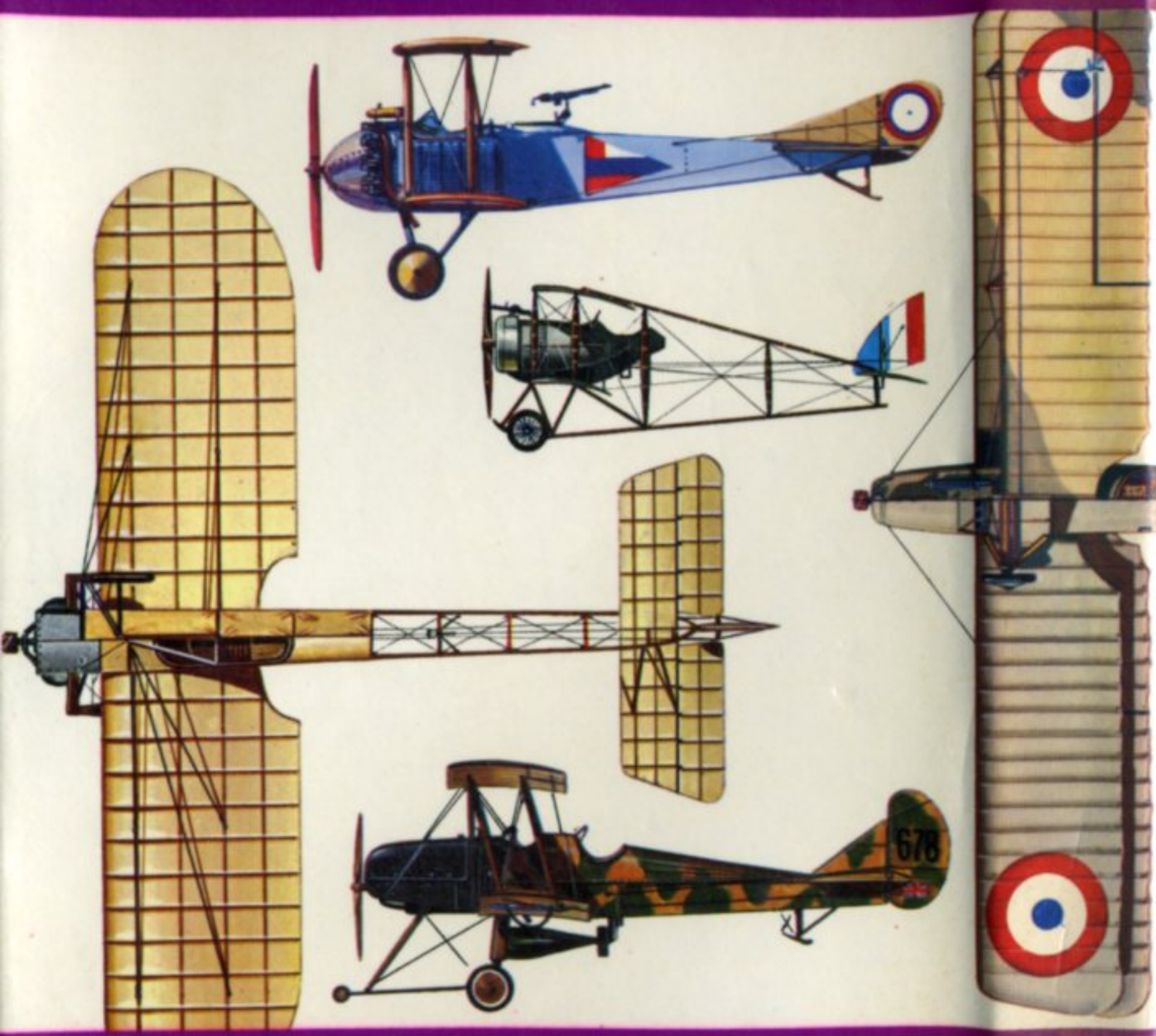
Blandford Colour Series

Bombers 1914-19

Patrol and Reconnaissance Aircraft



Kenneth Munson

Bombers 1914-19

Munson

Blandford

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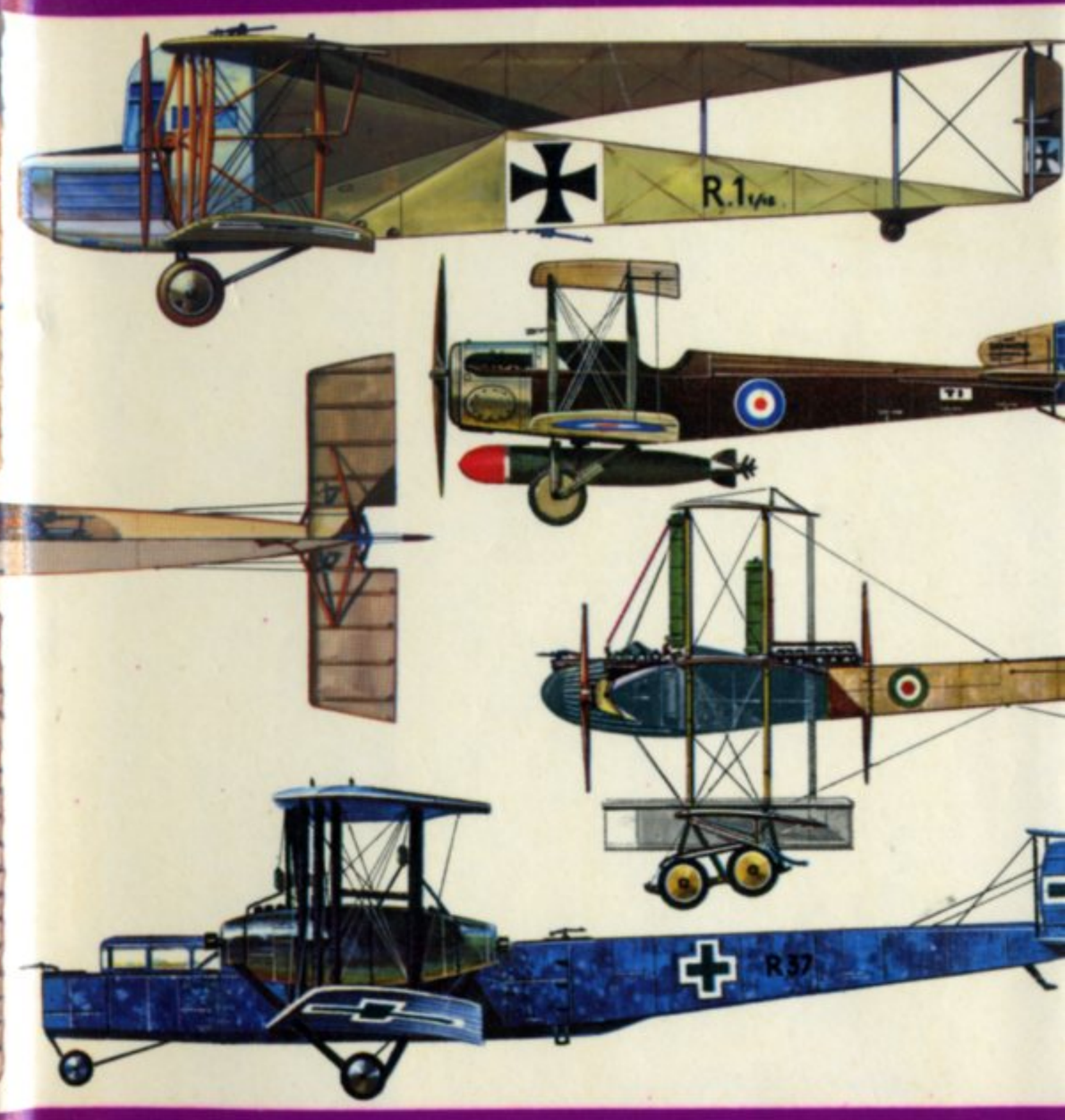

Kenneth Munson

Bombs were dropped from an aeroplane at least as early as November 1911, nearly three years before the outbreak of the First World War, and hence the bomber may claim to ante-date the fighter aeroplane as a weapon of war. At any rate, while there were no true fighters in existence in August 1914, there were bombers – from the frail Voisins of France to the giant four-engined Russian Ilya Mouromets.

The ensuing four years of war provided a testing-ground for such outstanding and varied bomber designs as the Gotha Grossflugzeuge, the Breguet 14 and the Handley Page O/400.

In addition, throughout the war the evolution of reconnaissance aircraft progressed to the extent that, to succeed the frail, defenceless Taube and Albatros machines of 1914, armed 2-seaters were evolved that in 1918 could out-fly and out-climb some of the ablest fighters in service.

The 67 aircraft in this volume reflect the development of such aircraft throughout the first truly formative period in military aviation history. The period 1914-19 is selected so as to include certain important types designed during the war, but which arrived too late for combat service.

First published in 1968, this new edition of a now firmly established favourite amongst aircraft enthusiasts contains some necessary textual corrections and clarification as well as amendments to minor illustration detail in two of the colour plates. Four types of aircraft which were not in the earlier edition have been added; to make room for these, a number of flying-boats and floatplanes have been transferred to the companion volume *Flying Boats and Seaplanes Since 1910*.

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The Pocket Encyclopaedia of World Aircraft in Colour

BOMBERS

PATROL AND RECONNAISSANCE AIRCRAFT

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PATROL AND RECONNAISSANCE AIRCRAFT

1914–1919

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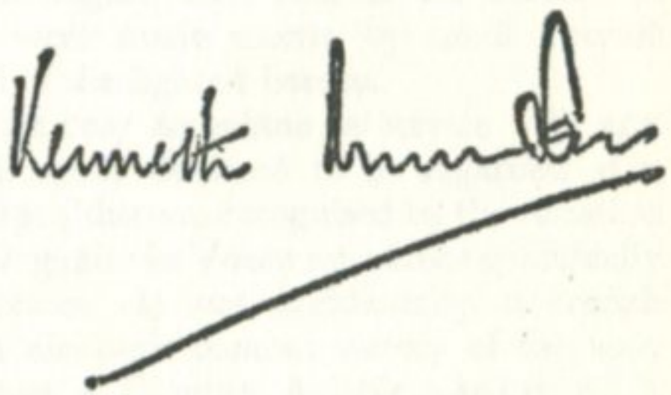
PREFACE

So far as the colour plates in this volume are concerned, we owe an incalculable debt of gratitude to Ian D. Huntley, A.M.R.Ae.S., whose extensive researches have provided the basis for all of the colour work in this volume. A short account of Ian Huntley's researches – and a few of the results that they have yielded – appear in the Appendices. These, if read in conjunction with the notes on page 15, should obviate a number of misconceptions which apparently confused some readers of the first edition.

For help or reference material of other kinds, I am indebted to material published by the American journal *Air Progress*, by Harleyford Publications Ltd. and by Profile Publications Ltd. Individual assistance with the original edition, also much appreciated, was given by Messrs. Charles F. Andrews of BAC, Bo Widfelt of the Swedish Aviation Historical Society and Lt. Col. N. Kindberg of the Royal Swedish Air Force; this revised edition has benefited in no small measure from material kindly made available subsequently by Chaz Bowyer, Jack Bruce, Roland Eichenberger and Douglas Pardee. To them all I am delighted to express again my thanks, both for their kindness and for the helpful spirit in which their assistance was offered.



May 1976

INTRODUCTION

It is difficult to establish with certainty when bombs were first dropped from an aeroplane in the furtherance of a military campaign, but the earliest recorded occasion was on 1 November 1911, when Giulio Gavotti of the Squadriglia di Tripoli, flying a Rumpler Taube of the Italian Air Service, released four small bombs over the North African townships of Tagiura and Ain Zara. At any rate it is certain that, as a type, the use of the aeroplane as a bomber antedated the fighter by several years, for machines capable of such activity were in service or being designed some time before the outbreak of World War 1.

One of the leading types at this time was the French Voisin, and the first bombing attack of the war was made by Voisins of the Aviation Militaire which bombed the Zeppelin hangars at Metz-Frascaty on 14 August 1914. During the early part of the war Germany and Austro-Hungary relied almost exclusively upon the Zeppelin airship as their main vehicle for bombing raids, and many of the first offensive sorties made by the Allies were directed at the factories or airfield sites where these 'monsters of the purple twilight' were built or housed. Before the end of 1914 a few successful bombing raids were also carried out by aircraft of the Royal Naval Air Service. It is probably fair to say that their morale value was higher than that of the actual destruction caused, for they were made mostly by small aircraft carrying only a modest load of the lightest bombs.

The Voisin was almost the only aeroplane in service with any of the warring nations that really deserved to be regarded as a bomber, and in September 1914 this was recognised by the Aviation Militaire, which began to reorganise its Voisin squadrons specifically to carry out bombing activities. (It was, incidentally, a French Voisin that scored the first air-to-air combat victory of the war, when its observer shot down a German Aviatik 2-seater on 5 October 1914.) France's first steps towards the creation of a bombing force were soon followed by the formation, in the Imperial Russian Air Service, of Tsar Nicholas II's 'Squadron of Flying Ships' (or

E.V.K.), equipped with the giant Sikorsky Ilya Mouromets. The Ilya Mouromets was the first (and, at that time, still the only) four-engined bomber in the world. This enormous machine, which had flown for the first time in January 1914, was a development of the record-setting *Le Grand*, also designed by Igor Sikorsky early in 1913. The E.V.K. made its first bombing raid with these machines on 15 February 1915 from its base at Jablonna in Poland.

Two months before this, Commodore Murray F. Sueter of the British Admiralty's Air Department had set the wheels in motion to produce what he called a 'bloody paralyser of an aeroplane' to bomb targets in Germany, although the bomber that resulted from this specification, the Handley Page O/100, was not to enter service until nearly the end of 1916.

In the meantime, in May 1915 the Aviation Militaire began a sustained bombing campaign using its squadrons of Voisin aircraft, the strength of which was eventually built up to a total of some six hundred aircraft. Both Britain and Italy bought Voisin and Breguet bombing types from France and began to build them under licence as well. Russia, too, essayed the licence production of the Voisin, with local modifications, but with unfortunate results.

On 24 May 1915 another protagonist joined the conflict on the side of the Allies. Italy's combined total of military and naval aeroplanes at this time was little more than a hundred, and a high proportion of these were of French origin. They did include, however, a number of examples of the excellent Caproni Ca 2 bombers with the range and reliability to undertake the long, hazardous flight across the Alps to targets in Austro-Hungary, and the first such raid by these aircraft was carried out on 20 August 1915.

For the first half of the war, the Zeppelins continued to be Germany's chief vehicles for heavy bombing, but thereafter they were used mostly by the German Naval Air Service while the military arm turned to using aeroplanes. Daylight raids on Great Britain, using A.E.G. and Gotha twin-engined bombers, began early in 1917. During the summer these attacks were stepped up to such an intensity that the R.F.C. and R.N.A.S. were obliged to recall aircraft that they could ill afford to spare from the Western Front in order to expand the number of Home Defence squadrons. These fighters, some of them makeshift conversions of 2-seat types, resisted the German raiders to such good effect that they were at

first obliged to attack only by night and finally to abandon the raids altogether in May 1918.

The Gothas typified the German bombers of the period and were the principal types to be used, but they were abetted by smaller numbers of the similar Friedrichshafen G types and, in the later stages, by the bigger Zeppelin (Staaken) R types. Allied bombers of the later war years included later and improved models of the Caproni series and the Ilya Mouromets, together with such excellent new types as the Breguet 14, D.H.4 and Handley Page O/400. Some other bomber types, notably the D.H.9 and the R.E.8, were produced in far greater numbers which their combat value did not merit. In June 1918 Britain established the Independent Force in Europe, a strategic bombing force equipped in the main with Handley Page bombers, to undertake the bombing of targets in the German homeland. The United States of America had come into the war on 6 April 1917, and for most of 1918 the American Expeditionary Force, equipped predominantly with fighters and bombers of French origin, made an important contribution to the bombing offensive which was sustained until the end of the war.

The load-carrying abilities of the bomber aeroplane had increased to such an extent by the end of World War 1 that, from the little 20-lb. or 10-kg. weapons that had been the norm in 1914, high explosive 'block-busters' weighing 1,650 lb. (nearly 750 kg.) had been developed and used. The weapons in most general use were those weighing around 100 kg. – 250 lb., but the Handley Page V/1500, which was all ready to go into action when the Armistice was signed, was able to carry two bombs each weighing 3,300 lb. (1,497 kg.). The small-size bombs were often carried by observation 2-seaters, more for their 'nuisance' value than anything else, but occasionally these could be used in other ways with spectacular results. One such occasion was the destruction of the Zeppelin LZ.37 in June 1915 by Flight Sub-Lieutenant Warneford of the R.N.A.S., who flew along the length of the dirigible dropping six of these tiny bombs into the airship's envelope. Warneford was awarded the Victoria Cross for his action, which was the first time a Zeppelin had been brought down by an attack from another aircraft. So far as armament was concerned, the guns carried by bombing, patrol or reconnaissance aircraft were primarily for defensive purposes. The Parabellum, the standard German observer's weapon, was the pre-war LMG.08 version of the Maxim

infantry machine-gun; its standard Allied equivalent was the Lewis.

One variation of the orthodox bomber evolved during 1914–18 was the torpedo bomber, but such aircraft as a class did not contribute a significant amount towards the progress of the war. Successful launches of torpedoes were made from several different aircraft types, but the actual amount of shipping sunk or damaged by this form of attack was small in comparison with that accounted for by ordinary high explosive bombs.

The use of water-borne aircraft in patrolling the seas and defending naval shore stations was an important element in the conduct of the war as a whole. Germany, alone of the major combatants, eschewed the value of the flying-boat for these purposes, but she did employ a considerable variety of floatplanes, both on board seaplane carriers or other naval vessels and at naval shore stations, for defensive or patrol duties. Their British counterparts included such useful workhorses as the Fairey Campania, Short 184 and Sopwith Baby.

The Lohner, Macchi, Tellier and F.B.A. flying-boats, of Austrian, Italian and French origin respectively, were mostly medium-sized 2-seaters with a modest defensive armament and a small bomb load. They were among the less glamourised aircraft of World War 1, but they carried out a vast amount of routine but valuable work. The large flying-boat appeared first in the form of the indifferent Curtiss 'America' series from the U.S.A., which Squadron Commander John Porte of the R.N.A.S. transformed into the Felixstowe F.2A, a thoroughly efficient and seaworthy long range patroller that set a pattern for flying-boat evolution lasting for two decades and more after the war ended. Porte was one of a select band of naval officers who made an incalculable contribution to the development of marine aviation during these formative years; another was Squadron Commander E. H. Dunning, who lost his life in August 1917 while carrying out a test landing in a Sopwith Pup in connection with the evolution of deck take-off and landing techniques.

World War 1 was the background for the first true air war, and in this as in all subsequent conflicts the glamour attached itself chiefly to the fighter and bomber aircraft involved. But in 1914–18 the real workhorses in every air service were the 2-seat observation and reconnaissance machines. Right from the outset

of World War 1 the aeroplane's principal – indeed, its only – value had been thought in most official circles to be that of observing and reporting the progress of the war on the ground, rather than making a positive contribution to that progress. Even when this way of thinking had been proved to be wrong, the value of the reconnaissance machine remained undiminished.

Aircraft of both sides were sent over enemy lines during the first few months of the war to report the progress of troop movements or the accuracy of their own side's artillery fire. At first, the majority of aircraft used for this role were unarmed, but before the war was many weeks old some observers began to take into the air with them service revolvers, cavalry carbines, duck rifles and all manner of other, often bizarre, weapons with which to 'have a go' at any enemy machine they chanced to meet while out on a patrol. Once this practice had started, other observers were obliged to equip themselves with similar means of protection or retaliation; and from the first few sporadic encounters of this kind the foundations were laid of the arts and skills of aerial fighting. On the one hand this led, naturally enough, to the evolution of the fighter as a specialised combat type. At the same time it created the need to evolve faster, more manoeuvrable and better-armed observation types that could defend themselves adequately against attack from fighters or other 2-seaters.

It must be remembered that at this period of the war the standard arrangement of most 2-seaters was to place the observer in the front cockpit. In a tractor biplane, the most common configuration, he therefore had the engine block in front of him, bracing struts and wires on either side and the pilot behind him. Consequently, when weapons began to be carried he had little worthwhile field of fire at all, and his field of view for carrying out his observation duties was not very much better. Moreover, the risk of a bullet fracturing a bracing wire – or, more important, a control wire – was always present. Yet, despite the difficulties, several successes were achieved with hand-held guns operated from the front cockpit in this fashion.

First to break out of the rut was Germany, which introduced its new category of C type armed 2-seaters in the spring of 1915. In these machines the observer more logically occupied the rearmost of the two cockpits, where he had a much wider field of view and the freedom to fire a gun in almost every direction except

directly below. The hand-held rifle or other weapon was replaced by a ring-type mounting for a machine-gun that could be rotated to right or left, elevated or depressed, and from then onward the German armed 2-seater was an opponent to be reckoned with for as long as the war continued. Most of the German and Austrian C types had a fair degree of manoeuvrability, and some of them could give even the best Allied fighters a run for their money. Late-war fighters of the calibre of the S.E.5a found the best of them, the D.F.Ws. and L.V.Gs, more than worthy opponents in the hands of a good crew. Some of the high altitude photographic C types, like the later Rumplers, could climb to heights above 20,000 feet (6,100 metres), well above the ceiling of most Allied fighters. For such missions they qualified for heated flying suits and oxygen breathing apparatus to be issued to the crews – both comparative rarities in other classes of wartime aircraft.

Germany, having a large domestic aircraft industry, was able to undertake the development of a wide variety of reconnaissance 2-seaters, but on the Allied side such types were less diversified. The Italian SAML and Ansaldo scouts were among the best, the latter (a single-seater) being probably the fastest reconnaissance aircraft used by any combatant during the entire war. Russia's only original contribution was the indifferent Anatra, while France relied to a large extent on pre-war Farmans or Caudrons or unspectacular Spad and Nieuport designs until the Salmson 2 appeared early in 1918. Britain pinned its faith for too much of the war upon the unfortunate B.E.2 series designed at the Royal Aircraft Factory, which were the principal prey of the Fokker monoplanes and later German biplane fighters. From the structural and design viewpoints the B.E. was a fine, well-thought-out piece of engineering with many desirable flying qualities. Unfortunately, what did not get through to the men with influence over its production and employment was the fact that the very qualities that made it such an excellent, safe and stable flying machine were the direct cause of its downfall against the German fighters. Its stability made it virtually impossible for the B.E.2 to outmanoeuvre the agile enemy single-seaters, its speed was not great enough nor its ceiling high enough for it to outrun or outclimb them; and by clinging obstinately to the outmoded practice of putting the observer in the front seat surrounded by a 'cage' of struts, wires and engine its sponsors severely limited what little defensive firepower it

had. It was not to be wondered at that the wretched B.Es. were shot down in their dozens.

In order to study the aircraft of 1914–18 in a proper perspective it is helpful if one appreciates some of the conditions under which they and their crews had to carry out their combat duties. In nearly every case crews had to fly in unheated flying suits, in open cockpits, at altitudes where the intense cold affected not only their own physical efficiency but the lubrication and cooling systems of their engines and guns. Gun stoppages were still an all-too-frequent occurrence, even in excellent late-war designs with otherwise good performance, and often an engagement had to be broken off by one or other participant because of a jammed gun or some similar circumstance. While on the ground, the aircraft were usually either pegged down in the open, or, at best, stored in canvas field hangars, and the depredations to their fabric from the bitter Russian cold, the miserable dampness of the Western Front or the blistering Middle Eastern heat can well be imagined. Performance figures recorded for individual types are those obtaining under more or less ideal flying conditions, but for much of the time such conditions were not enjoyed.

