. Two XP6M-1 prototypes, named SeaMaster, were ordered; the first of these flew on 14 July 1955, followed by the second on 18 May 1956. Characteristics of the design were the high-mounted 'T' tail (reminiscent of that of the P5M-2 version of the Marlin), the high length/beam ratio (more than 13:1) of the streamlined hull, and the grouping of the 13,000 lb (5,897 kg) st Allison J71-A-4 afterburning jet engines in pairs above the sharply-swept wings to keep the intakes from ingesting spray during take-off and landing. The XP6M-1 carried a crew of four, and had a pair of 20 mm guns in a remotely-controlled tail turret as the only defensive armament. In the underside of the hull was installed a watertight rotary bomb door, on the inside of which could be mounted a weapon load of mines or bombs, a camera pod or other equipment. The intention was to employ the SeaMaster in small, widely-dispersed numbers, with refuelling and other services provided by submarines or other small, mobile Naval units. However, both XP6M-1's crashed during flight testing, due to faults in the tail and tailplane-actuating mechanism, and of the Navy's order for six YP6M-1's and twenty-four P6M-2 production aircraft only the YP6M-1's and three P6M-2's were completed. The former were basically similar to the prototypes, except for redesigned intakes and a modified fin fairing, and the first example was flown on 20 January 1958. Four 17,500 lb (7,938 kg) st Pratt & Whitney J75-P-2 turbojets were installed in the P6M-2's, the first of which was flown on 17 February 1959; in the following August the US Navy terminated the SeaMaster programme, and the completed aircraft served only with a single squadron, based at Harvey Point Naval Air Station, North Carolina.

68 **Shin Meiwa PS-1 (SS-2)**
Due to enter service with the Japan Maritime Self-Defence Force in 1972, the PS-1 anti-submarine flying-boat has a development history going back to 1959, when Shin Meiwa (successor to the former Kawanishi Aircraft Company) completed the rebuilding of a Grumman UF-1 Albatross amphibian as a small-scale flying model of the new design. Flight testing of this aircraft, which was known as the UF-XS, ended in September 1964, and in January 1966 the Japan Defence Agency awarded Shin Meiwa a development contract and an order for two prototype aircraft designated PX-S. Designed under the leadership of Dr Shizuo Kikuhara, the first was completed in August 1967 and flew for the first time on 5 October that year. This aircraft bore the serial number 5801; the second aircraft (5802) made its first flight on 14 June 1968, and by the end of 1968 both had begun evaluation by the 415th Flight Test Squadron of the JMSDF at Iwakuni. Two more aircraft, ordered in March 1969, were due for delivery by the end of January 1972, and are pre-production models with the designation PS-1. Production plans up to early 1971, which then still remained to be negotiated, were for delivery of ten more PS-1's by 1973 and purchase of another 20 by 1976.

As one of the only two modern maritime reconnaissance flying-boats in production/service, the Japanese design is of especial interest. Despite a deceptively conventional appearance, the

PS-1 has, in particular, an excellent STOL performance which includes a touchdown speed of 47 mph (76 km/hr) and a take-off run of less than 1,000 ft (305 m) to clear a 50 ft (15 m) obstacle. Its anti-submarine equipment includes Jezebel acoustic search gear and 20 sonobuoys, Julie echo ranging gear with 30 explosive charges, smoke bombs and four 330 lb (150 kg) anti-submarine bombs, search radar in the nose and a retractable MAD 'sting' in the rear fuselage. Four homing torpedoes and six 5 in (12·7 cm) air-to-surface rockets can be carried beneath the wings, and a searchlight is installed below the outer starboard wing panel. The PS-1 is able to operate in rough seas with waves of 13 ft (4 m) or higher and in winds of up to 25 knots (47 km/hr), using its 'dunking' sonar while at rest on the surface, and has a patrol endurance of 15 hours. A crew of ten is normally carried. High-lift devices are fitted, and low-speed stability and control are aided by a boundary layer control system which 'blows' the flaps, elevators and rudder. Carefully-positioned bow grooves and strakes and a high angle of wing incidence keep the engines and propellers well clear of spray, and a retractable tricycle beaching gear is built into the hull. The wingtip floats are non-retractable.

A second version, the air/sea rescue SS-2A, was announced during 1970. This would be basically similar to the PS-1, retaining the nose radar but carrying five medical attendants and up to 36 stretchers in a hull lengthened by approximately 6½ ft (2 m). Other variants under consideration at that time included an early warning patrol version, and amphibious and landplane commercial transport versions.