THE COLOUR PLATES

As an aid to identification, the sixty-seven colour plates which follow have been arranged on a visual basis, within the broad sequence: tractor monoplanes, pusher biplanes, tractor biplanes, flying-boats and seaplanes. The Curtiss H-4/12/16, Fairey Campania and Felixstowe F.2A/F.3 seaplanes, which appeared in the original edition of this volume, can now be found in the *Flying Boats and Seaplanes since 1910* volume in the series. The 'split' plan view is adopted to give upper and lower surface markings within a single plan outline. The reference number of each aircraft corresponds to the appropriate text matter, and an index to all types appears on pages 186 and 187.

To clarify some apparent misconceptions arising from the first edition:

(*a*) It should not be assumed, from the 'split' plan view presentation, that the unseen portion of the plan view of a camouflaged aircraft is a 'mirror image' of the half that is portrayed.

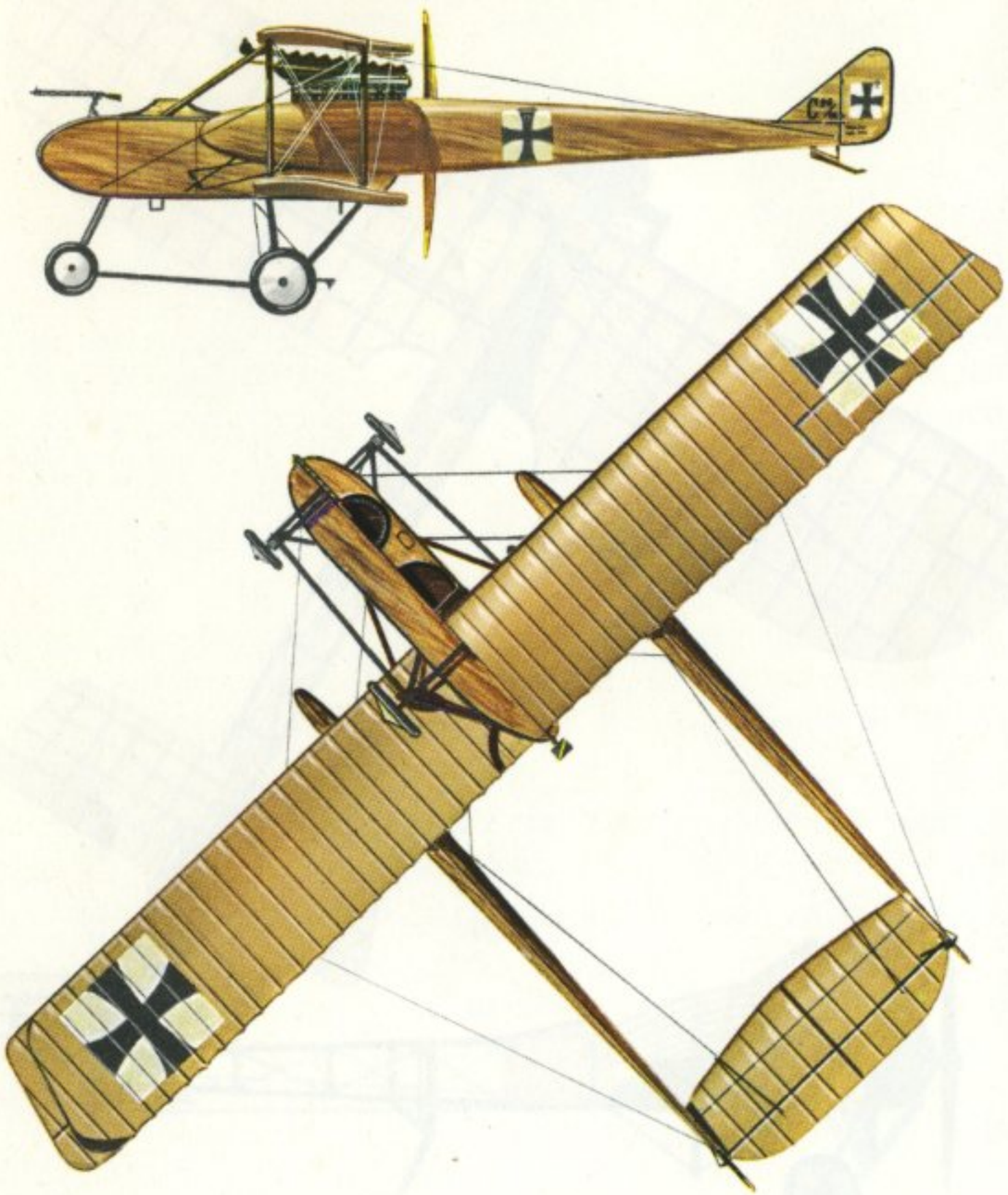
(*b*) It should not be assumed that all colour plates are intended to show standard colour schemes or a pristine 'ex-works' state of finish. Indeed, several plates deliberately show 'weathered' aircraft.

(*c*) Note (*b*) above applies particularly to the British khaki/P.C.10 colouring (see Appendix 2) for which, within the limitations of the colour reproduction process, an attempt has been made to illustrate this finish in a wide variety of conditions, from an ex-works aircraft with maximum 'green shift' (e.g. page 59) to a much-weathered aircraft (e.g. page 64).

1

Blériot XI-2 *Artillerie,* possibly an aircraft of No. 3 Squadron R.F.C., 1914. *Engine:* One 70 h.p. Gnome 7 A rotary. *Span:* 29 ft. 2½ in. (8·90 m.). *Length:* 25 ft. 7 in. (7·80 m.). *Wing area:* 161·3 sq.ft. (15·00 sq.m.). *Take-off weight:* 882 lb. (400 kg.). *Maximum speed:* 55·9 m.p.h. (90 km./hr.) at sea level. *Service ceiling:* 6,562 ft. (2,000 m.). *Endurance:* 3 hr. 30 min.

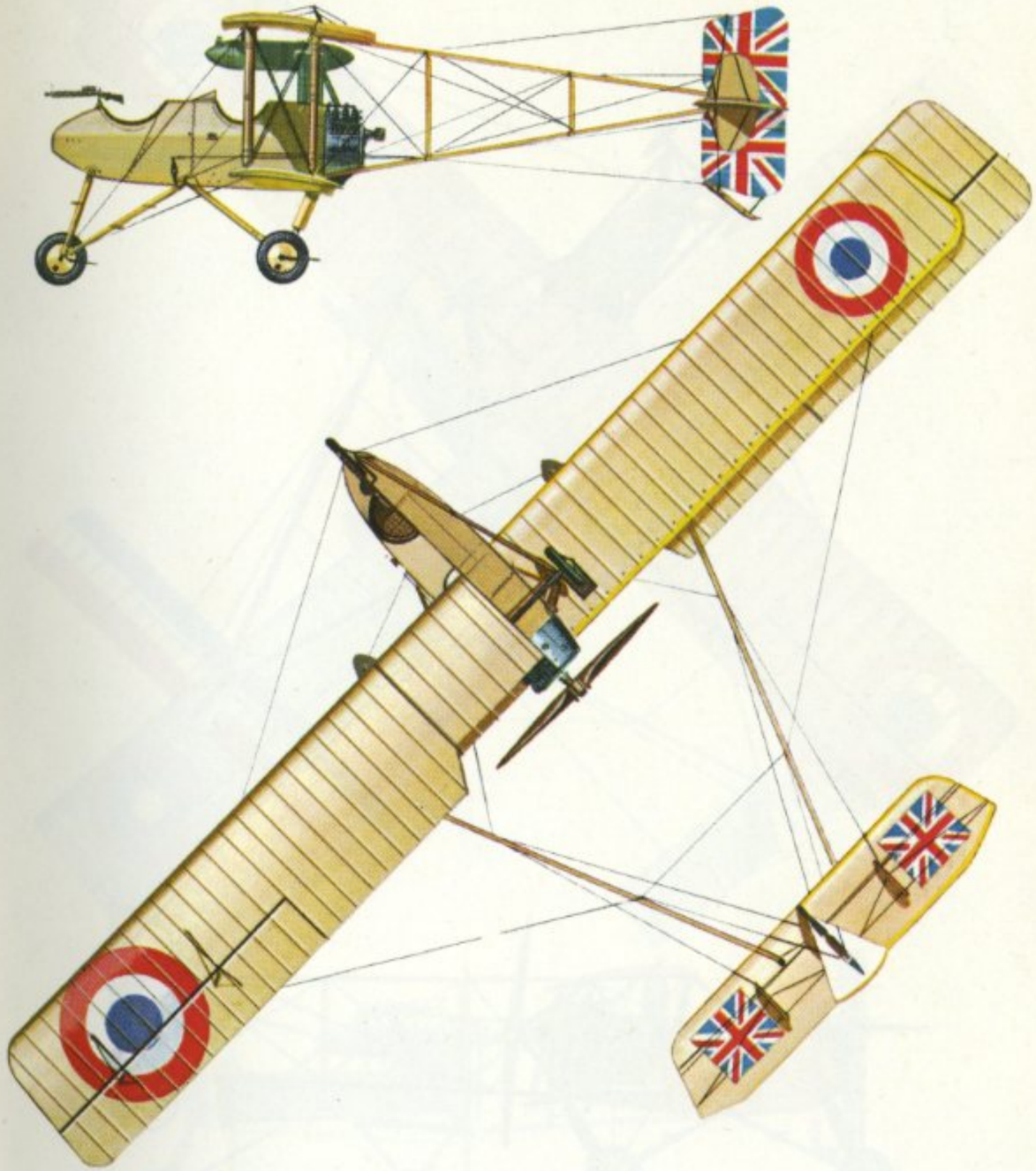
AGO C.II (Germany)



2

Ago C.II of the Imperial German Military Aviation Service, summer 1915. *Engine:* One 220 h.p. Benz Bz.IV water-cooled in-line. *Span:* 47 ft. $6\frac{7}{8}$ in. (14·50 m.). *Length:* 32 ft. $3\frac{3}{8}$ in. (9·84 m.). *Wing area:* approx. 510·2 sq.ft. (47·40 sq.m.). *Take-off weight:* 2,998 lb. (1,360 kg.). *Maximum speed:* 85·1 m.p.h. (137 km./hr.) at sea level. *Service ceiling:* approx. 14,764 ft. (4,500 m.). *Range:* 360 miles (580 km.).

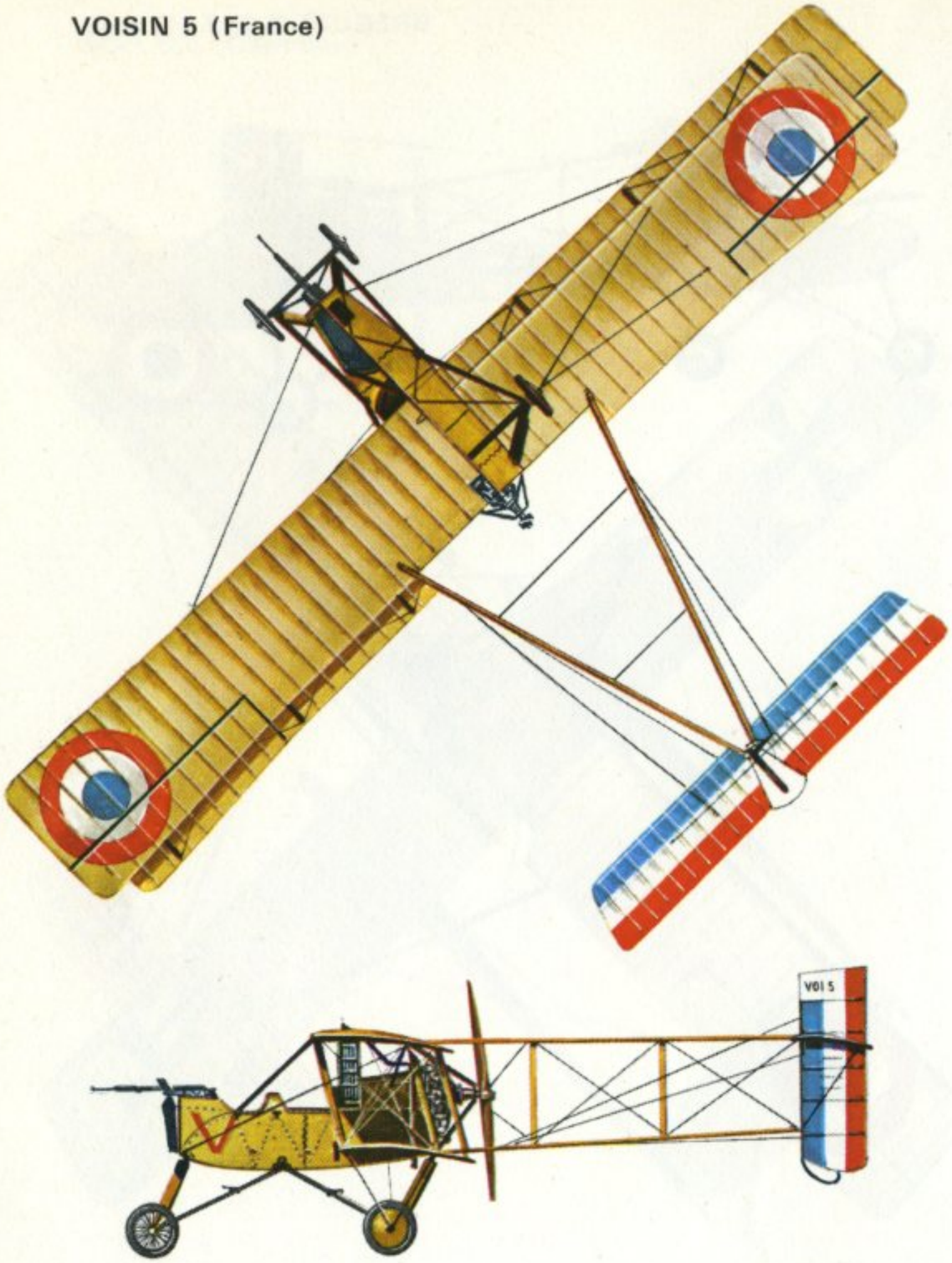
BREGUET BrM.5 (France)



3

The machine illustrated is believed to be a French-built pre-series Type 5 supplied as a pattern for the Grahame-White-built Type XIX in late summer 1915. *Data apply to the production G.W. XIX. Engine:* One 250 h.p. Rolls-Royce I (Eagle) water-cooled Vee-type. *Span:* 57 ft. $8\frac{1}{8}$ in. (17·58 m.). *Length:* 26 ft. $0\frac{3}{4}$ in. (7·94 m.). *Wing area:* 621·1 sq.ft. (57·70 sq.m.). *Take-off weight:* 4,740 lb. (2,150 kg.). *Maximum speed:* 85·7 m.p.h. (138 km./hr.) at sea level. *Service ceiling:* 14,108 ft. (4,300 m.). *Range:* 435 miles (700 km.).

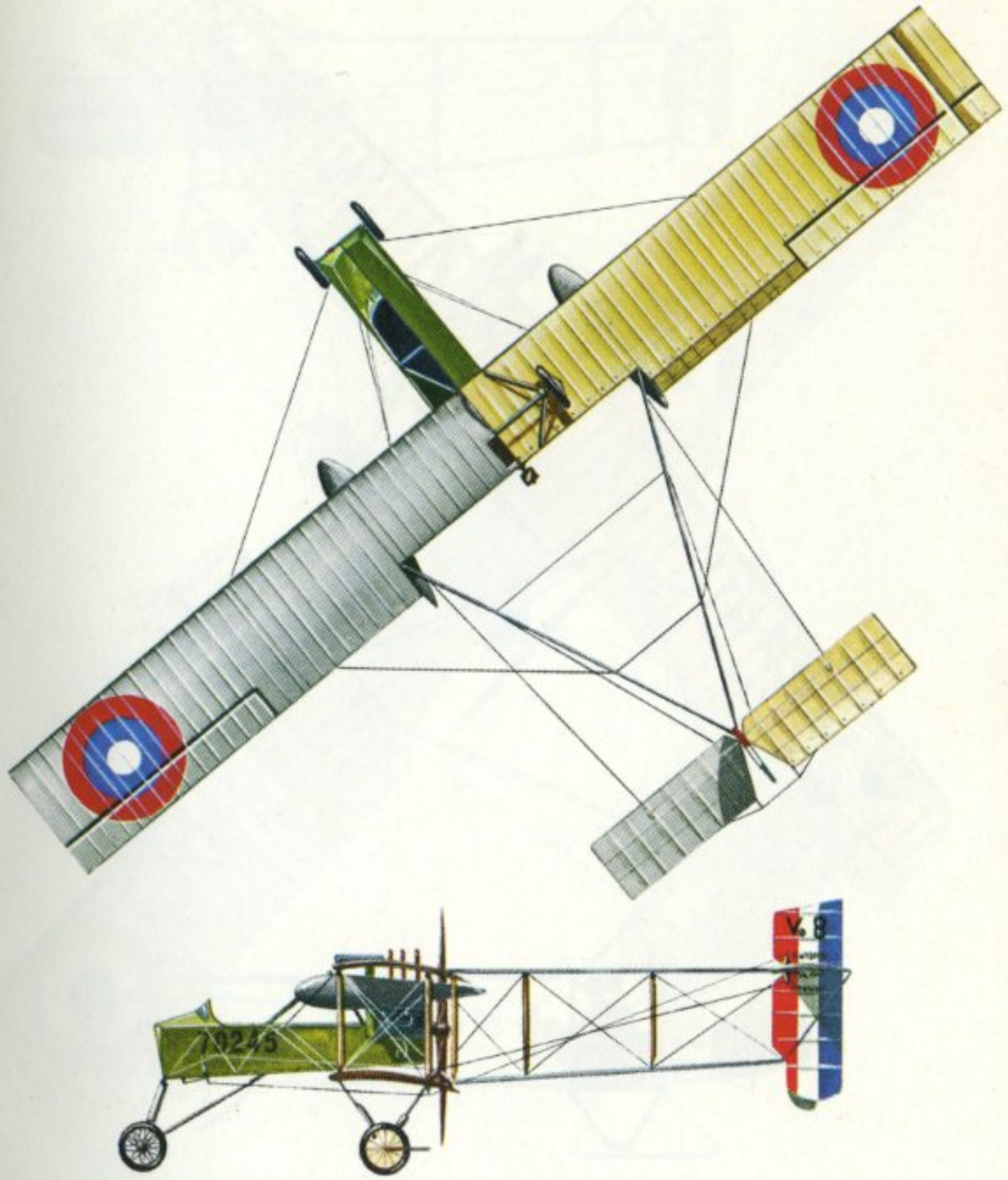
VOISIN 5 (France)



4

Voisin Voi.5B.2 (Type LA.S) of the French *Aviation Militaire, ca.* summer 1916. *Engine:* One 150 h.p. Salmson (Canton-Unné) 9 P water-cooled radial. *Span:* 48 ft. $4\frac{1}{4}$ in. (14·74 m.). *Length:* 31 ft. 2 in. (9·50 m.). *Wing area:* 484·4 sq.ft. (45·00 sq.m.). *Take-off weight:* 3,020 lb. (1,370 kg.). *Maximum speed:* 69·6 m.p.h. (112 km./hr.) at sea level. *Service ceiling:* 11,483 ft. (3,500 m.). *Endurance:* 3 hr. 30 min.

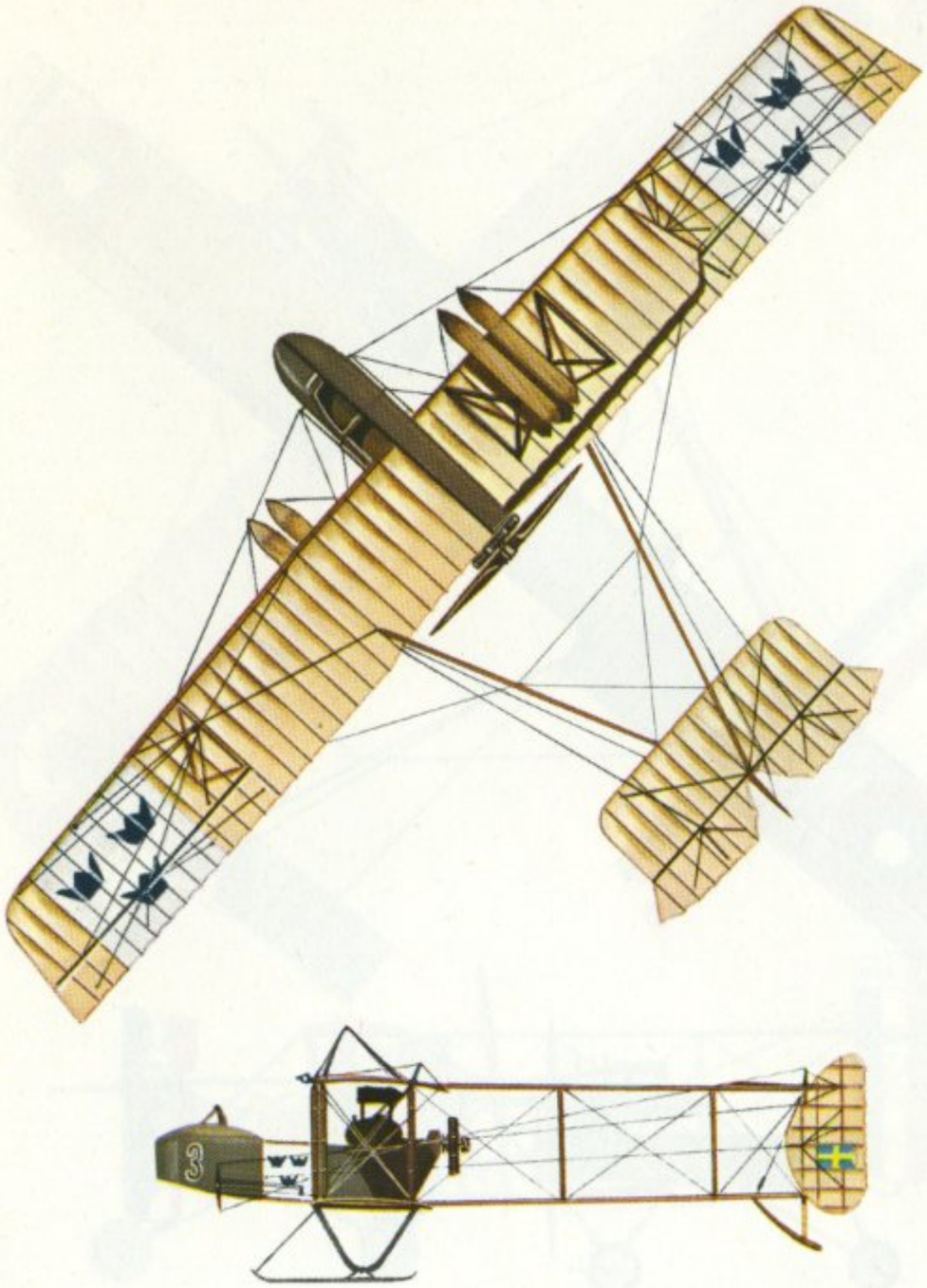
VOISIN 8 (France)



5

Voisin Voi.8Bn.2 (Type LA.P) bombing trainer of the American Expeditionary Force, France, *ca.* April 1918. *Engine:* One 220 h.p. Peugeot 8 Aa water-cooled in-line. *Span:* 59 ft. $0\frac{3}{4}$ in. (18·00 m.). *Length:* 33 ft. $11\frac{1}{2}$ in. (10·35 m.). *Wing area:* 678·1 sq.ft. (63·00 sq.m.). *Take-off weight:* 4,101 lb. (1,860 kg.). *Maximum speed:* 73·3 m.p.h. (118 km./hr.) at sea level. *Service ceiling:* 14,108 ft. (4,300 m.). *Endurance:* 4 hr. 0 min.

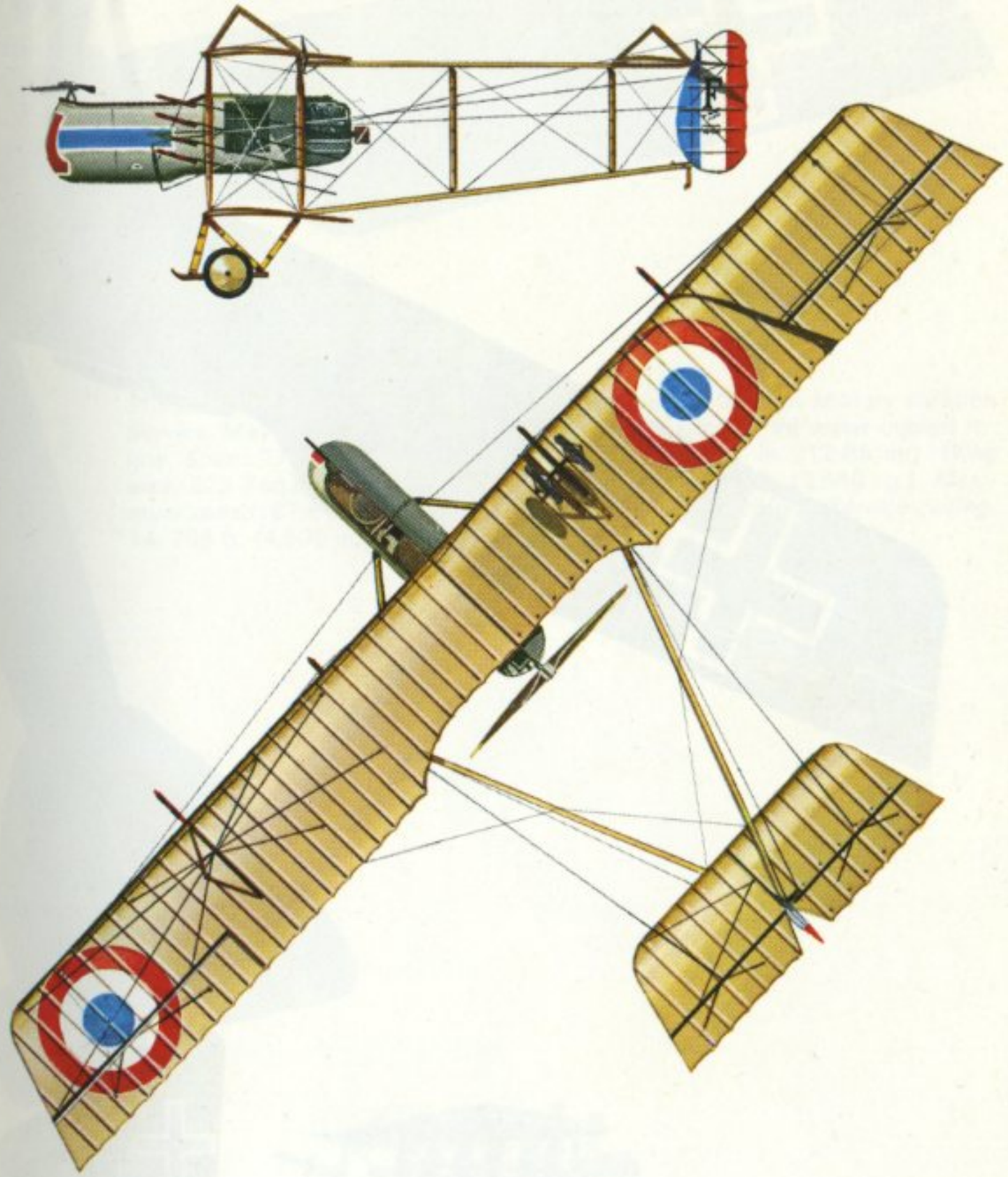
FARMAN HF.23 (France)



6

Södertälje-built Henry Farman HF.23 (SW.11) of the Royal Swedish Naval Aviation, 1914. *Engine:* One 80 h.p. Gnome 7 A rotary. *Span:* 49 ft. $2\frac{1}{2}$ in. (15·00 m.). *Length:* 29 ft. $2\frac{1}{2}$ in. (8·90 m.). *Wing area:* approx. 360·6 sq.ft. (33·50 sq.m.). *Take-off weight:* 1,499 lb. (680 kg.). *Maximum speed:* 55·9 m.p.h. (90 km./hr.) at sea level. *Service ceiling:* 9,022 ft. (2,750 m.). *Endurance:* 3 hr. 30 min.

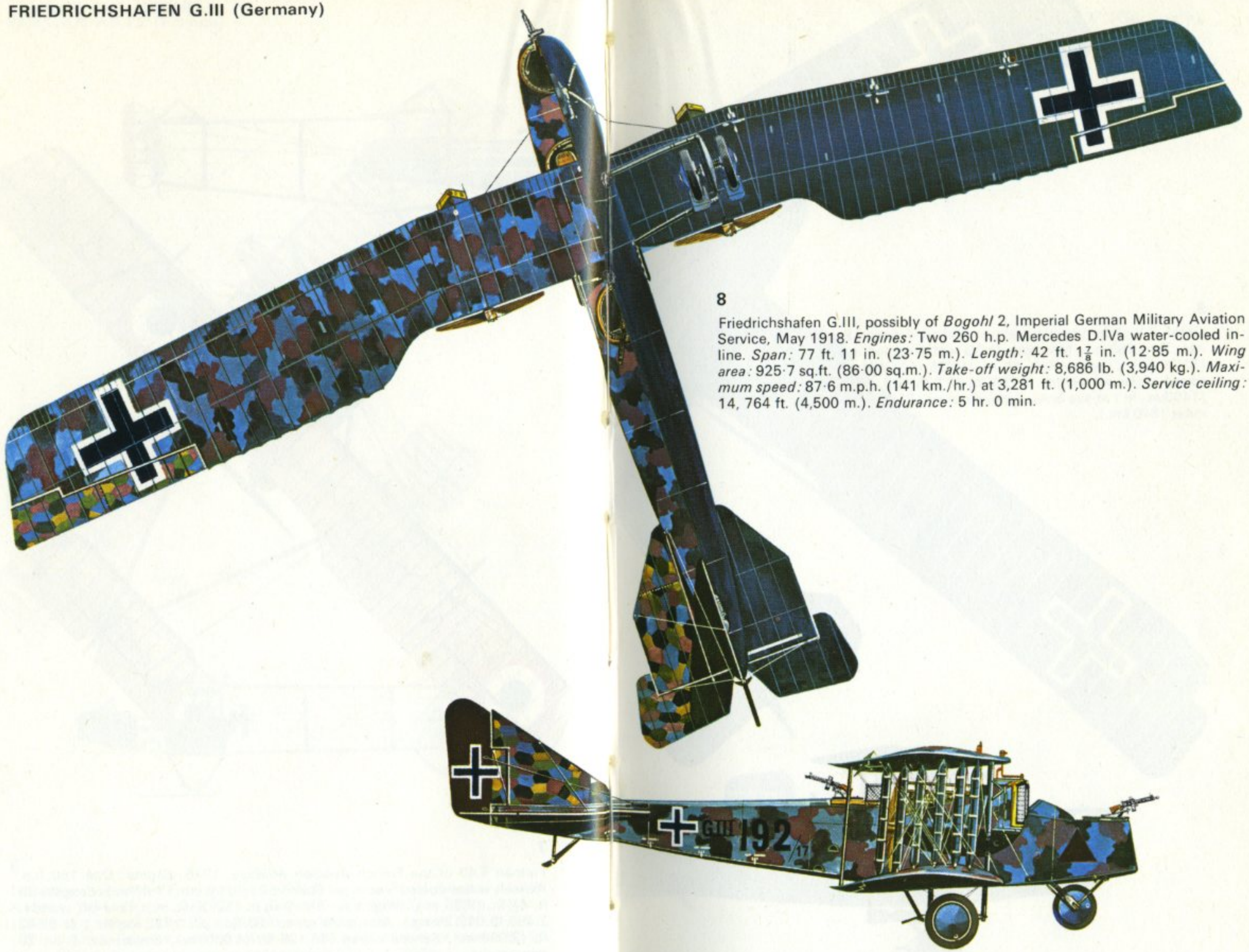
FARMAN F.40 (France)



7

Farman F.40 of the French *Aviation Militaire,* 1916. *Engine:* One 160 h.p. Renault water-cooled Vee-type. *Span:* 57 ft. $11\frac{5}{8}$ in. (17·67 m.). *Length:* 30 ft. $4\frac{1}{8}$ in. (9·25 m.). *Wing area:* 559·7 sq.ft. (52·00 sq.m.). *Take-off weight:* 2,469 lb. (1,120 kg.). *Maximum speed:* 83·9 m.p.h. (135 km./hr.) at 6,562 ft. (2,000 m.). *Service ceiling:* 13,123 ft. (4,000 m.). *Endurance:* 2 hr. 20 min.

FRIEDRICHSHAFEN G.III (Germany)



8

Friedrichshafen G.III, possibly of *Bogohl* 2, Imperial German Military Aviation Service, May 1918. *Engines:* Two 260 h.p. Mercedes D.IVa water-cooled in-line. *Span:* 77 ft. 11 in. (23·75 m.). *Length:* 42 ft. $1\frac{7}{8}$ in. (12·85 m.). *Wing area:* 925·7 sq.ft. (86·00 sq.m.). *Take-off weight:* 8,686 lb. (3,940 kg.). *Maximum speed:* 87·6 m.p.h. (141 km./hr.) at 3,281 ft. (1,000 m.). *Service ceiling:* 14, 764 ft. (4,500 m.). *Endurance:* 5 hr. 0 min.

9

Gotha G.V of the Imperial German Military Aviation Service, April 1918. *Engines:* Two 260 h.p. Mercedes D.IVa water-cooled in-line. *Span:* 77 ft. $9\frac{1}{8}$ in. (23·70 m.). *Length:* 40 ft. $6\frac{1}{4}$ in. (12·35 m.). *Wing area:* 963·4 sq.ft. (89·50 sq.m.). *Take-off weight:* 8,763 lb. (3,975 kg.). *Maximum speed:* 87 m.p.h. (140 km./hr.) at sea level. *Service ceiling:* 21,325 ft. (6,500 m.). *Range:* 522 miles (840 km.).

D.F.W. B.I (Germany)

10

D.F.W. B.I of the Imperial German Military Aviation Service, 1915. *Engine:* One 100 h.p. Mercedes D.I water-cooled in-line. *Span:* 45 ft. $11\frac{1}{8}$ in. (14·00 m.). *Length:* 27 ft. $6\frac{2}{3}$ in. (8·40 m.). *Wing area:* approx. 369·2 sq.ft. (34·30 sq.m.). *Take-off weight:* 2,238 lb. (1,015 kg.). *Maximum speed:* 74·6 m.p.h. (120 km./hr.) at sea level. *Service ceiling:* approx. 9,843 ft. (3,000 m.). *Endurance:* approx. 4 hr. 0 min.

LLOYD C.II (Austro-Hungary)

11

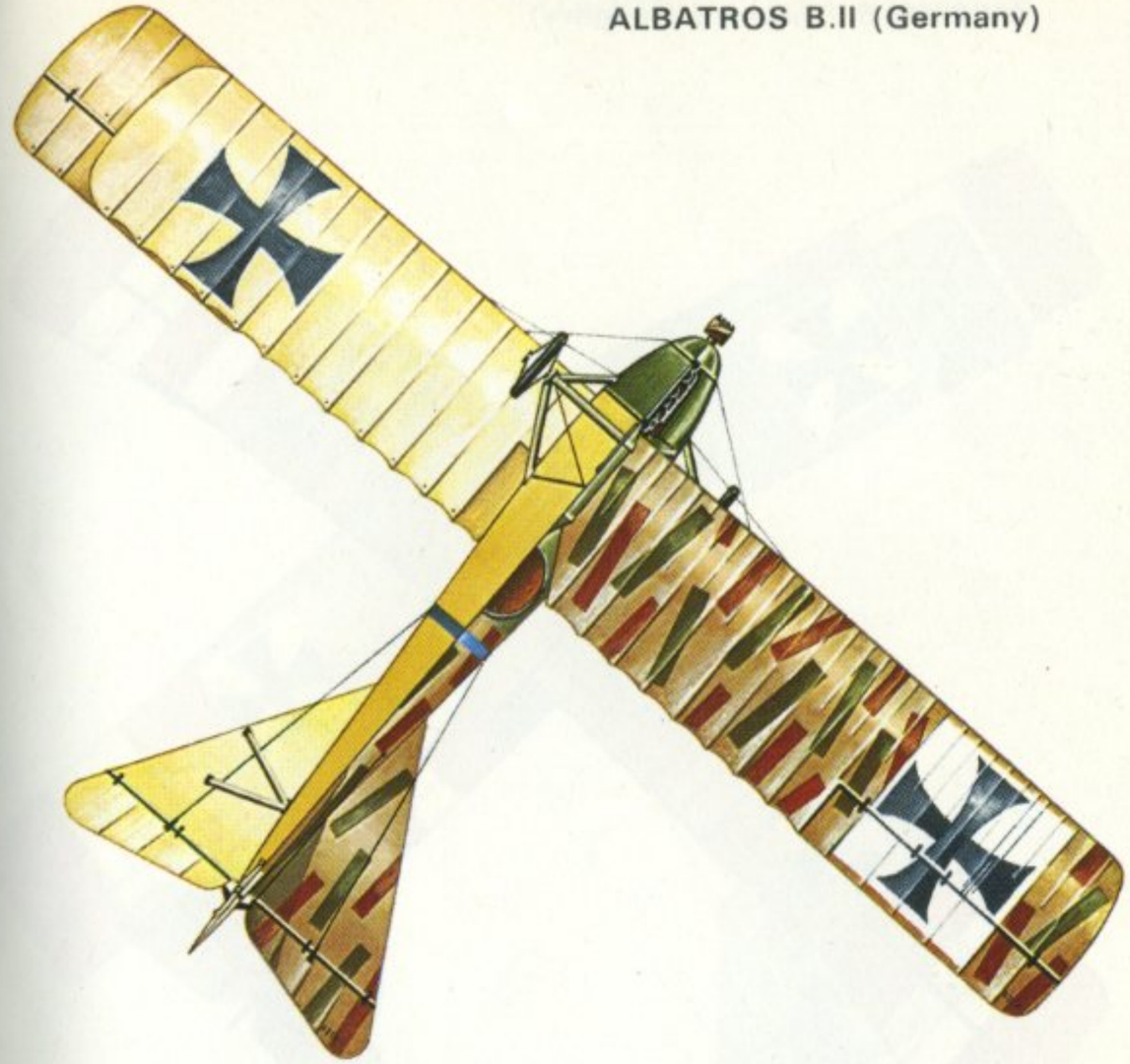
Lloyd-built C.II of the Austro-Hungarian Air Service, 1915. *Engine:* One 145 h.p. Hiero water-cooled in-line. *Span:* 45 ft. $11\frac{1}{8}$ in. (14·00 m.). *Length:* 29 ft. $6\frac{1}{3}$ in. (9·00 m.). *Wing area:* approx. 374·0 sq.ft. (34·75 sq.m.). *Take-off weight:* approx. 2,976 lb. (1,350 kg.). *Maximum speed:* approx. 79·5 m.p.h. (128 km./hr.) at sea level. *Service ceiling:* 9,843 ft. (3,000 m.). *Endurance:* approx. 2 hr. 30 min.

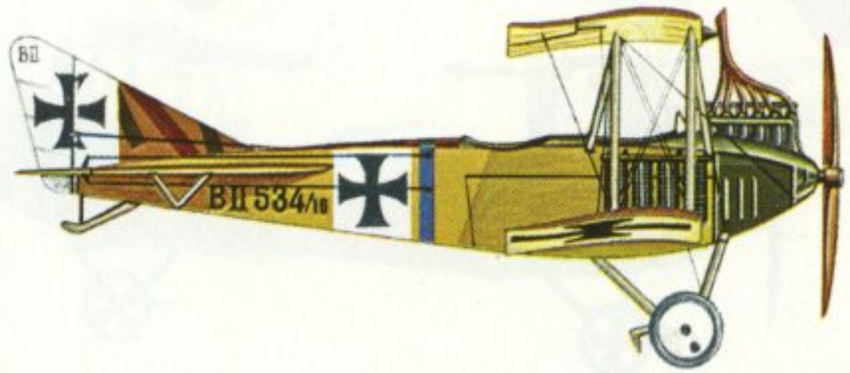
HANSA-BRANDENBURG C.I (Austro-Hungary)

12

Hansa-Brandenburg C.I of the Imperial German Military Aviation Service, *ca.* spring 1916. *Data for Phönix-built Series 23. Engine:* One 160 h.p. Austro-Daimler water-cooled in-line. *Span:* 43 ft. 0½ in. (13·12 m.). *Length:* 26 ft. 10¾ in. (8·20 m.). *Wing area:* 467·8 sq.ft. (43·46 sq.m.). *Take-off weight:* 2,337 lb. (1,060 kg.). *Maximum speed:* 77·6 m.p.h. (125 km./hr.) at sea level. *Service ceiling:* 19,029 ft. (5,800 m.). *Endurance:* approx. 3 hr. 0 min.

ALBATROS B.II (Germany)





13

Albatros B.II of the Imperial German Military Aviation Service, *ca.* April 1916. *Engine:* One 100 h.p. Mercedes D.I water-cooled in-line. *Span:* 42 ft. 0 in. (12·80 m.). *Length:* 25 ft. 0⅜ in. (7·63 m.). *Wing area:* 431·8 sq.ft. (40·12 sq.m.). *Take-off weight:* 2,361 lb. (1,071 kg.). *Maximum speed:* 65·2 m.p.h. (105 km./hr.) at sea level. *Service ceiling:* 9,843 ft. (3,000 m.). *Endurance:* 4 hr. 0 min.

AVIATIK B.II (Austro-Hungary)

14

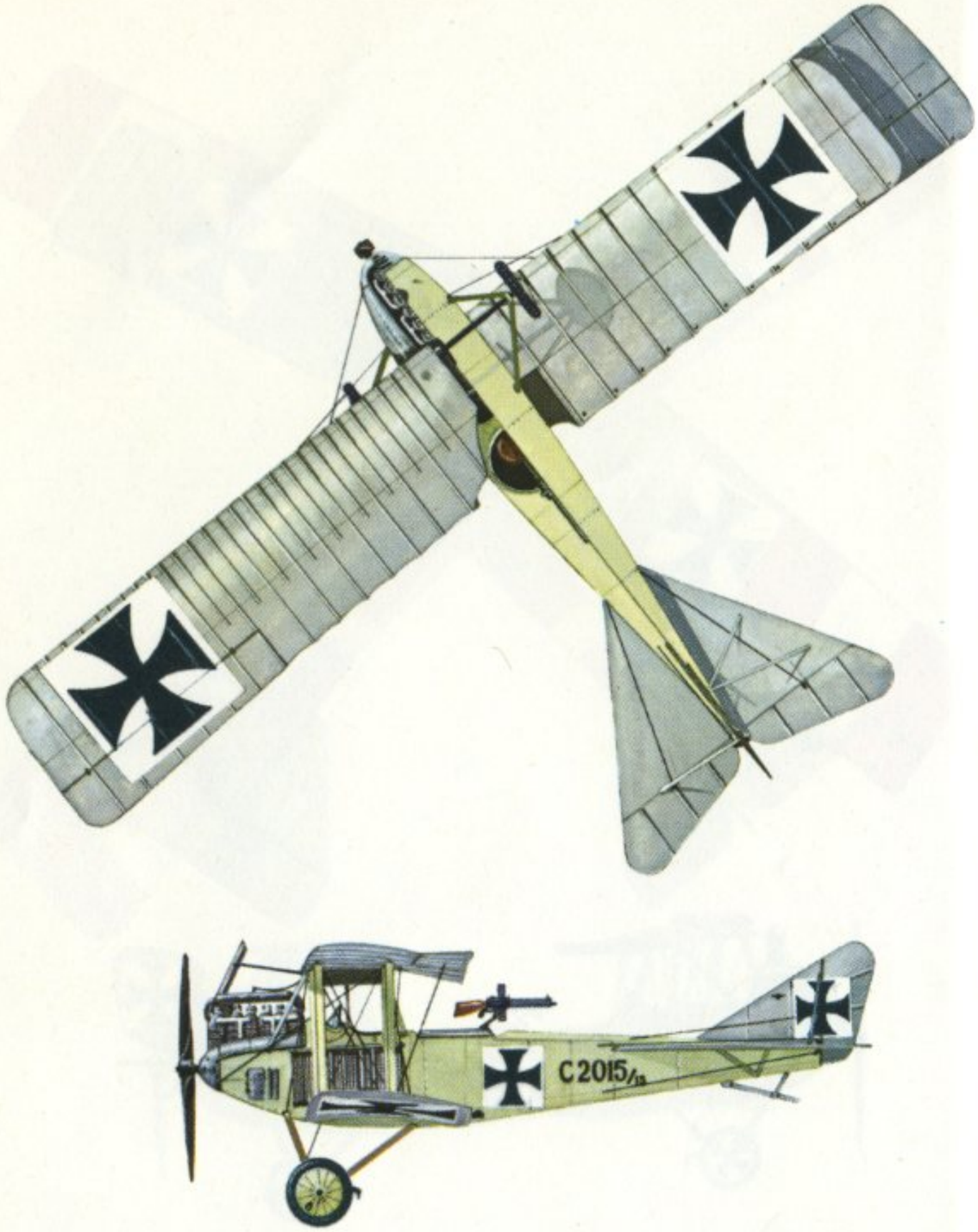
Austrian Aviatik B.II of the Austro-Hungarian Air Service, *ca.* early 1916. *Engine:* One 120 h.p. Austro-Daimler water-cooled in-line. *Span:* 45 ft. 11⅛ in. (14·00 m.). *Length:* 26 ft. 3 in. (8·00 m.). *Wing area:* approx. 349·8 sq.ft. (32·50 sq.m.). *Take-off weight:* 1,918 lb. (870 kg.). *Maximum speed:* 67·7 m.p.h. (109 km./hr.) at sea level. *Service ceiling:* 8,202 ft. (2,500 m.). *Endurance:* 4 hr. 0 min.

LOHNER C.I (Austro-Hungary)

15

Lohner-built C.I of the Austro-Hungarian Air Service, 1916. *Engine:* One 160 h.p. Austro-Daimler water-cooled in-line. *Span:* 44 ft. 1½ in. (13·45 m.). *Length:* 29 ft. 3 in. (9·22 m.). *Wing area:* approx. 413·3 sq.ft. (38·40 sq.m.). *Take-off weight:* approx. 2,998 lb. (1,360 kg.). *Maximum speed:* 85·1 m.p.h. (137 km./hr.) at sea level. *Service ceiling:* 11,483 ft. (3,500 m.). *Endurance:* approx. 3 hr. 0 min.