69 **Beriev Be-12 Tchaika (Seagull)** Georgi Mikhailovich Beriev is quite possibly the only aircraft designer in the world who, with a lifetime's work on water-borne aircraft behind him, is still designing flying-boats today. Since World War 2 he has been responsible for at least three noteworthy flying-boats for the Soviet Navy, of which the first was the twin-engined Be-6 (NATO code name 'Madge') which entered service in about 1949, some two years after the LL-143 prototype made its first flight. Powered by two 2,300 hp Shvetsov ASh-73TK radial engines, this flying-boat had a wing span of 108 ft 3¾ in (33·00 m) and a length of 76 ft 1½ in (23·20 m). Normal gross weight was 51,588 lb (23,400 kg), and a maximum speed of 258 mph (415 km/hr) at 7,875 ft (2,400 m) was attainable. For defensive armament, the Be-6 had a 23 mm gun in each of the dorsal and tail positions, and carried a variety of bombs, depth charges or other weapons on underwing pylons. It remained in fairly widespread use until the mid-1960s, but has since been superseded by later aircraft, not all of which are flying-boats.

In 1961 the Western nations were afforded their first glimpse of the jet-powered Be-10 ('Mallow'), four of which took part in the fly-past at that year's Tushino Air Display. Powered by two 14,330 lb (6,500 kg) st Type AL-7PB turbojet engines mounted on the fuselage beneath the roots of the sweptback shoulder wings, the Be-10 had a span of 73 ft 2 in (22·30 m), length of 102 ft 0½ in (31·10 m) and normal gross weight of about 90,390 lb (41,000 kg); maximum speed was 565 mph (910 km/hr) at 4,925 ft (1,500 m). Armament consisted of two 23 mm cannon in each of the nose and tail positions. The Be-10 is not thought to have served in very large numbers with the A-VMF (Soviet Naval Aviation), and has almost certainly been replaced now by the turboprop powered Be-12 ('Mail').

In overall appearance, with its twin tail assembly and gull-wing layout, the Be-12 bears a superficial resemblance to the earlier Be-6. However, the provision of turboprop power, a retractable wheeled landing gear to give amphibious capability, and the latest in sea-going detection equipment and anti-shipping weapons, clearly mark the Be-12 as one of the major maritime patrol aircraft currently in service. It was first seen, at Tushino, in 1961, at the same time as the Be-10, and in October 1964 the designation M-12 was quoted for an aircraft of the Be-12 type which set up six new international height records (with and without payloads) for seaplanes. These revealed that the aircraft was capable of reaching 39,977 ft (12,185 m) without a payload, and of carrying a 22,046 lb (10,000 kg) load to an altitude of 30,682 ft (9,352 m). Closed-circuit speed and distance records followed during 1968, by which year production examples of the Be-12 were in service with the Northern and Black Sea Fleets of the Soviet Navy. More recently, they have been reported in operation from Egyptian bases. Externally-visible features of the Be-12 include an elongated 'thimble' radome at the nose, a retractable MAD (Magnetic Anomaly Detection) 'stinger' housed in the extreme rear of the fuselage, an internal weapons bay aft of the hull step and three pylons beneath each wing for the carriage of external stores.

GLOSSARY

Amphibian. An aeroplane (usually a flying-boat but occasionally a floatplane) capable normally of taking off from, and alighting on, either land or water. (*N.B.* A flying-boat fitted with a permanent beaching gear cannot alight on land and is therefore not a true amphibian.)
Beam. The width of a float or hull at its widest point.
Chine. The line along the side of a float or hull, parallel to the keel, which marks the change in angle between the side plating and the planing bottom.
Flare. The outward slope of a flying-boat hull from the chine to the gunwale.
Float. A watertight body which gives buoyancy and stability on the water to a seaplane, enabling it to take off and alight.
Floatplane (or *Float seaplane*). A seaplane in which the means of ensuring buoyancy and alighting on the water is provided by a float landing gear.
Flying-boat (or *Boat seaplane*). A seaplane in which the main body or hull provides the means of support on the water.
Gunwale. The line along the side of the hull which marks the change in angle between the side plating and the top-decking.
Hull. The main structure and flotation body of a flying-boat or amphibian.
Planing bottom. That part of the float or hull undersurface forward of the main step.
Pontoon. Alternative term for *Float*, used principally in the United States.
Porpoising. The undulating fore-and-aft motion of a seaplane while taxying.
Seaplane. Any aeroplane capable of taking off from, and normally alighting solely on, water – i.e. it is a generic term covering both floatplanes and flying-boats.
Sponson. A short, wing-like projection, usually of aerofoil section and sometimes referred to as a 'sea-wing', on each side of the lower portion of a flying-boat's hull, to maintain its lateral balance on the water.
Step. A break in the undersurface of a float or hull designed to facilitate take-off. Where there are more than one, these are usually referred to as the main step and rear step respectively.

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