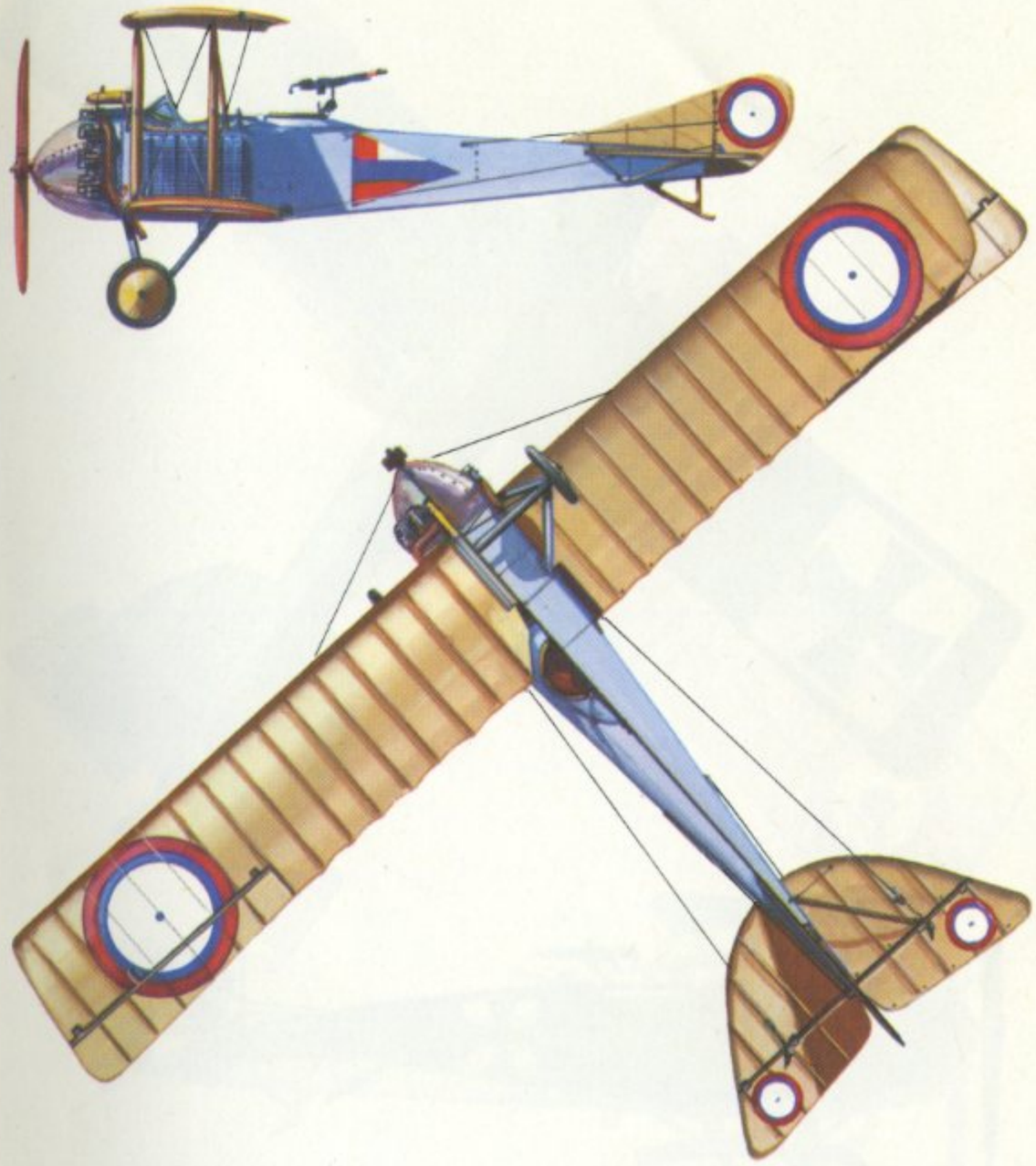
ALBATROS C.I (Germany)



16

Albatros C.I of the Imperial German Military Aviation Service, late 1915. *Engine:* One 160 h.p. Mercedes D.III water-cooled in-line. *Span:* 42 ft. $3\frac{7}{8}$ in. (12·90 m.). *Length:* 25 ft. 9 in. (7·85 m.). *Wing area:* 434·9 sq.ft. (40·40 sq.m.). *Take-off weight:* 2,624 lb. (1,190 kg.). *Maximum speed:* 87 m.p.h. (140 km./hr.) at sea level. *Service ceiling:* 9,843 ft. (3,000 m.). *Endurance:* 2 hr. 30 min.

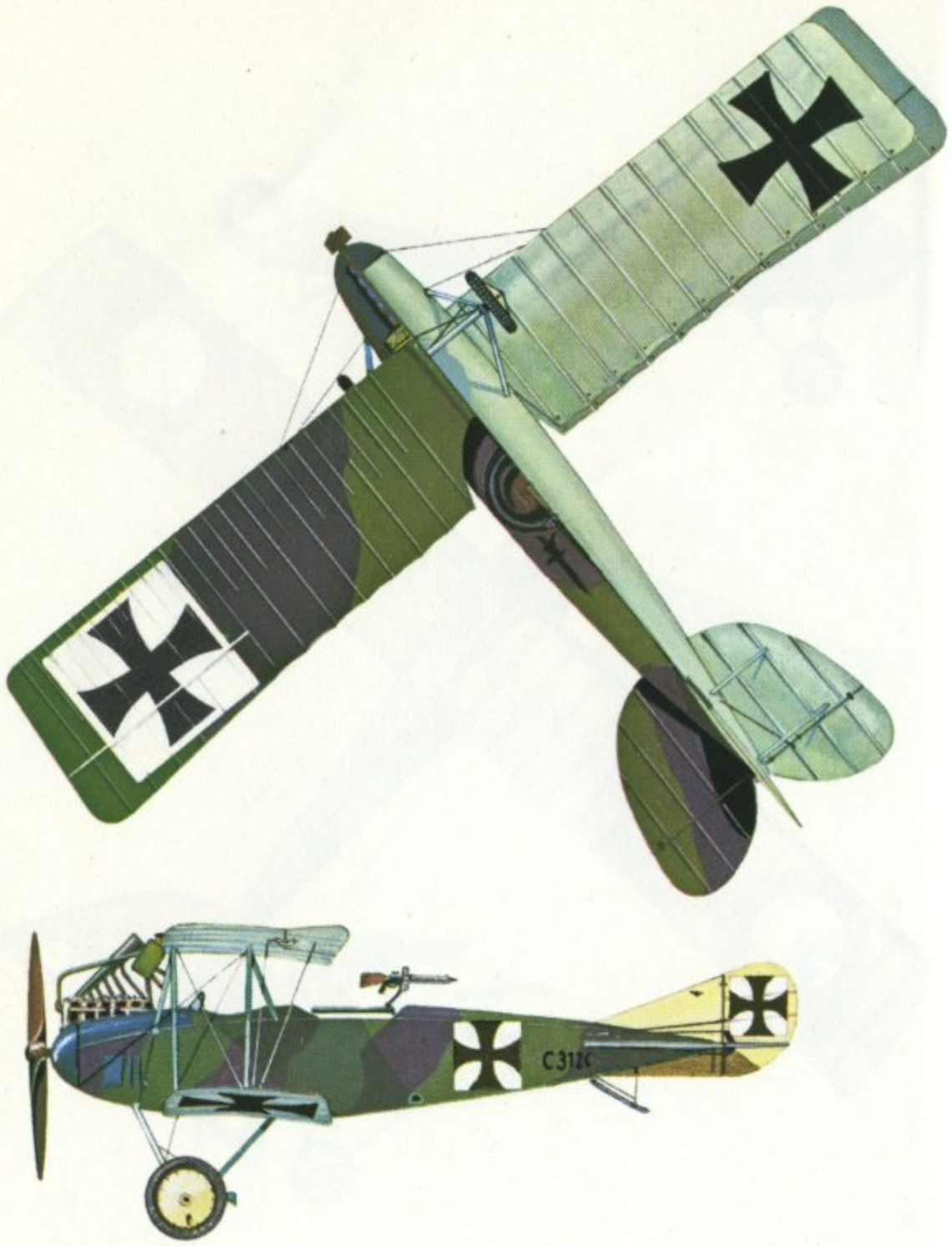
LEBED'-XII (Russia)



17

Lebed'-XII of the Imperial Russian Air Service, *ca.* summer 1917. *Engine:* One 150 h.p. Salmson (Canton-Unné) 9 P water-cooled radial. *Span:* 43 ft. $1\frac{3}{4}$ in. (13·15 m.). *Length:* 26 ft. $1\frac{1}{2}$ in. (7·96 m.). *Wing area:* 452·1 sq.ft. (42·00 sq.m.). *Take-off weight:* 2,672 lb. (1,212 kg.). *Maximum speed:* 82·6 m.p.h. (133 km./hr.) at sea level. *Service ceiling:* 11,483 ft. (3,500 m.). *Endurance:* 3 hr. 0 min.

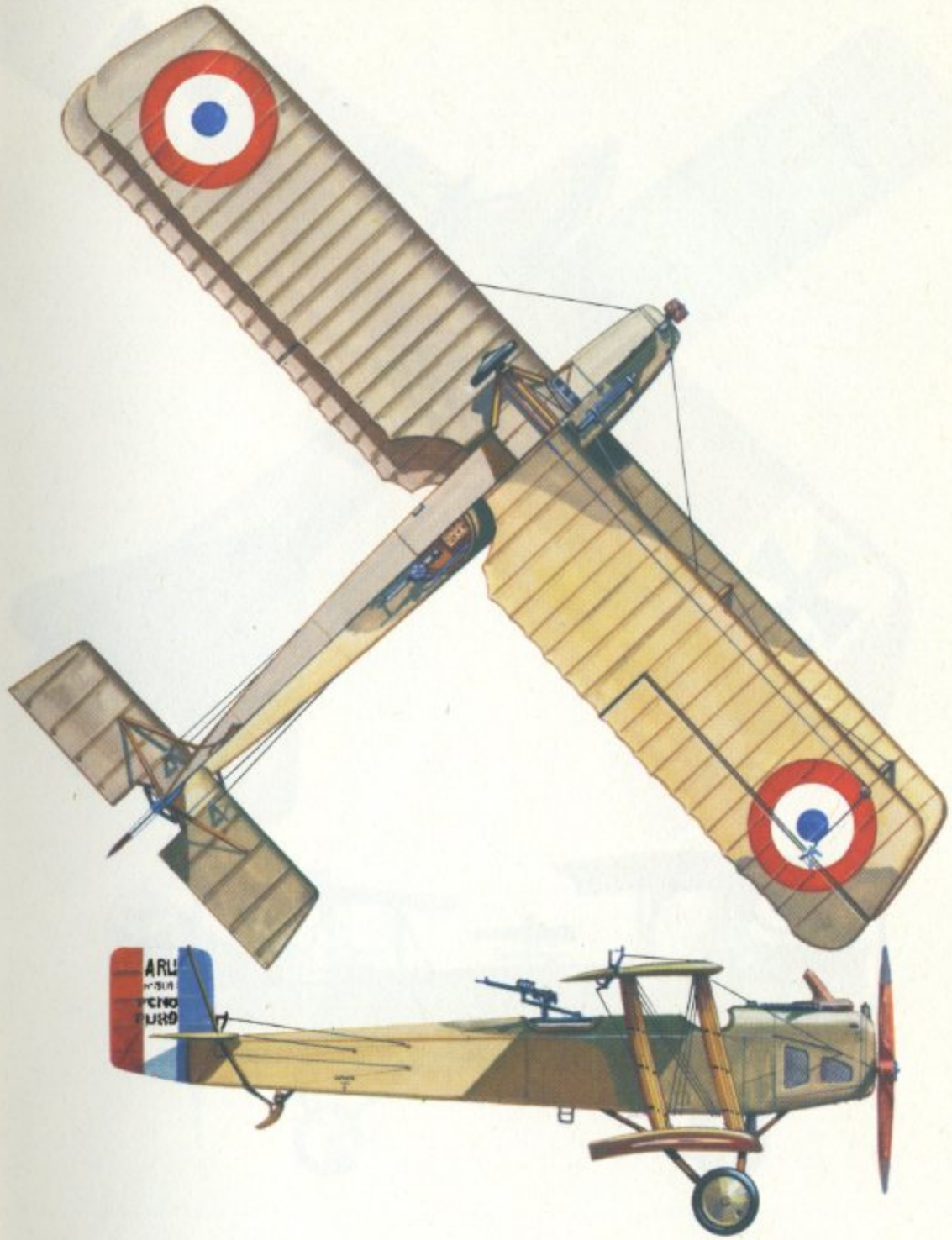
ALBATROS C.III (Germany)



18

Albatros C.III of the Imperial German Military Aviation Service, *ca.* summer 1916. *Engine:* One 160 h.p. Mercedes D.III water-cooled in-line. *Span:* 38 ft. $4\frac{5}{8}$ in. (11·70 m.). *Length:* 26 ft. 3 in. (8·00 m.). *Wing area:* 397·2 sq.ft. (36·90 sq.m.). *Take-off weight:* 2,983 lb. (1,353 kg.). *Maximum speed:* 87 m.p.h. (140 km./hr.) at sea level. *Service ceiling:* 11,155 ft. (3,400 m.). *Endurance:* 4 hr. 0 min.

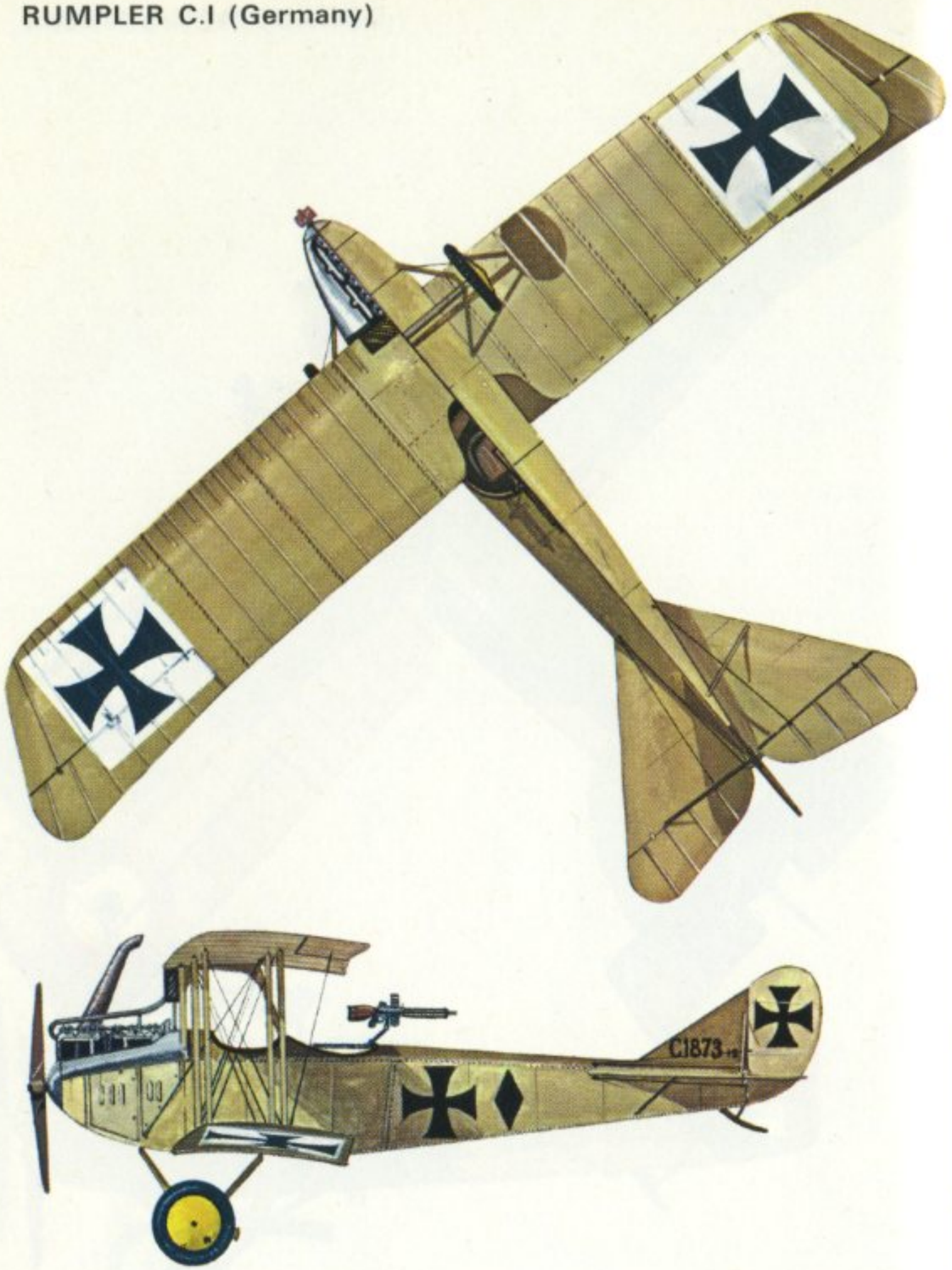
DORAND ARL.1 (France)



19

Dorand ARL.1.A2 of the French *Aviation Militaire, ca.* late 1916. *Data are for AR.1.A2. Engine:* One 190 h.p. Renault 8 Bd Vee-type. *Span:* 43 ft. $6\frac{1}{2}$ in. (13·27 m.). *Length:* 29 ft. $11\frac{3}{4}$ in. (9·14 m.). *Wing area:* 542·1 sq.ft. (50·36 sq.m.). *Take-off weight:* 2,756 lb. (1,250 kg.). *Maximum speed:* 95 m.p.h. (153 km./hr.) at 6,562 ft. (2,000 m.). *Service ceiling:* 18,045 ft. (5,500 m.). *Endurance:* 3 hr. 0 min.

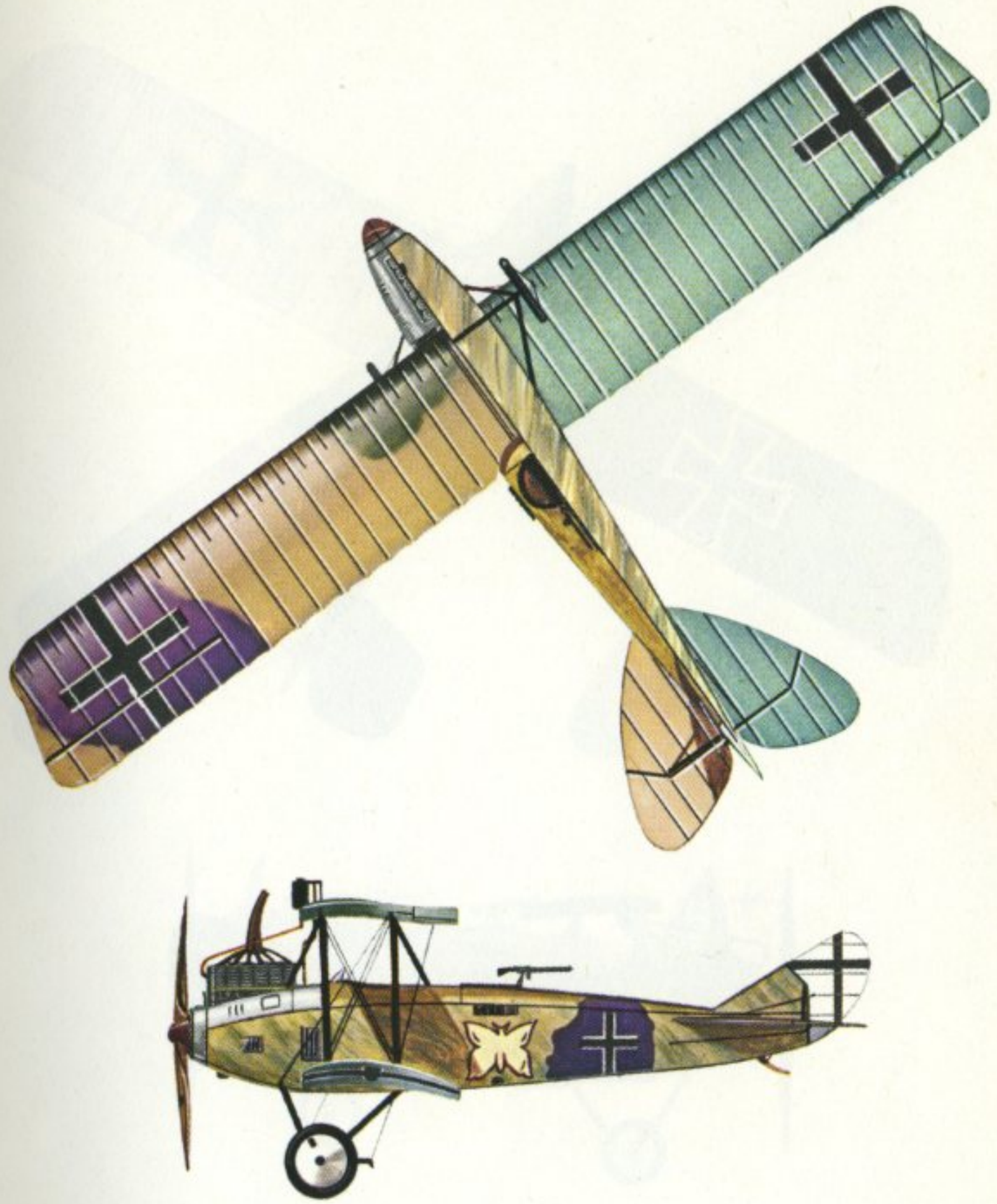
RUMPLER C.I (Germany)



20

Rumpler C.I of the Imperial German Military Aviation Service, 1915. *Engine:* One 160 h.p. Mercedes D.III water-cooled in-line. *Span:* 39 ft. 10⅓ in. (12·15 m.). *Length:* 25 ft. 9 in. (7·85 m.). *Wing area:* 384·3 sq.ft. (35·70 sq.m.). *Take-off weight:* 2,932 lb. (1,330 kg.). *Maximum speed:* 94·4 m.p.h. (152 km./hr.) at sea level. *Service ceiling:* 16,568 ft. (5,050 m.). *Endurance:* 4 hr. 0 min.

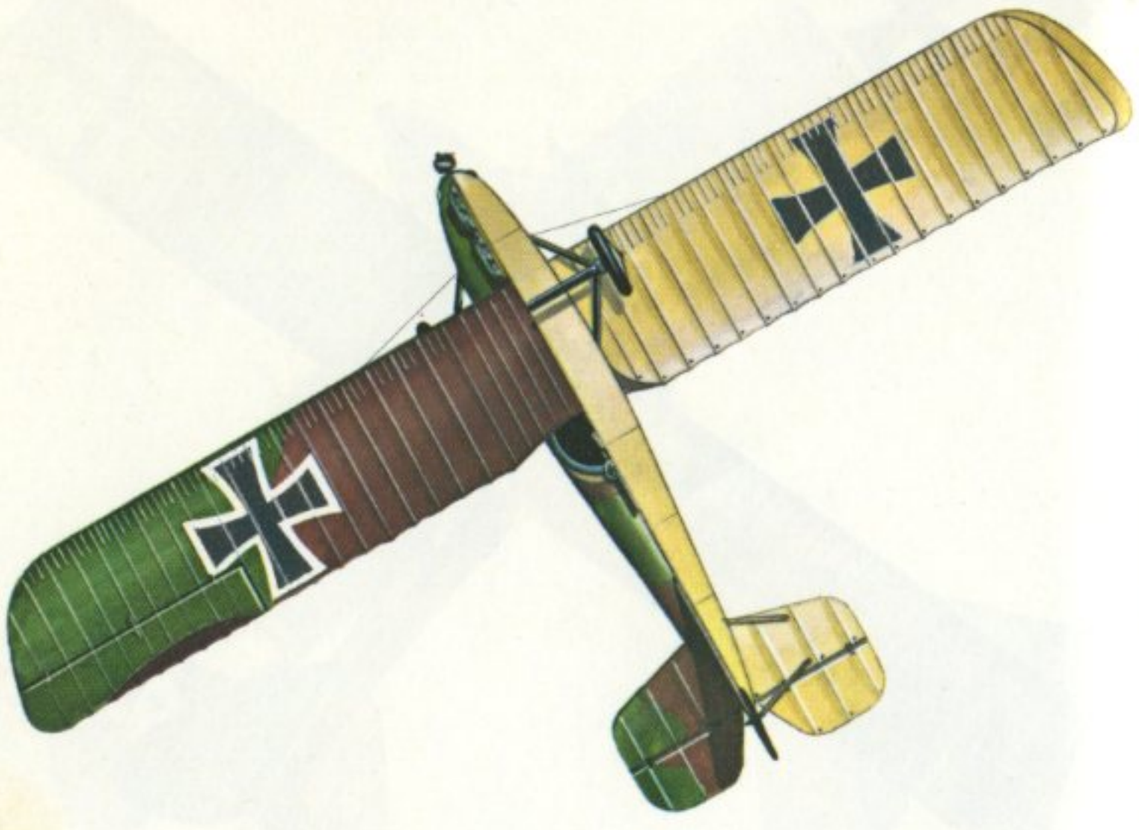
D.F.W. C.V (Germany)



21

D.F.W. C.V of the Imperial German Military Aviation Service, captured by U.S. forces in July 1918. *Engine:* One 200 h.p. Benz Bz.IV water-cooled in-line. *Span:* 43 ft. 6½ in. (13·27 m.). *Length:* 25 ft. 10 in. (7·87 m.). *Wing area:* 457·5 sq.ft. (42·50 sq.m.). *Take-off weight:* 3,153 lb. (1,430 kg.). *Maximum speed:* 96·3 m.p.h. (155 km./hr.) at 3,281 ft. (1,000 m.). *Service ceiling:* 20,997 ft. (6,400 m.). *Endurance:* 4 hr. 30 min.

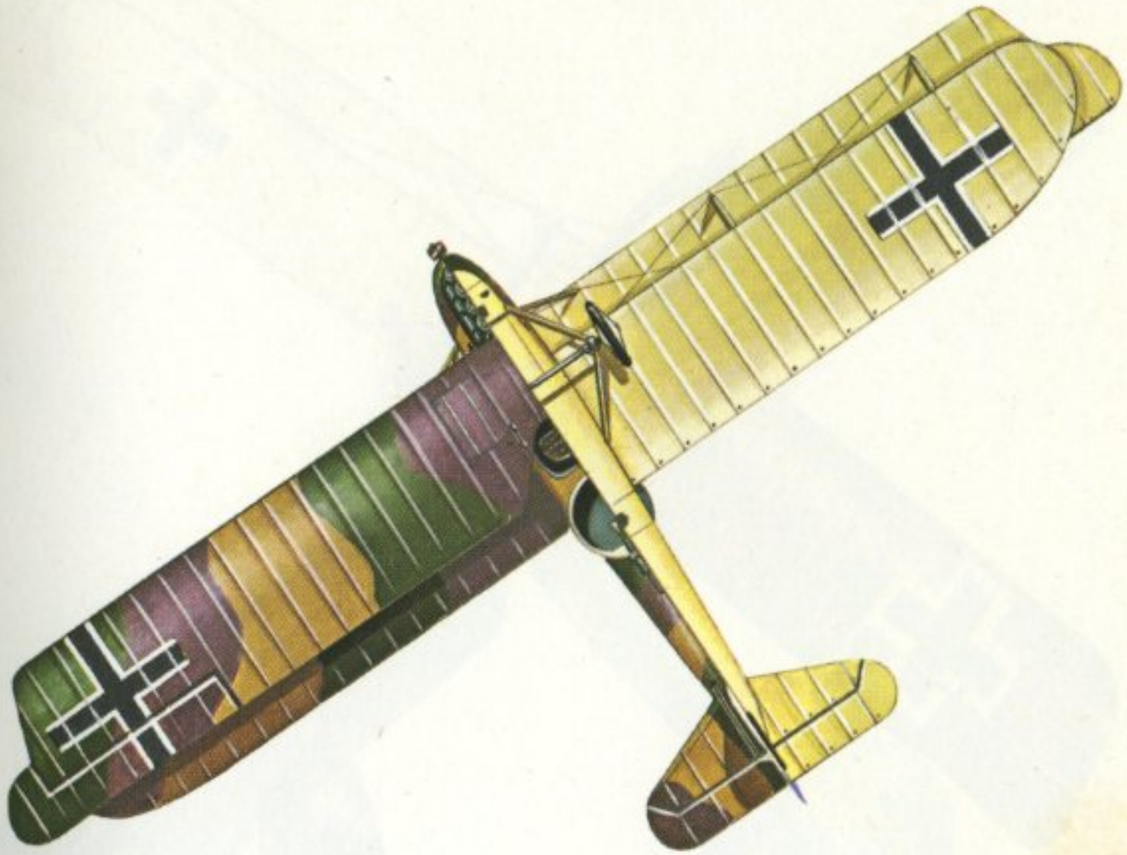
A.E.G. C.IV (Germany)



22

A.E.G. C.IV of the Imperial German Military Aviation Service, 1916. *Engine:* One 160 h.p. Mercedes D.III water-cooled in-line. *Span:* 44 ft. $1\frac{7}{8}$ in. (13·46 m.). *Length:* 23 ft. $5\frac{1}{2}$ in. (7·15 m.). *Wing area:* 419·8 sq.ft. (39·00 sq.m.). *Take-off weight:* 2,469 lb. (1,120 kg.). *Maximum speed:* 98·2 m.p.h. (158 km./hr.) at sea level. *Service ceiling:* 16,404 ft. (5,000 m.). *Endurance:* 4 hr. 0 min.

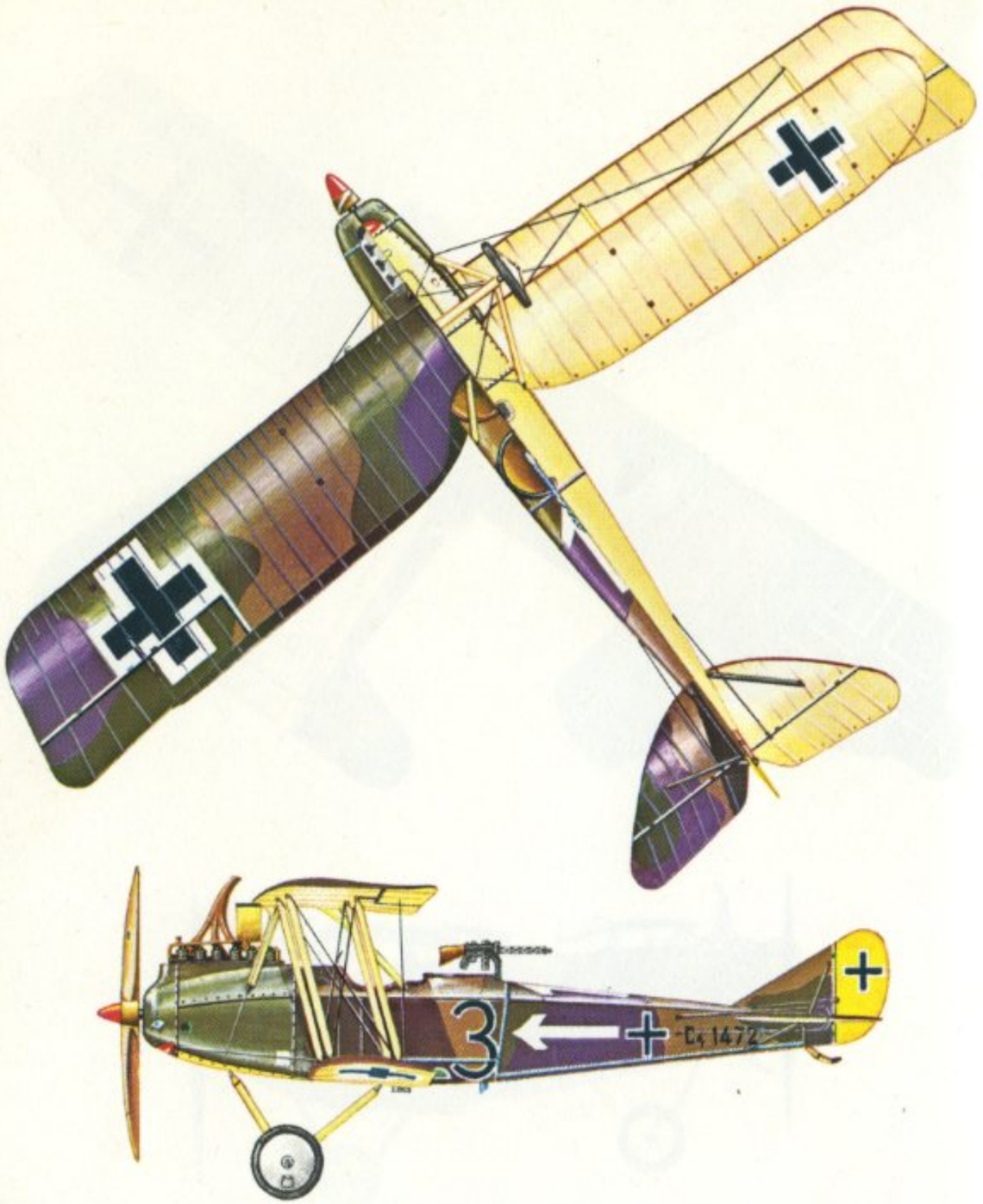
HALBERSTADT C.V (Germany)



23

Halberstadt (possibly Aviatik-built) C.V of the Imperial German Military Aviation Service, *ca.* summer 1918. *Engine:* One 220 h.p. Benz Bz.IV water-cooled in-line. *Span:* 44 ft. $8\frac{1}{3}$ in. (13·62 m.). *Length:* 22 ft. $8\frac{1}{2}$ in. (6·92 m.). *Wing area:* 462·8 sq.ft. (43·00 sq.m.). *Take-off weight:* 3,009 lb. (1,365 kg.). *Maximum speed:* 105·6 m.p.h. (170 km./hr.) at sea level. *Service ceiling:* 16,404 ft. (5,000 m.). *Endurance:* 3 hr. 30 min.

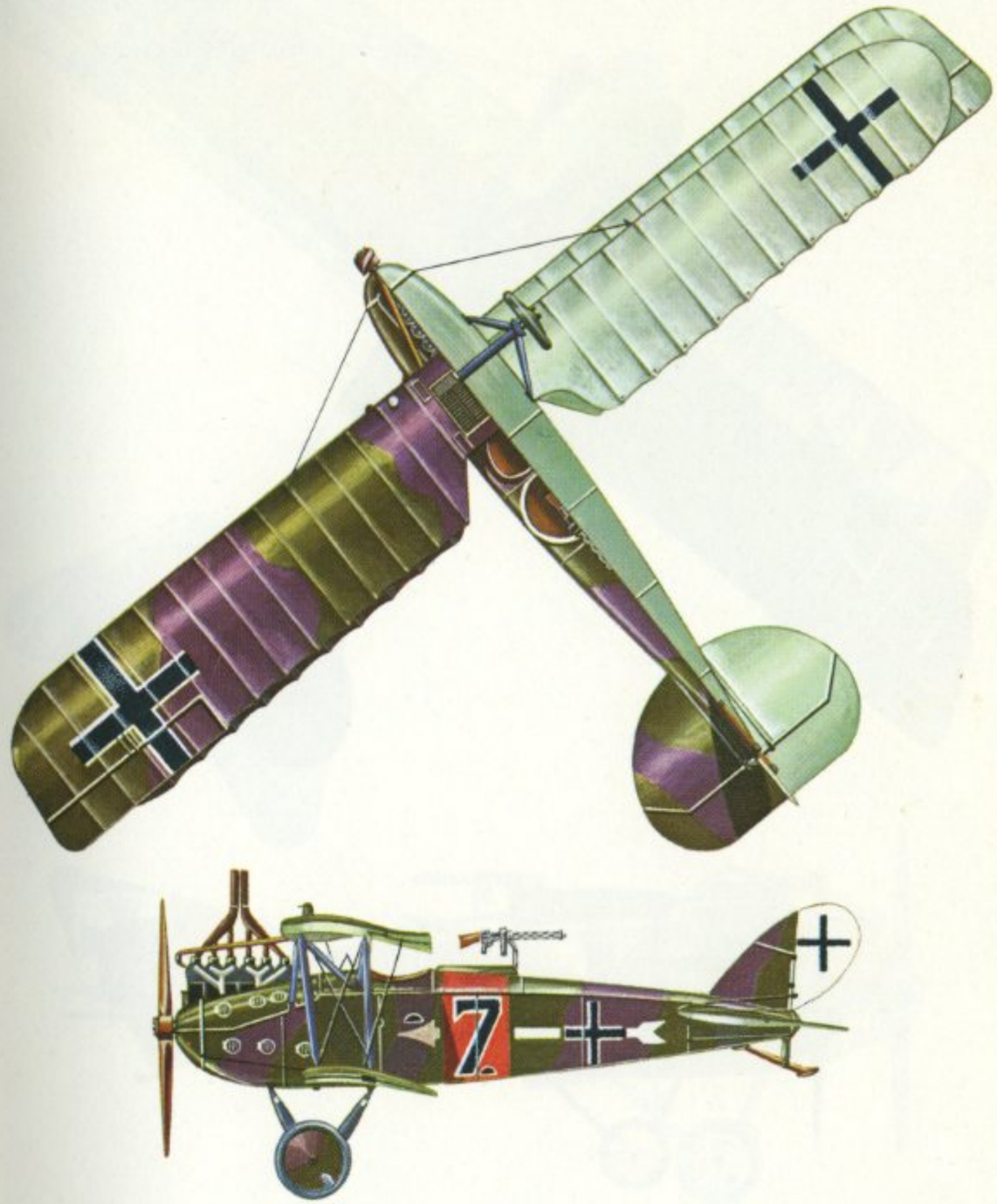
RUMPLER C.IV (Germany)



24

Rumpler C.IV of the Imperial German Military Aviation Service, late 1917. *Engine:* One 260 h.p. Mercedes D.IVa water-cooled in-line. *Span:* 41 ft. $6\frac{3}{8}$ in. (12·66 m.). *Length:* 27 ft. $7\frac{1}{8}$ in. (8·41 m.). *Wing area:* 360·6 sq.ft. (33·50 sq.m.). *Take-off weight:* 3,373 lb. (1,530 kg.). *Maximum speed:* 106·3 m.p.h. (171 km./hr.) at 1,640 ft. (500 m.). *Service ceiling:* 20,997 ft. (6,400 m.). *Endurance:* 3 hr. 30 min.

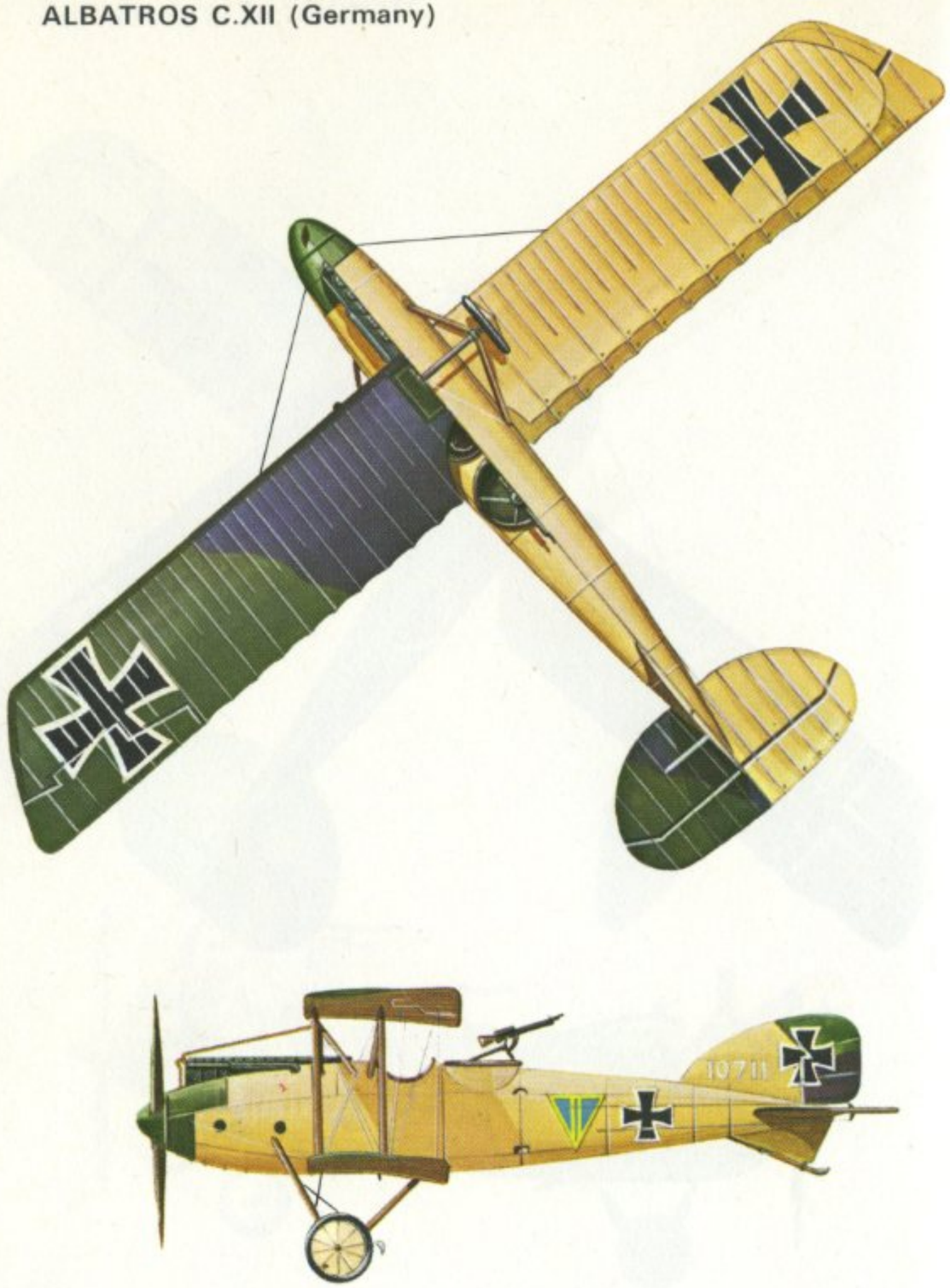
L.V.G. C.VI (Germany)



25

L.V.G. C.VI of the Imperial German Military Aviation Service, 1918. *Engine:* One 200 h.p. Benz Bz.IV water-cooled in-line. *Span:* 42 ft. $7\frac{3}{4}$ in. (13·00 m.). *Length:* 24 ft. $5\frac{1}{3}$ in. (7·45 m.). *Wing area:* 372·4 sq.ft. (34·60 sq.m.). *Take-off weight:* 2,888 lb. (1,310 kg.). *Maximum speed:* 105·6 m.p.h. (170 km./hr.) at sea level. *Service ceiling:* 21,325 ft. (6,500 m.). *Endurance:* 3 hr. 30 min.

ALBATROS C.XII (Germany)



26

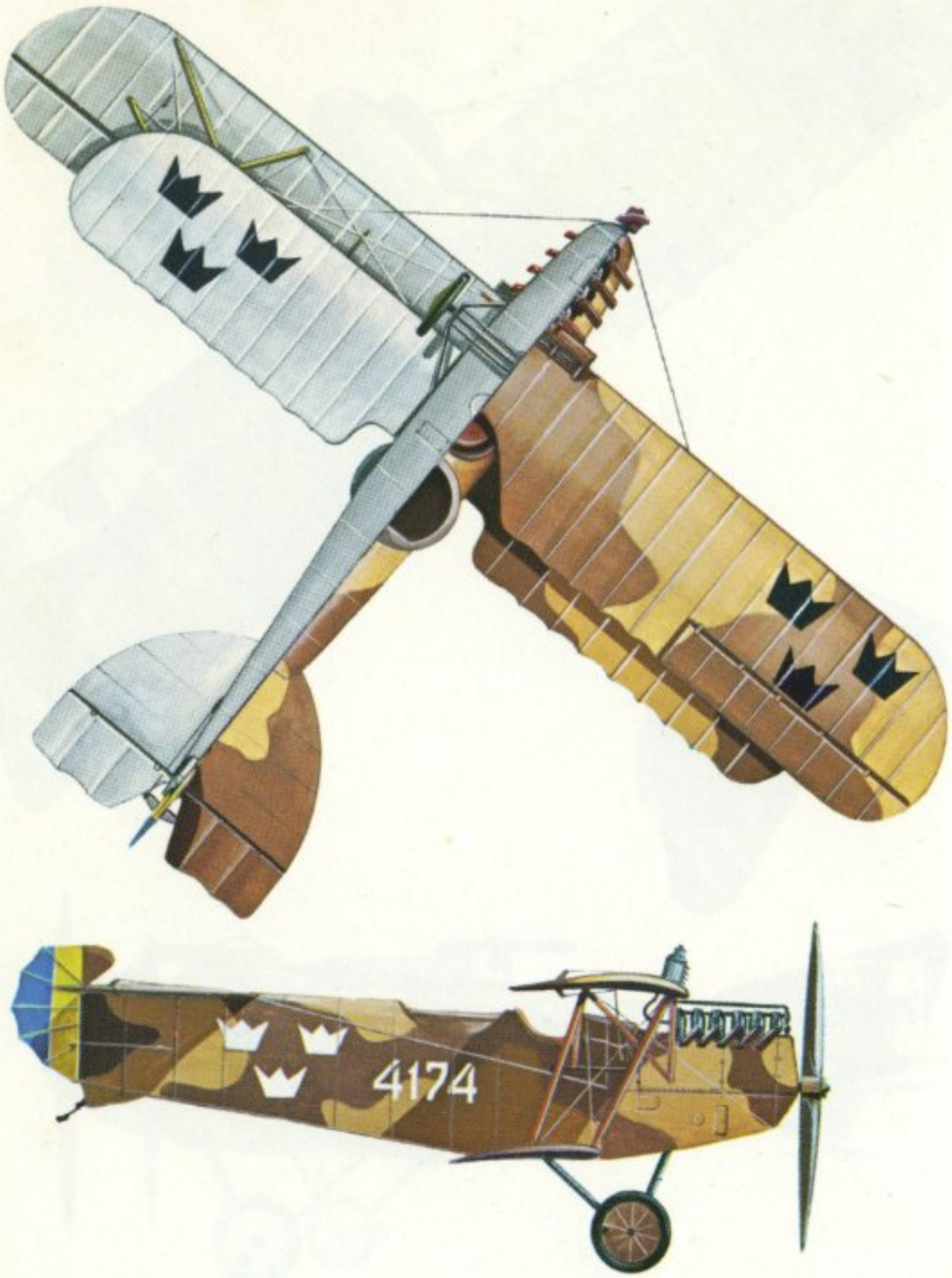
Albatros C.XII of the Imperial German Military Aviation Service, 1918. *Engine:* One 260 h.p. Mercedes D.IVa water-cooled in-line. *Span:* 47 ft. $1\frac{3}{4}$ in. (14·37 m.). *Length:* 29 ft. $0\frac{3}{8}$ in. (8·85 m.). *Wing area:* 459·6 sq.ft. (42·70 sq.m.). *Take-off weight:* 3,616 lb. (1,640 kg.). *Maximum speed:* 108·7 m.p.h. (175 km./hr.) at sea level. *Service ceiling:* 16,404 ft. (5,000 m.). *Endurance:* 3 hr. 15 min.

ROLAND C.II (Germany)

27

L.F.G. (Roland)-built C.II of an unidentified *Feld Flieger Abteilung,* Imperial German Military Aviation Service, Western Front, late 1916. *Engine:* One 160 h.p. Mercedes D.III water-cooled in-line. *Span:* 33 ft. $10\frac{3}{4}$ in. (10·33 m.). *Length:* 24 ft. $8\frac{1}{8}$ in. (7·52 m.). *Wing area:* 279·9 sq.ft. (26·00 sq.m.). *Take-off weight:* 2,886 lb. (1,309 kg.). *Maximum speed:* 102·5 m.p.h. (165 km./hr.) at sea level. *Service ceiling:* 13,123 ft. (4,000 m.). *Endurance:* 4 hr. 0 min.

PHÖNIX C.I (Austro-Hungary)



28

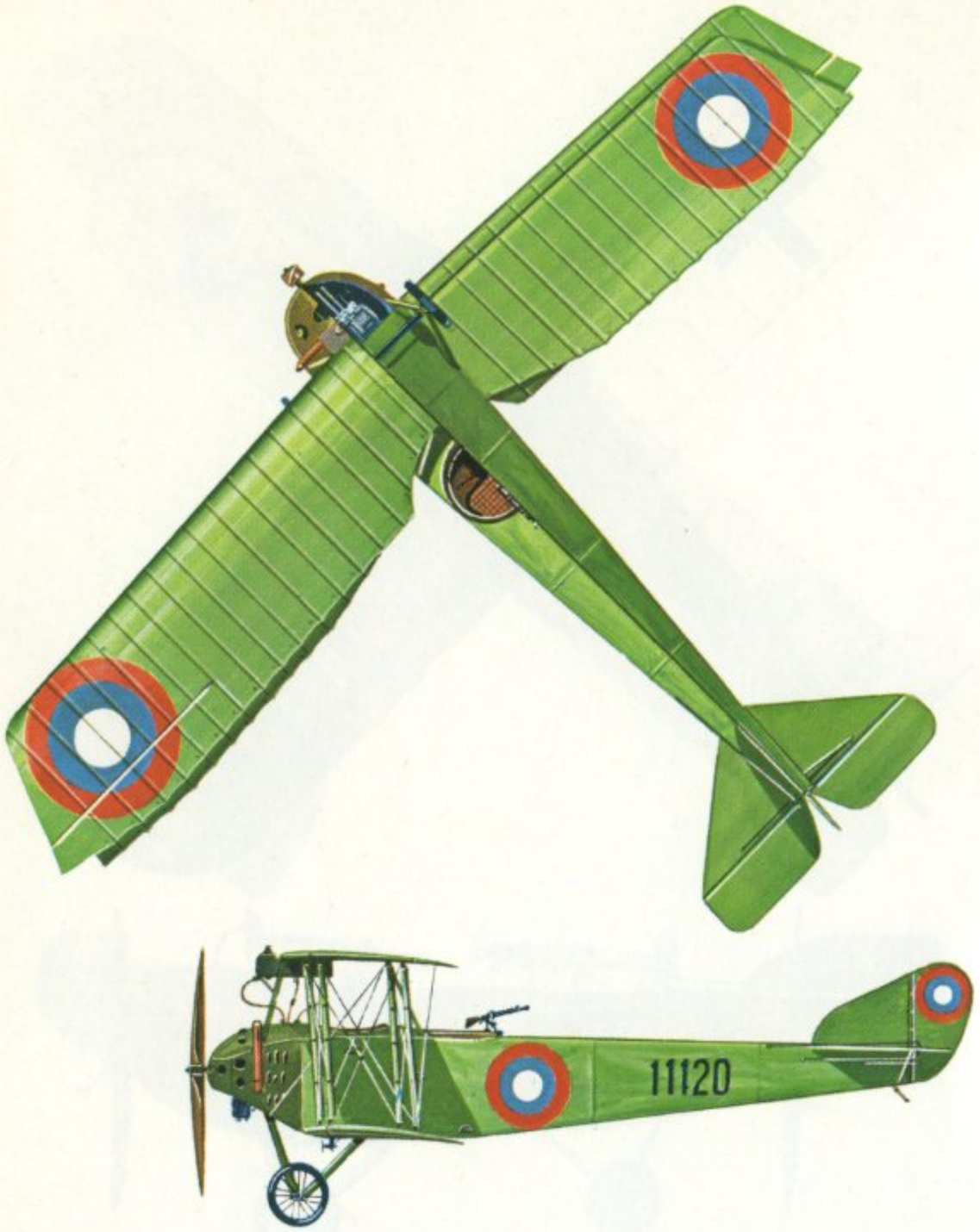
Swedish-built C.I *(Phönix-Dront)* of the Royal Swedish Army Aviation, 1919. *Engine:* One 220 h.p. Benz Bz.IV water-cooled in-line. *Span:* 36 ft. $1\frac{1}{8}$ in. (11·00 m.). *Length:* 24 ft. $8\frac{1}{8}$ in. (7·52 m.). *Wing area:* approx. 249·2 sq.ft. (23·15 sq.m.). *Take-off weight:* 2,436 lb. (1,105 kg.). *Maximum speed:* 110 m.p.h. (177 km./hr.) at sea level. *Service ceiling:* 17,716 ft. (5,400 m.). *Endurance:* approx. 3 hr. 30 min.

UFAG C.I (Austro-Hungary)

29

Ufag-built C.I of the Austro-Hungarian Air Service, *ca.* autumn 1918. *Engine:* One 230 h.p. Hiero water-cooled in-line. *Span:* 35 ft. 2 in. (10·72 m.). *Length:* 23 ft. $7\frac{1}{2}$ in. (7·20 m.). *Wing area:* approx. 290·6 sq.ft. (27·00 sq.m.). *Take-off weight:* approx. 2,315 lb. (1,050 kg.). *Maximum speed:* 118·1 m.p.h. (190 km./hr.) at sea level. *Service ceiling:* 16,076 ft. (4,900 m.). *Endurance:* approx. 3 hr. 30 min.

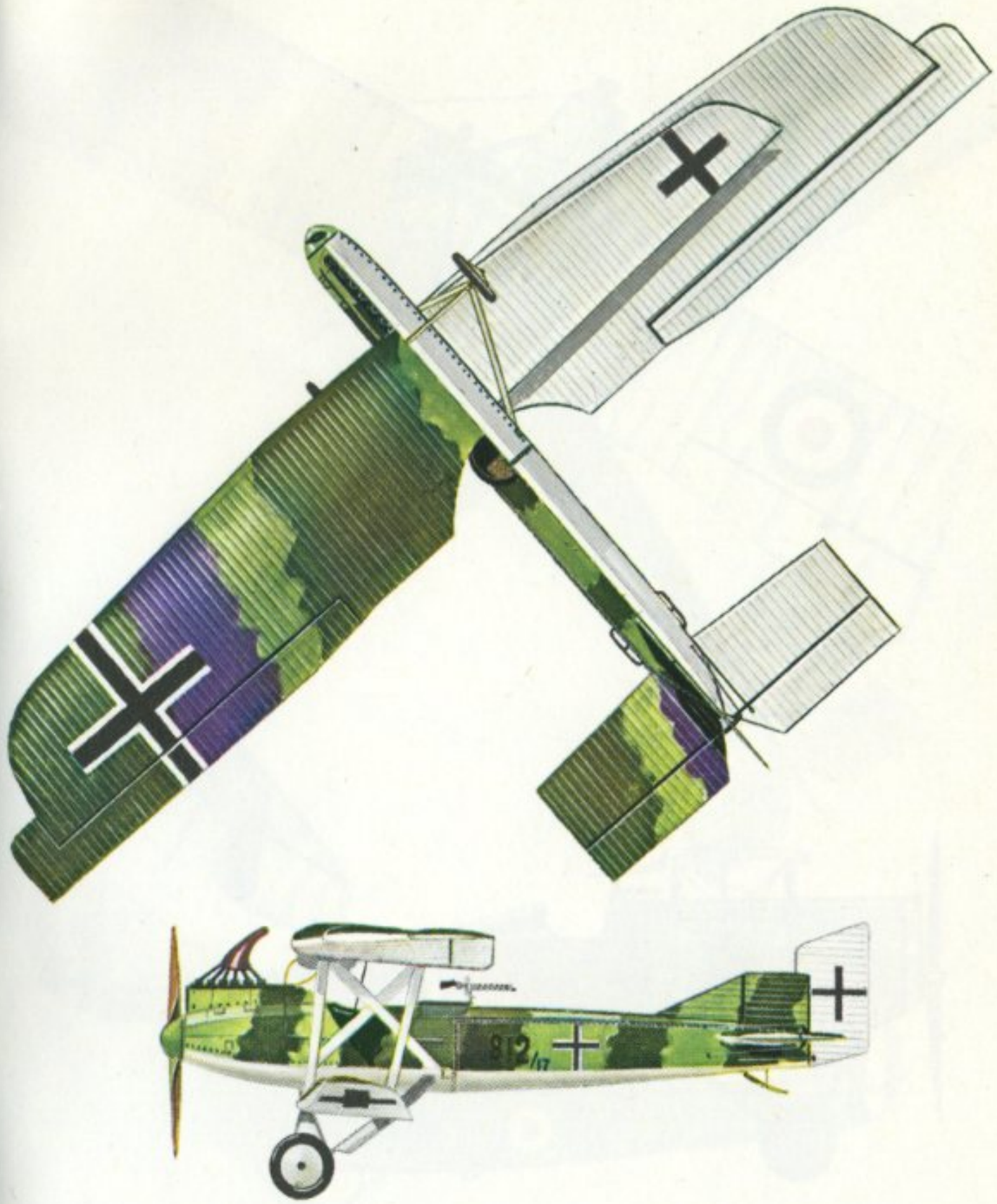
ANATRA DS (Russia)



30

Anatra DS of the Imperial Russian Air Service, *ca.* spring 1917. *Engine:* One 150 h.p. Salmson (Canton-Unné) water-cooled radial. *Span:* 37 ft. $5\frac{1}{2}$ in. (11·42 m.). *Length:* 26 ft. $6\frac{7}{8}$ in. (8·10 m.). *Wing area:* 398·3 sq.ft. (37·00 sq.m.). *Take-off weight:* 2,566 lb. (1,164 kg.). *Maximum speed:* 89·5 m.p.h. (144 km./hr.) at sea level. *Service ceiling:* 14,108 ft. (4,300 m.). *Endurance:* 3 hr. 30 min.

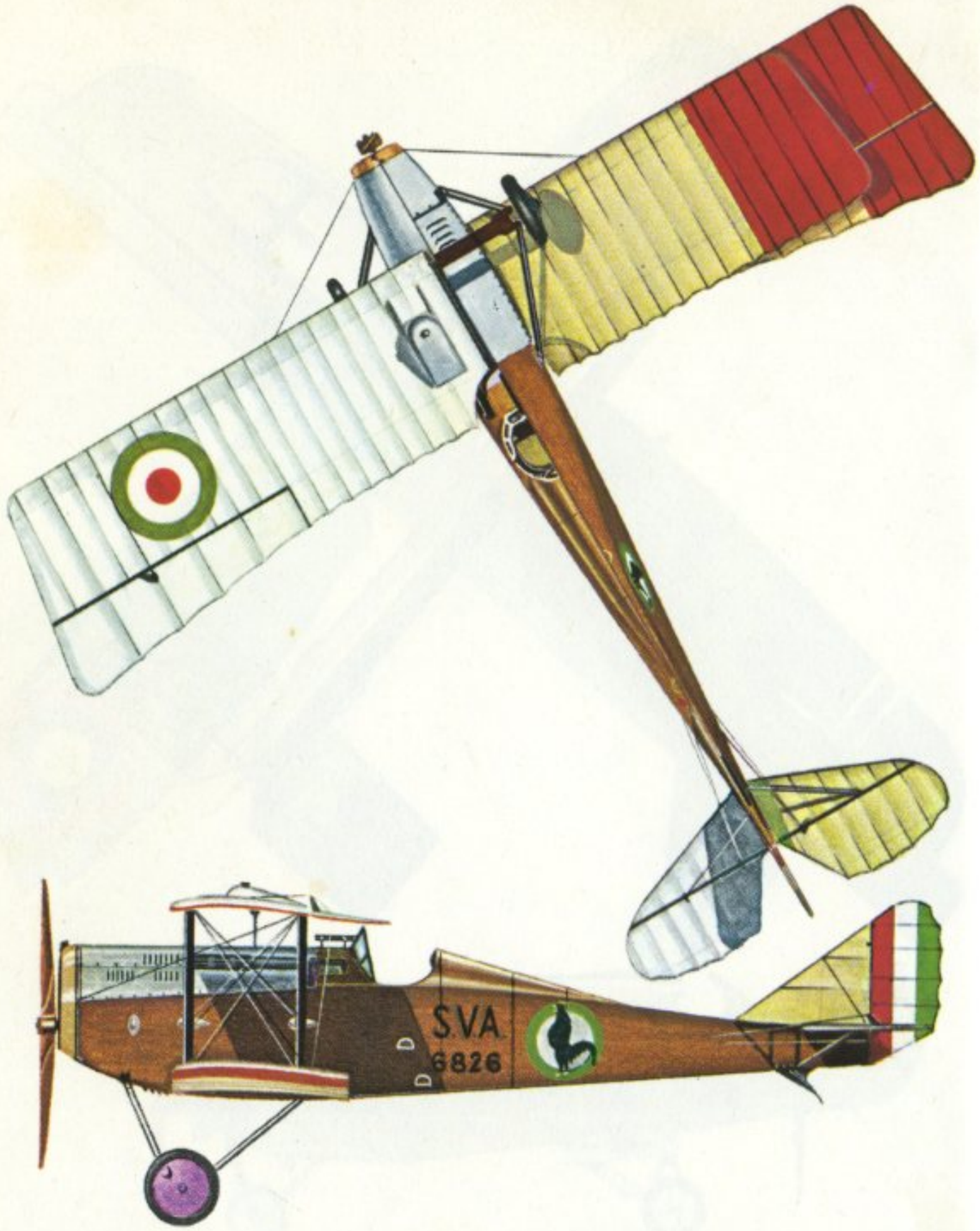
JUNKERS J.I (Germany)



31

Junkers J.I of the Imperial German Military Aviation Service, *ca.* early 1918. *Engine:* One 200 h.p. Benz Bz.IV water-cooled in-line. *Span:* 52 ft. $5\frac{7}{8}$ in. (16·00 m.). *Length:* 29 ft. $10\frac{1}{4}$ in. (9·10 m.). *Wing area:* 531·7 sq.ft. (49·40 sq.m.). *Take-off weight:* 4,797 lb. (2,176 kg.). *Maximum speed:* 96·3 m.p.h. (155 km./hr.) at sea level. *Operational ceiling:* approx. 5,000 ft. (1,524 m.). *Range:* 193 miles (310 km.).

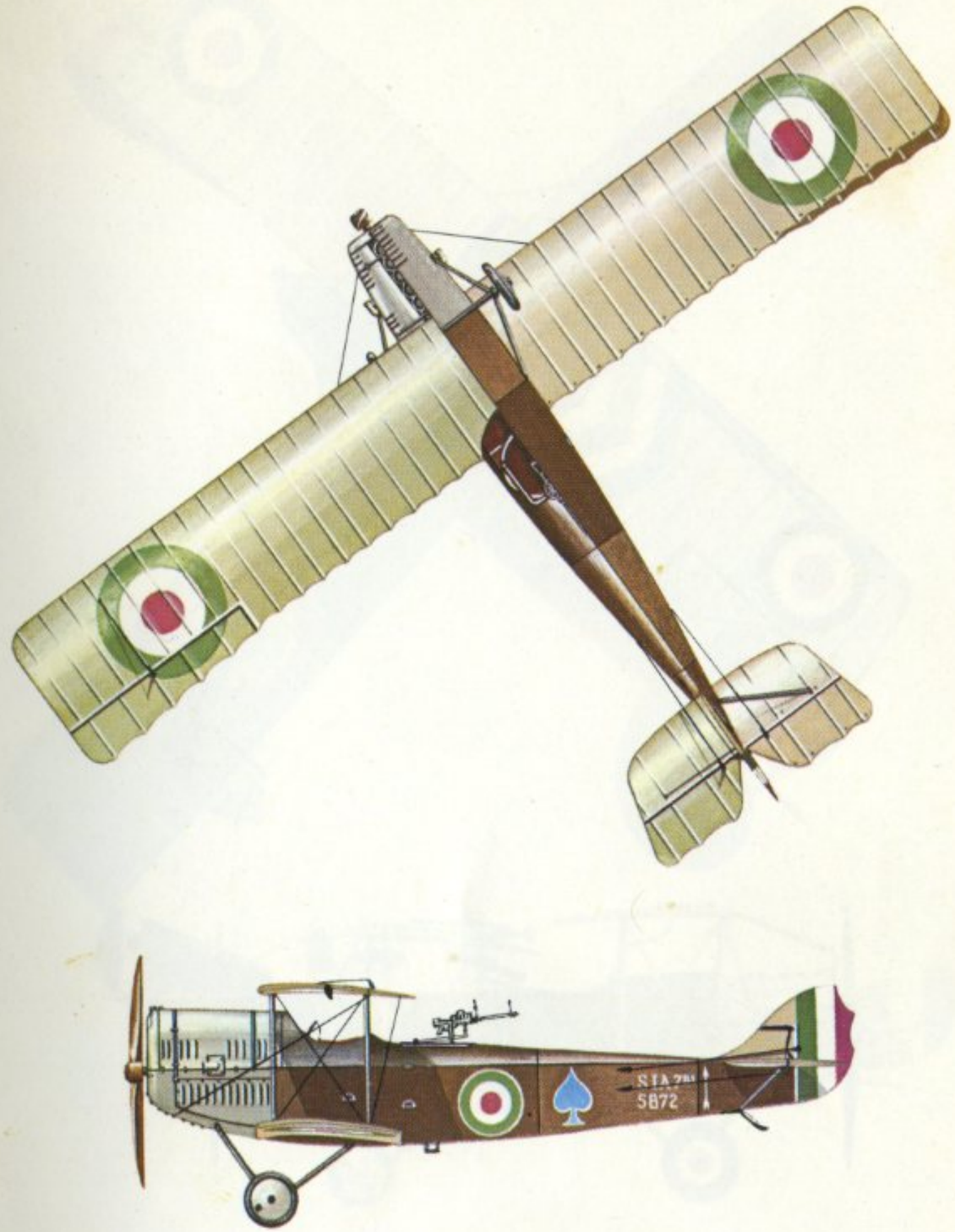
ANSALDO S.V.A.5 (Italy)



32

Ansaldo S.V.A.5 of the 3° *Gruppo Aeroplani, Corpo Aeronautica Militare,* Italian Front, June 1918. *Engine:* One 220 h.p. SPA 6A water-cooled in-line. *Span:* 30 ft. 1½ in. (9·18 m.). *Length:* 26 ft. 8 in. (8·13 m.). *Take-off weight:* 2,150 lb. (975 kg.). *Maximum speed:* 136·7 m.p.h. (220 km./hr.) at sea level. *Service ceiling:* 16,404 ft. (5,000 m.). *Endurance:* 6 hr. 0 min.

S.I.A. 7B (Italy)



33

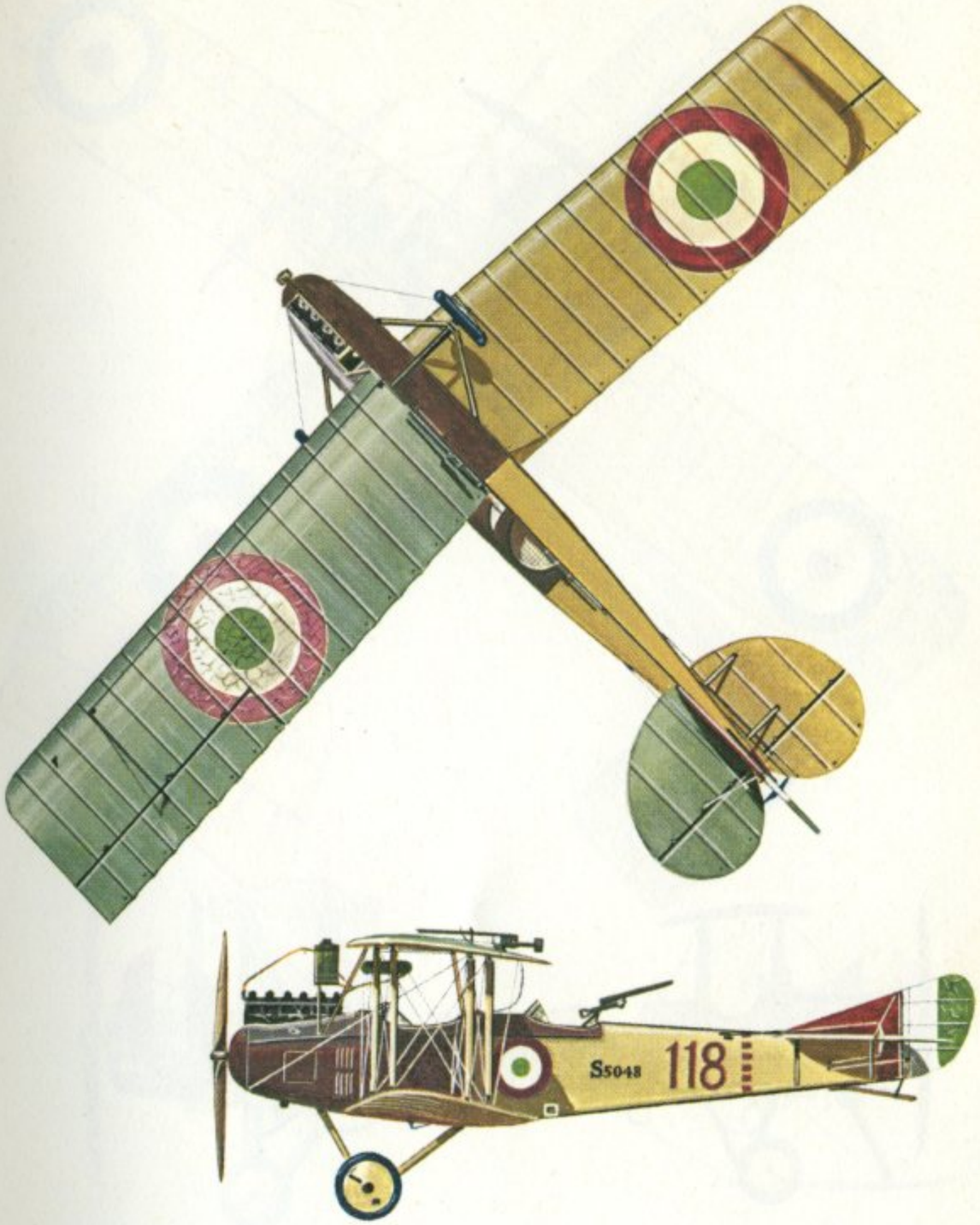
S.I.A. 7B.1 of the *Corpo Aeronautica Militare, ca.* December 1917. *Engine:* One 260 h.p. Fiat A-12 water-cooled in-line. *Span:* 43 ft. 8⅜ in. (13·32 m.). *Length:* 29 ft. 8⅜ in. (9·06 m.). *Wing area:* 430·6 sq.ft. (40·00 sq.m.). *Take-off weight:* 2,425 lb. (1,100 kg.). *Maximum speed:* 124·3 m.p.h. (200 km./hr.) at sea level. *Service ceiling:* 22,966 ft. (7,000 m.). *Endurance:* 4 hr. 0 min.

POMILIO PE (Italy)

34

Pomilio PE of the *Corpo Aeronautica Militare, ca.* spring 1918. *Engine:* One 300 h.p. Fiat A-12*bis* water-cooled in-line. *Span:* 38 ft. $8\frac{5}{8}$ in. (11·80 m.). *Length:* 29 ft. 4 in. (8·94 m.). *Wing area:* 495·1 sq.ft. (46·00 sq.m.). *Take-off weight:* 3,388 lb. (1,537 kg.). *Maximum speed:* 120·5 m.p.h. (194 km./hr.) at sea level. *Service ceiling:* 16,404 ft. (5,000 m.). *Endurance:* 3 hr. 30 min.

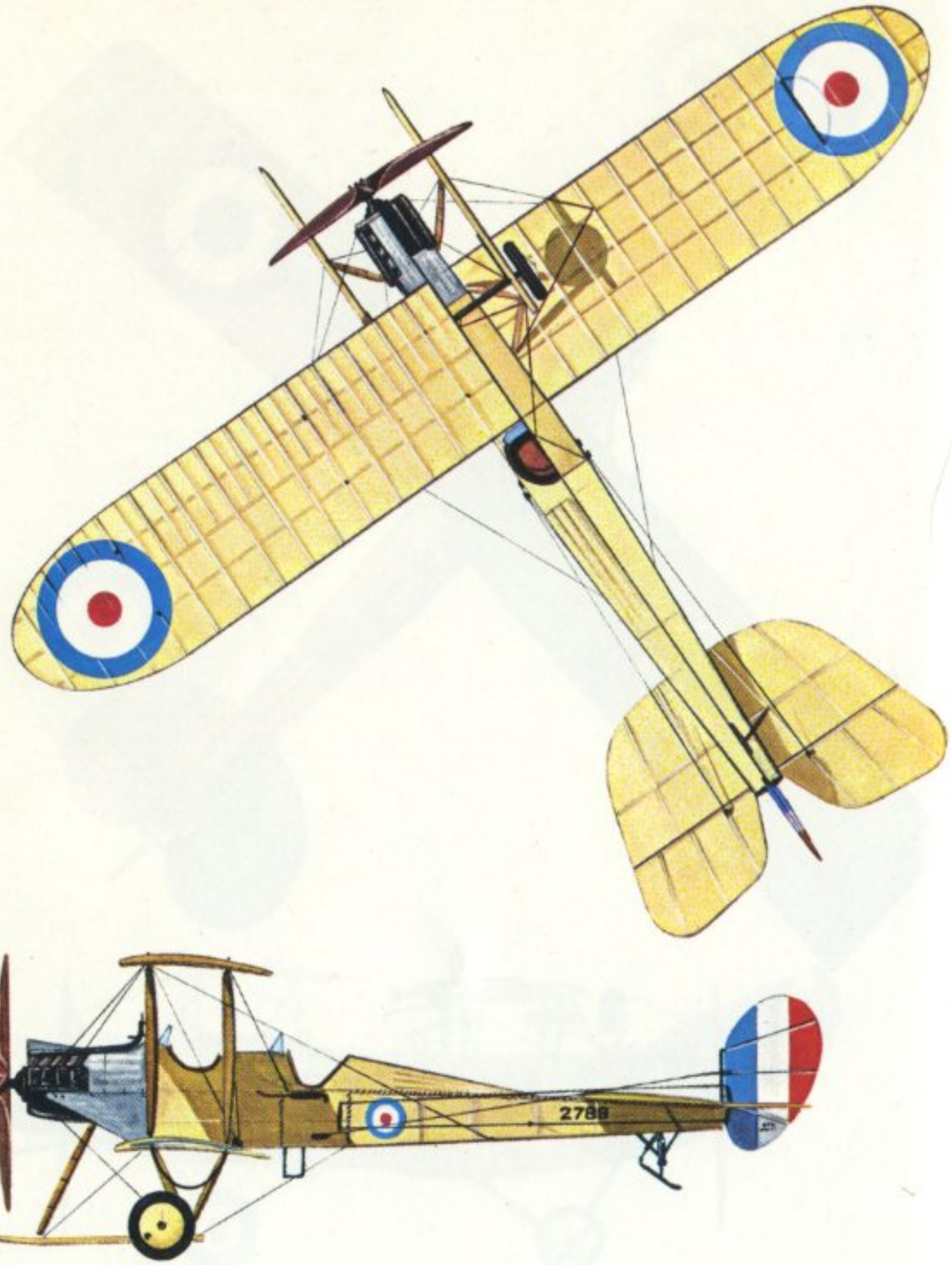
SAML S.2 (Italy)



35

SAML S.2 of the 118a *Squadriglia da Ricognizione, Corpo Aeronautica Militare,* Middle East, *ca.* late 1917. *Engine:* One 300 h.p. Fiat A-12*bis* water-cooled in-line. *Span:* 39 ft. $8\frac{3}{8}$ in. (12·10 m.). *Length:* 27 ft. $10\frac{2}{3}$ in. (8·50 m.). *Wing area:* 419·8 sq.ft. (39·00 sq.m.). *Take-off weight:* 3,075 lb. (1,395 kg.). *Maximum speed:* 100·7 m.p.h. (162 km./hr.) at sea level. *Service ceiling:* approx. 16,404 ft. (5,000 m.). *Endurance:* 3 hr. 30 min.

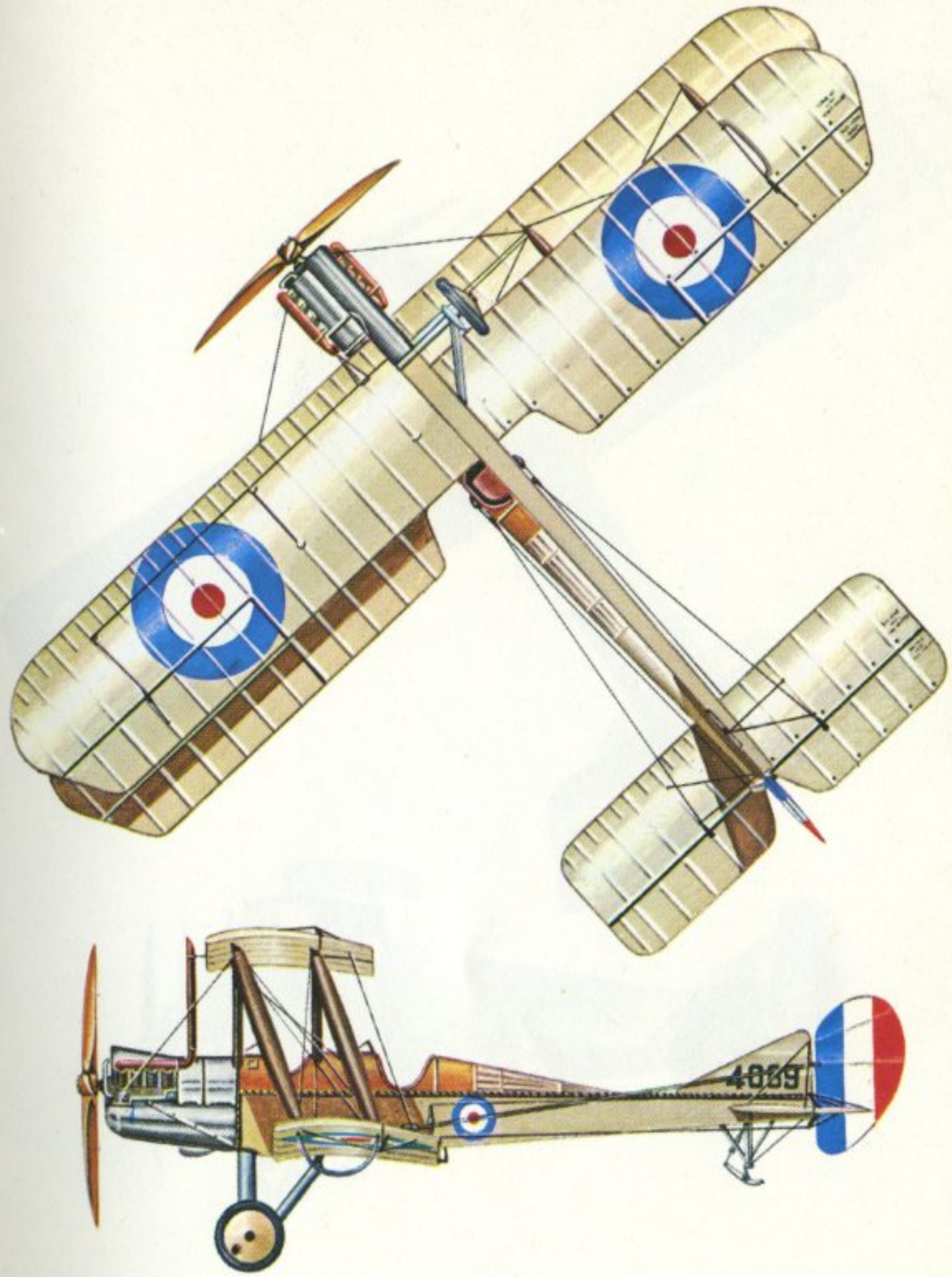
B.E.2b (U.K.)



36

Joucques-built B.E.2b, possibly an aircraft of No. 16 Reserve Squadron R.F.C., Beaulieu, late 1916. *Engine:* One 70 h.p. Renault air-cooled Vee-type. *Span:* 35 ft. 0½ in. (10·68 m.). *Length:* 29 ft. 6½ in. (9·00 m.). *Wing area:* 352·0 sq.ft. (32·70 sq.m.). *Take-off weight:* 1,600 lb. (726 kg.). *Maximum speed:* 70 m.p.h. (112·7 km./hr.) at sea level. *Service ceiling:* 10,000 ft. (3,048 m.). *Endurance:* 3 hr. 0 min. *(Weight and performance data are for basically similar B.E.2a).*

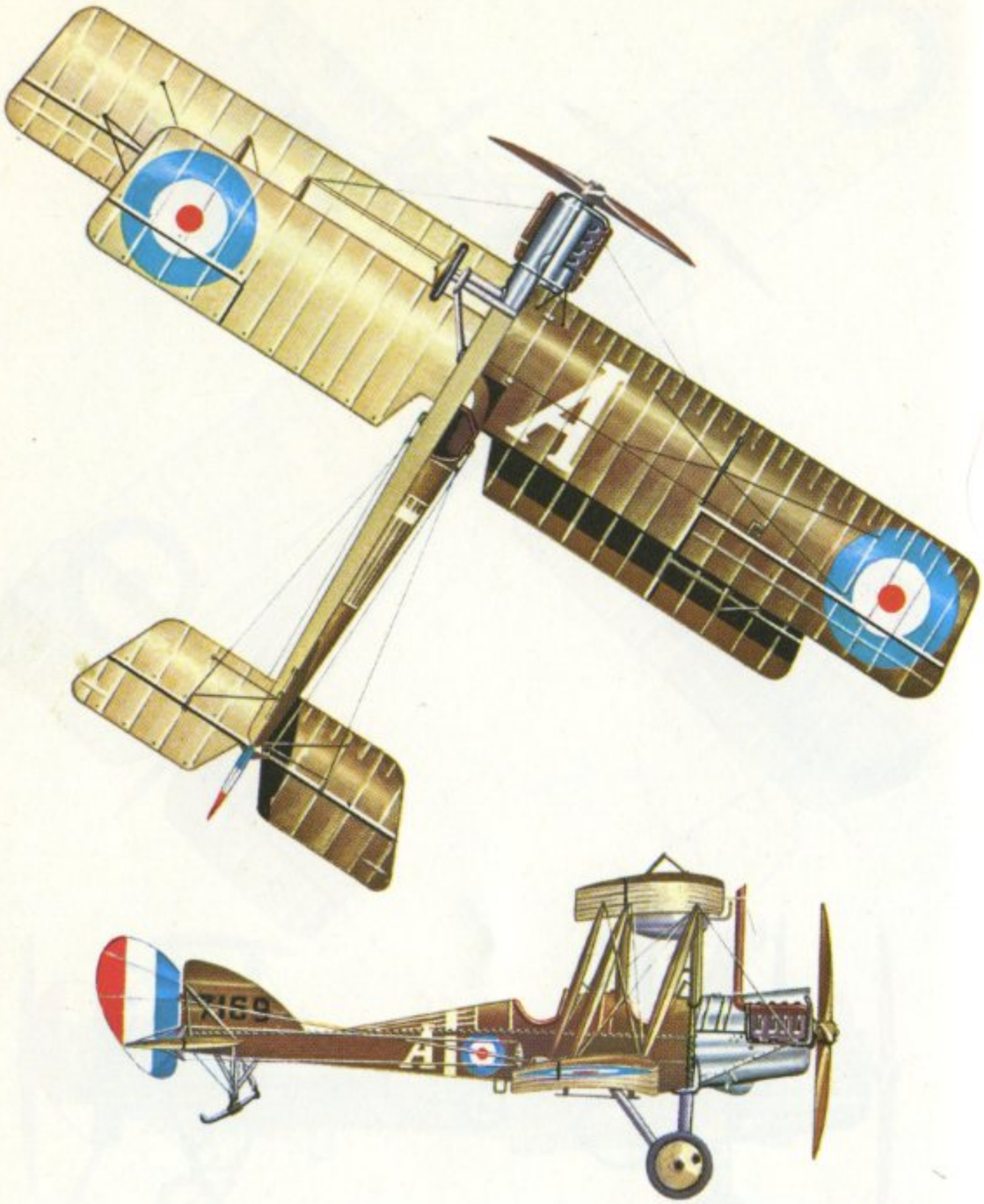
B.E.2c (U.K.)



37

Bristol-built B.E.2c of No. 13 Squadron R.F.C., prior to leaving for France, October 1915. *Engine:* One 90 h.p. R.A.F.1a air-cooled Vee-type. *Span:* 37 ft. 0 in. (11·28 m.). *Length:* 27 ft. 3 in. (8·31 m.). *Wing area:* 371·0 sq.ft. (34·47 sq.m.). *Take-off weight:* 2,142 lb. (972 kg.). *Maximum speed:* 72 m.p.h. (115·9 km./hr.) at 6,500 ft. (1,981 m.). *Service ceiling:* 10,000 ft. (3,048 m.). *Endurance:* 3 hr. 15 min.

B.E.2e (U.K.)



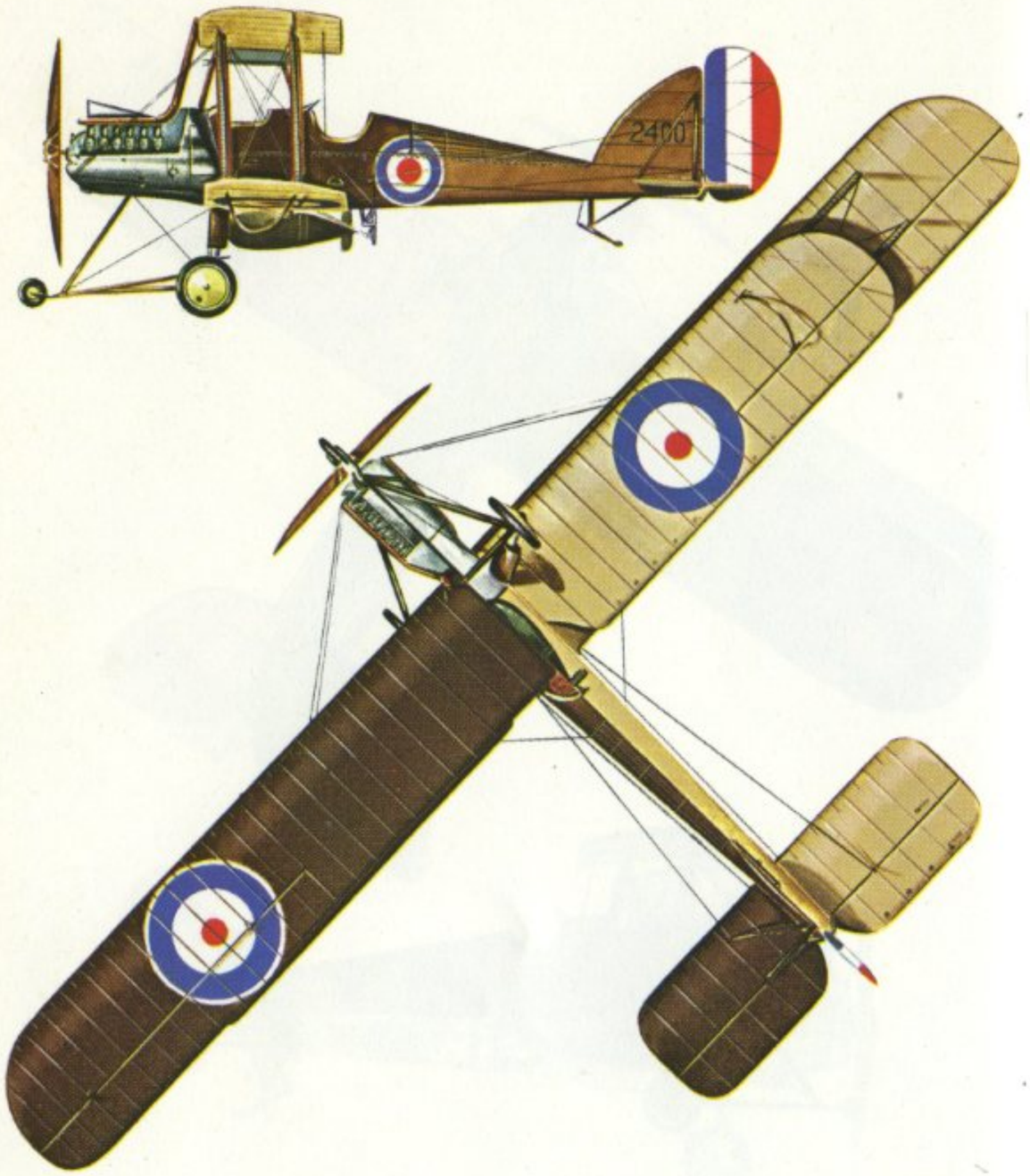
38

Bristol-built B.E.2e of an unknown R.F.C. squadron, France, October 1916. *Engine:* One 90 h.p. R.A.F.1a air-cooled Vee-type. *Span:* 40 ft. 9 in. (12·42 m.). *Length:* 27 ft. 3 in. (8·31 m.). *Wing area:* 360·0 sq.ft. (33·46 sq.m.). *Take-off weight:* 2,100 lb. (953 kg.). *Maximum speed:* 82 m.p.h. (132 km./hr.) at 6,500 ft. (1,981 m.). *Service ceiling:* 10,000 ft. (3,048 m.). *Endurance:* 4 hr. 0 min.

R.E.5 (U.K.)

39

Royal Aircraft Factory-built R.E.5, possibly an aircraft of No. 7 Squadron R.F.C., France, *ca.* April/May 1915. *Engine:* One 120 h.p. Beardmore-built Austro-Daimler water-cooled in-line. *Span:* 44 ft. 6 in. (13·56 m.). *Length:* 26 ft. 2 in. (7·98 m.). *Wing area:* 400·0 sq.ft. (37·16 sq.m.). *Typical take-off weight:* 2,300 lb. (1,043 kg.). *Maximum speed:* 78 m.p.h. (125·5 km./hr.) at sea level. *Service ceiling:* 15,000 ft. (4,572 m.). *Endurance:* 4 hr. 30 min.

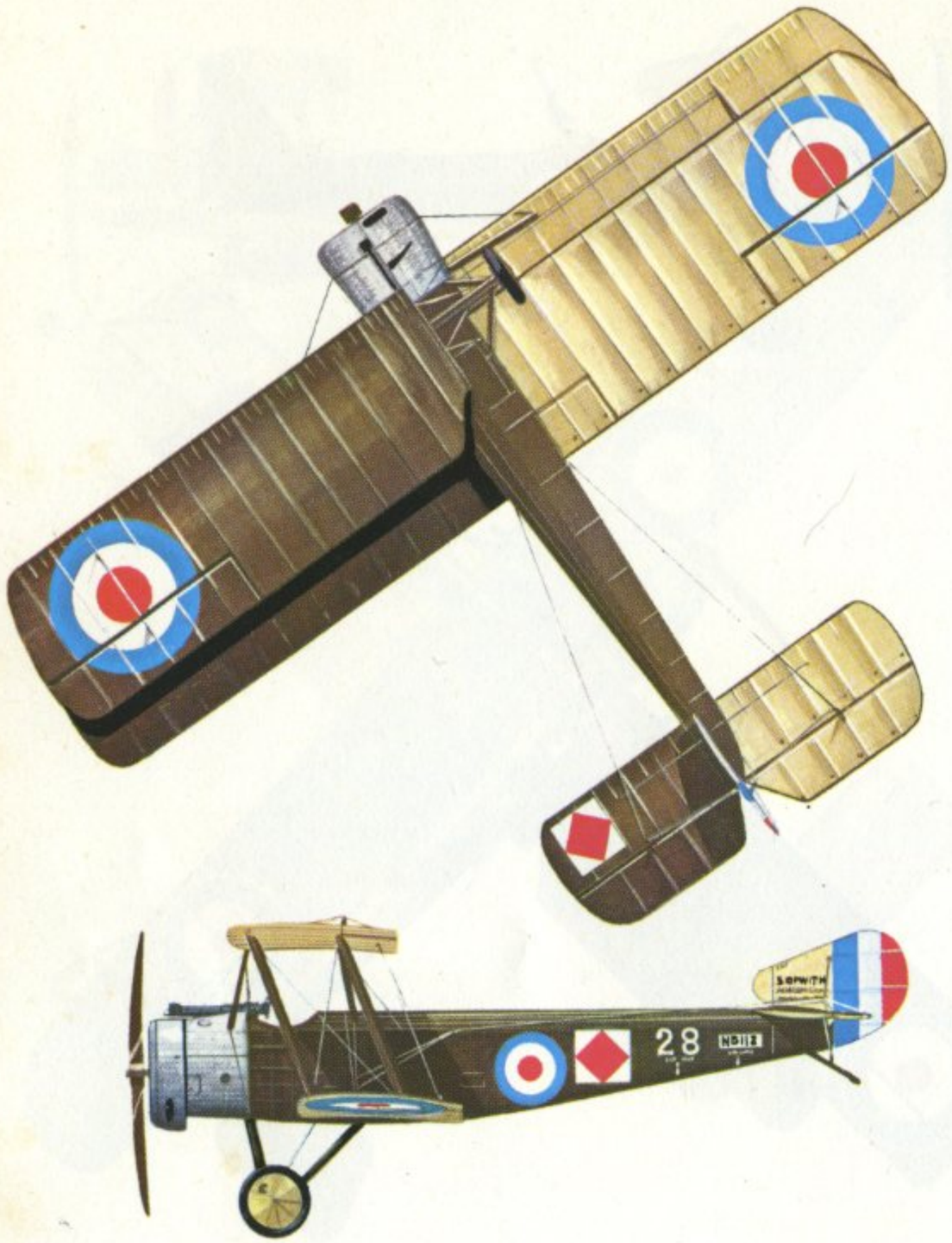


40

Siddeley-Deasy-built R.E.7 at the Royal Aircraft Factory, Farnborough, 1915, with 336-lb. bomb. *Engine:* One 150 h.p. R.A.F.4a air-cooled Vee-type. *Span:* 57 ft. 0 in. (17·37 m.). *Length:* 31 ft. 10½ in. (9·72 m.). *Wing area:* 548.0 sq.ft. (50·91 sq.m.). *Take-off weight:* 3,449 lb. (1,564 kg.). *Maximum speed:* 84·9 m.p.h. (136·6 km./hr.) at sea level. *Service ceiling:* 6,500 ft. (1,981 m.). *Endurance:* 6 hr. 0 min.

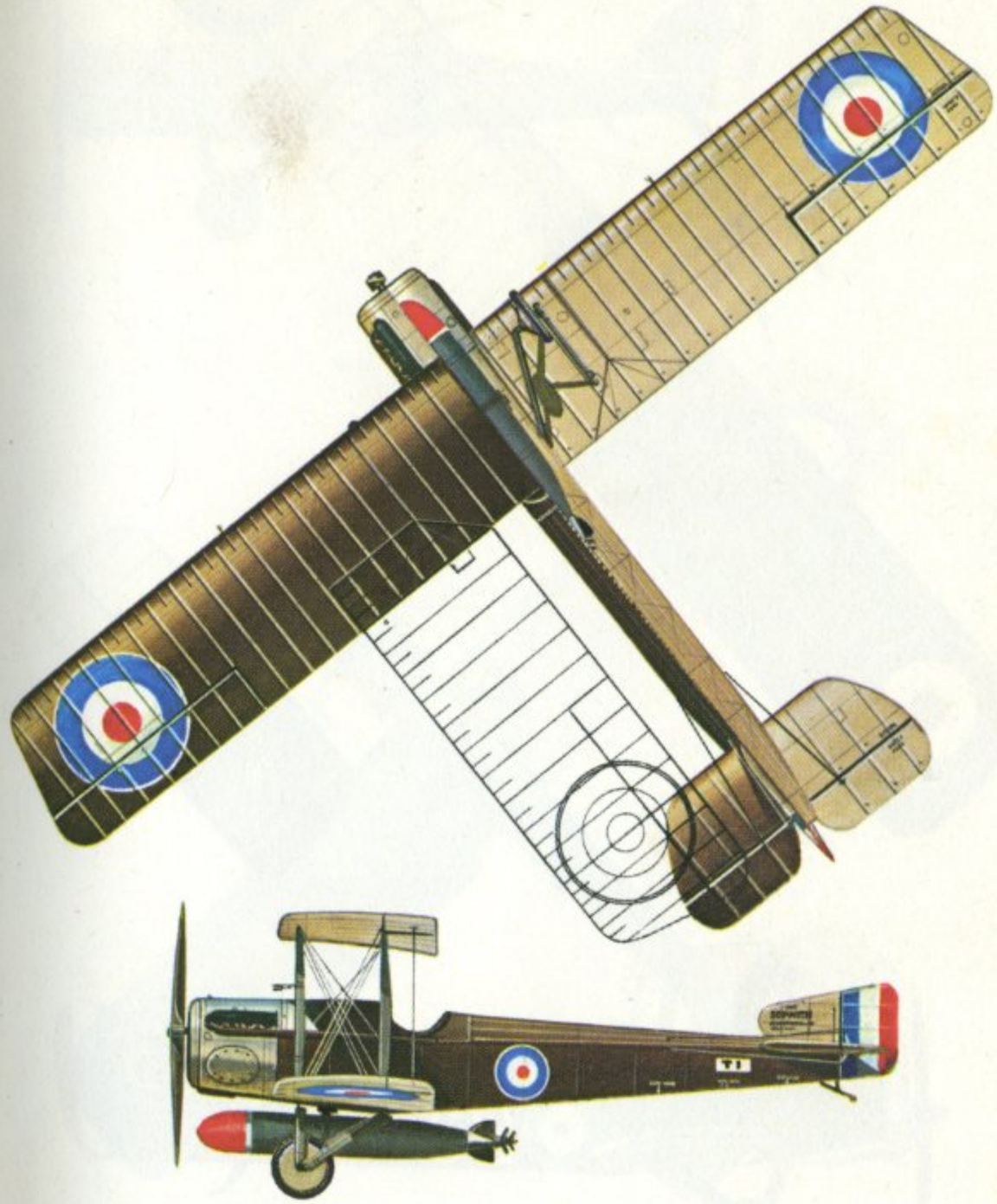
41

Daimler-built R.E.8 of 'A' Flight, No. 59 Squadron R.A.F., Vert Galand, May 1918. *Engine:* One 150 h.p. R.A.F.4a air-cooled Vee-type. *Span:* 42 ft. 7 in. (12·98 m.). *Length:* 27 ft. 10½ in. (8·50 m.). *Wing area:* 377·5 sq.ft. (35·07 sq.m.). *Take-off weight:* 2,678 lb. (1,215 kg.). *Maximum speed:* 102 m.p.h. (164·2 km./hr.) at 6,500 ft. (1,981 m.). *Service ceiling:* 13,500 ft. (4,115 m.). *Endurance:* 4 hr. 15 min.



42

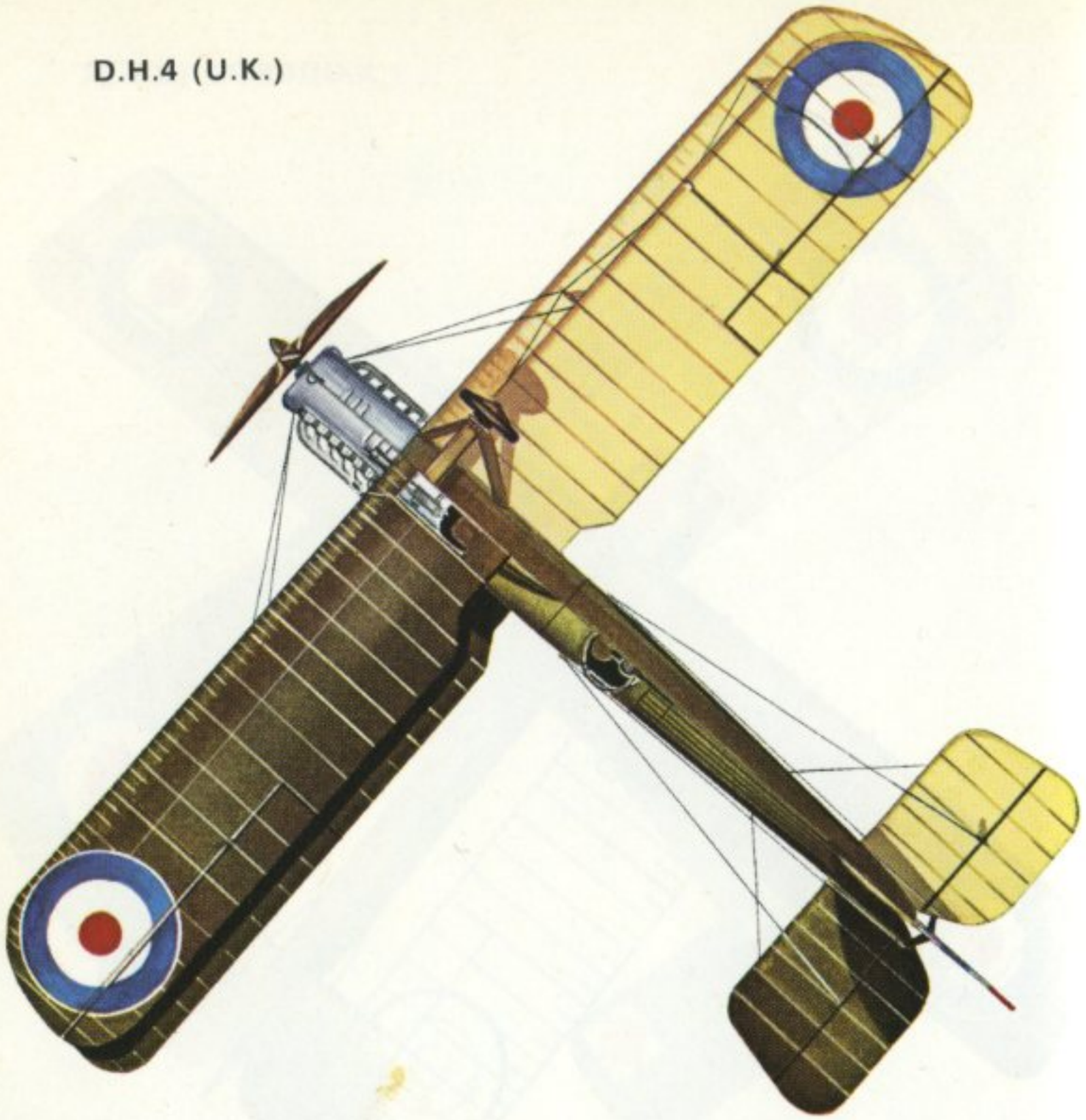
Sopwith-built Type 9700 (converted from Type 9400) of No. 3 Wing R.N.A.S., Luxeuil, France, *ca.* September 1916. *Engine:* One 130 h.p. Clerget 9 B rotary. *Span:* 33 ft. 6 in. (10·21 m.). *Length:* 25 ft. 3 in. (7·70 m.). *Wing area:* 346·0 sq.ft. (32·14 sq.m.). *Take-off weight:* 2,342 lb. (1,062 kg.). *Maximum speed:* 102 m.p.h. (164·2 km./hr.) at 6,500 ft. (1,981 m.). *Service ceiling:* 13,000 ft. (3,962 m.). *Endurance:* approx. 4 hr. 0 min.

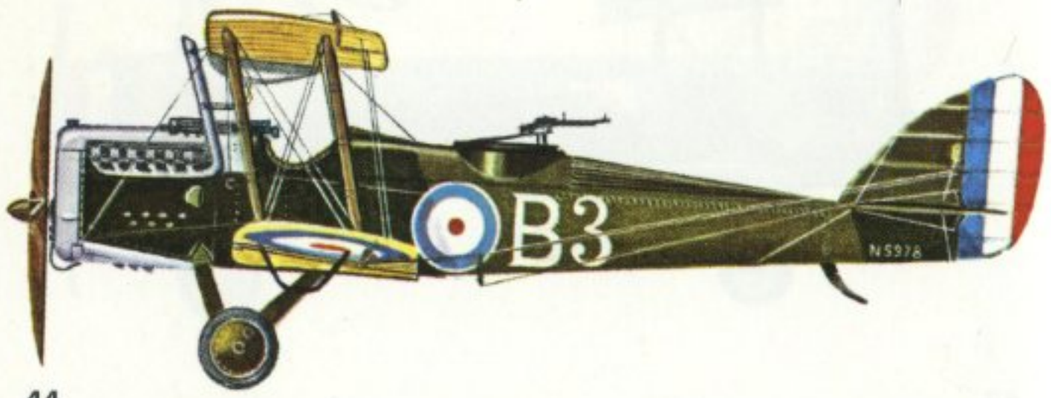


43

Sopwith T.1 Cuckoo prototype in R.N.A.S. colours, at the Isle of Grain, July 1917. *Engine:* One 200 h.p. Hispano-Suiza water-cooled Vee-type. *Span:* 46 ft. 9 in. (14·25 m.). *Length:* 28 ft. 6 in. (8·69 m.). *Wing area:* 566·0 sq.ft. (52·58 sq.m.). *Take-off weight:* 3,572 lb. (1,620 kg.). *Maximum speed:* 103·5 m.p.h. (166·6 km./hr.) at 6,500 ft. (1,981 m.). *Service ceiling:* 15,600 ft. (4,755 m.). *Endurance:* 3 hr. 45 min.

D.H.4 (U.K.)

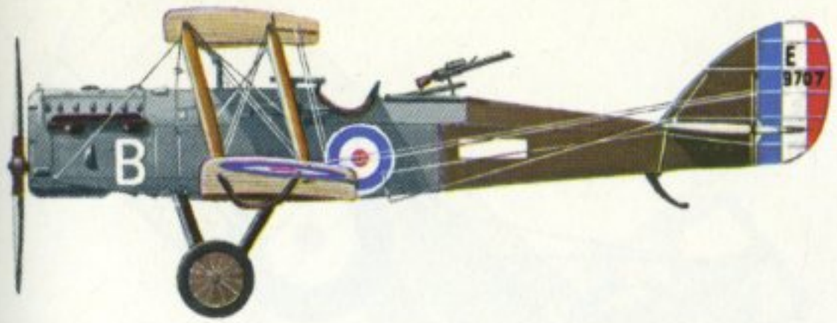


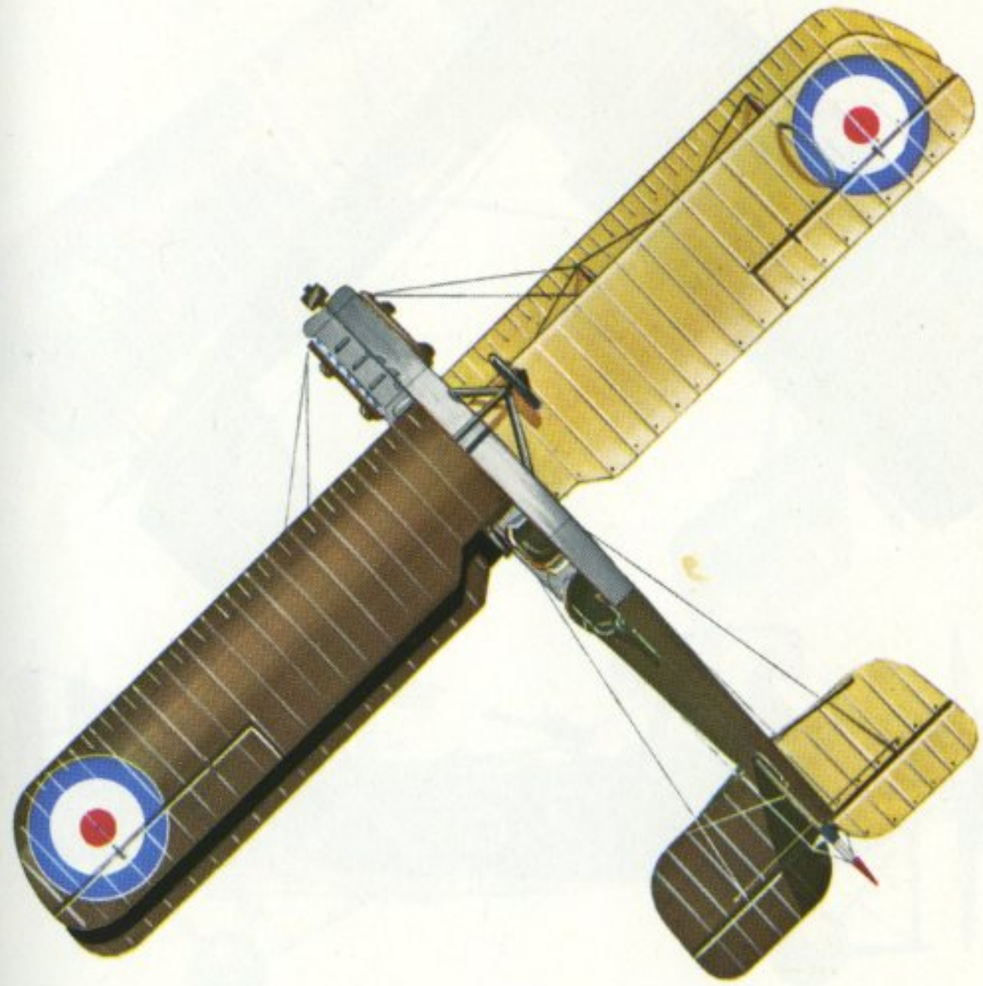


44

Westland-built D.H.4 of No. 5 Wing R.N.A.S., Dunkirk, *ca.* summer 1917. *Engine:* One 250 h.p. Rolls-Royce III (Eagle III) water-cooled Vee-type. *Span:* 42 ft. $4\frac{5}{6}$ in. (12·92 m.). *Length:* 30 ft. 8 in. (9·35 m.). *Wing area:* 434·0 sq.ft. (40·32 sq.m.). *Take-off weight:* 3,313 lb. (1,503 kg.). *Maximum speed:* 117 m.p.h. (188·3 km./hr.) at 6,500 ft. (1,981 m.). *Service ceiling:* 16,000 ft. (4,877 m.). *Endurance:* 3 hr. 30 min.

D.H.9A (U.K.)

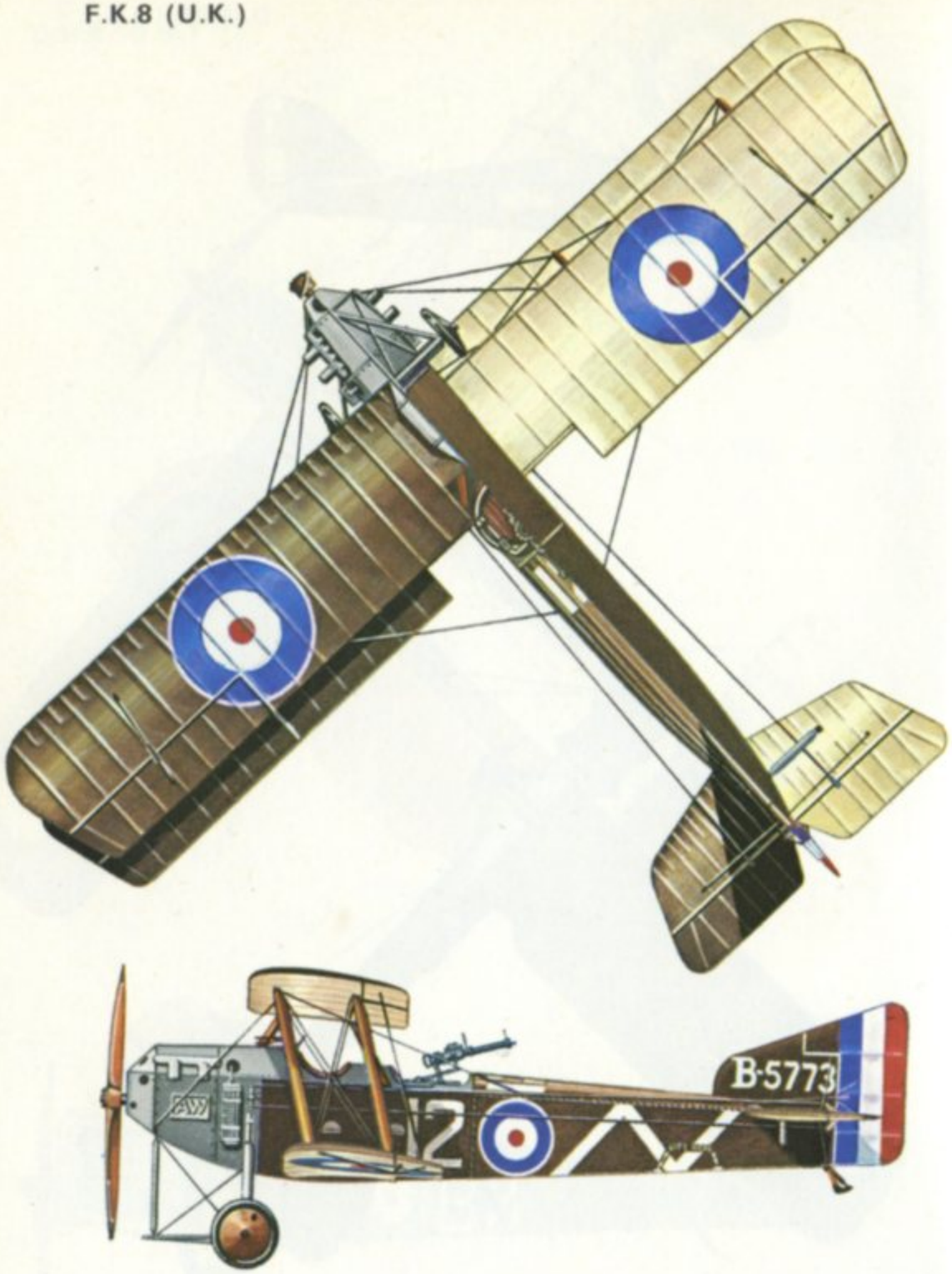




45

Mann, Egerton-built D.H.9A of No. 205 Squadron R.A.F., autumn 1918. *Engine:* One 400 h.p. Liberty 12 water-cooled Vee-type. *Span:* 45 ft. $11\frac{1}{2}$ in. (14·00 m.). *Length:* 30 ft. 3 in. (9·22 m.). *Wing area:* 434·0 sq.ft. (40·32 sq.m.). *Take-off weight:* 4,645 lb. (2,107 kg.). *Maximum speed:* 123 m.p.h. (197·9 km./hr.) at sea level. *Service ceiling:* 16,750 ft. (5,105 m.). *Endurance:* 5 hr. 15 min.

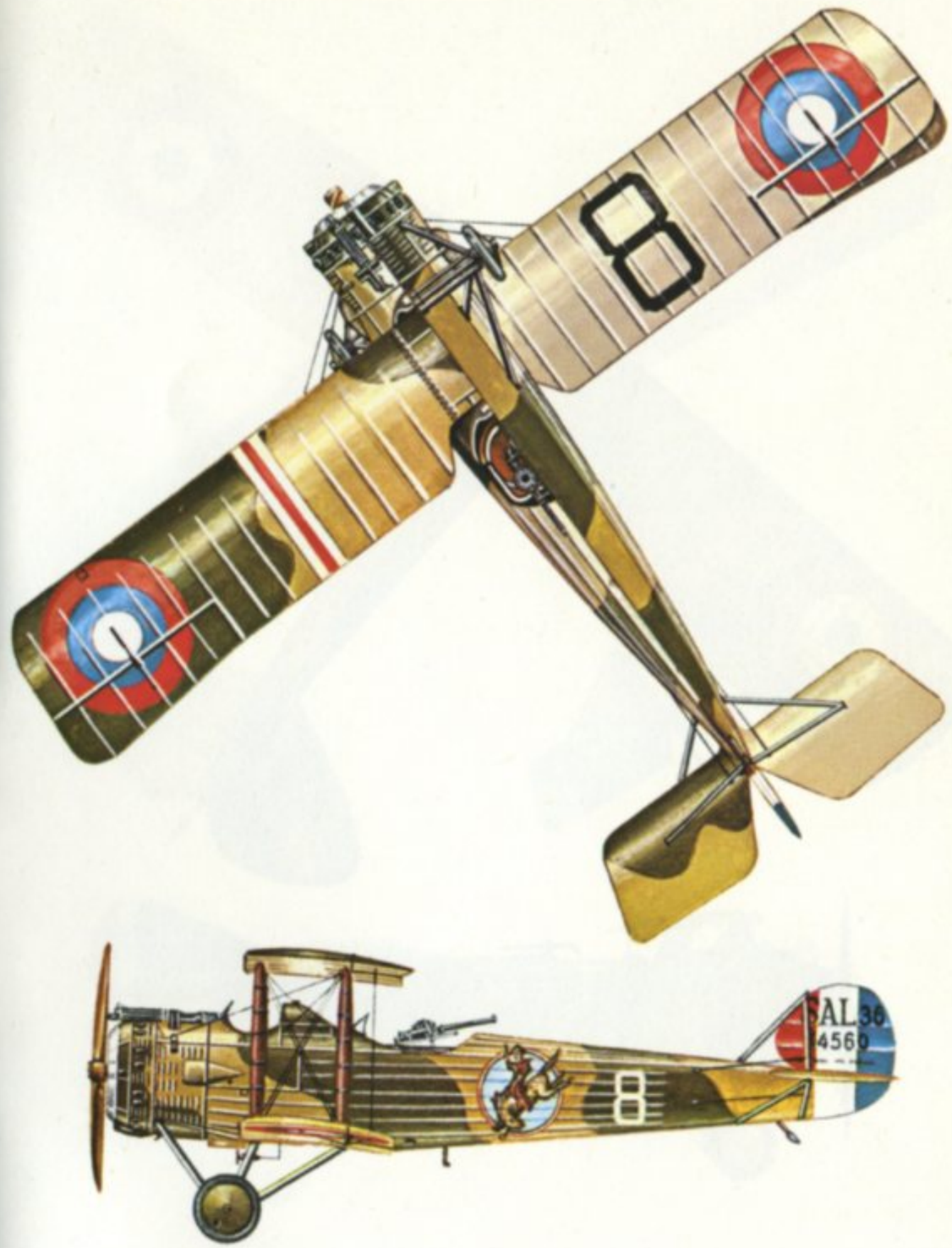
F.K.8 (U.K.)



46

Armstrong Whitworth-built F.K.8 flown by 2nd Lt. A. A. McLeod and Lt. A. W. Hammond of No. 2 Squadron R.F.C., France, March 1918. *Engine:* One 160 h.p. Beardmore water-cooled in-line. *Span:* 43 ft. 6 in. (13·26 m.). *Length:* 31 ft. 0 in. (9·45 m.). *Wing area:* 540·0 sq.ft. (50·17 sq.m.). *Take-off weight:* 2,811 lb. (1,275 kg.). *Maximum speed:* 93 m.p.h. (149·7 km./hr.) at 8,000 ft. (2,438 m.). *Service ceiling:* 13,000 ft. (3.962 m.). *Endurance:* 3 hr. 0 min.

SALMSON 2 (France)



47

Salmson 2A.2 of the 88th Aero Squadron, 1st Observation Group of the American Expeditionary Force, Marne, August 1918. *Engine:* One 260 h.p. Salmson (Canton-Unné) 9 Z water-cooled radial. *Span:* 38 ft. 6½ in. (11·75 m.). *Length:* 27 ft. 10⅔ in. (8·50 m.). *Wing area:* 401·2 sq.ft. (37·27 sq.m.). *Take-off weight:* 2,954 lb. (1,340 kg.). *Maximum speed:* 116 m.p.h. (187 km./hr.) at sea level. *Service ceiling:* 20,505 ft. (6,250 m.). *Endurance:* 3 hr. 0 min.

SPAD XI (France)

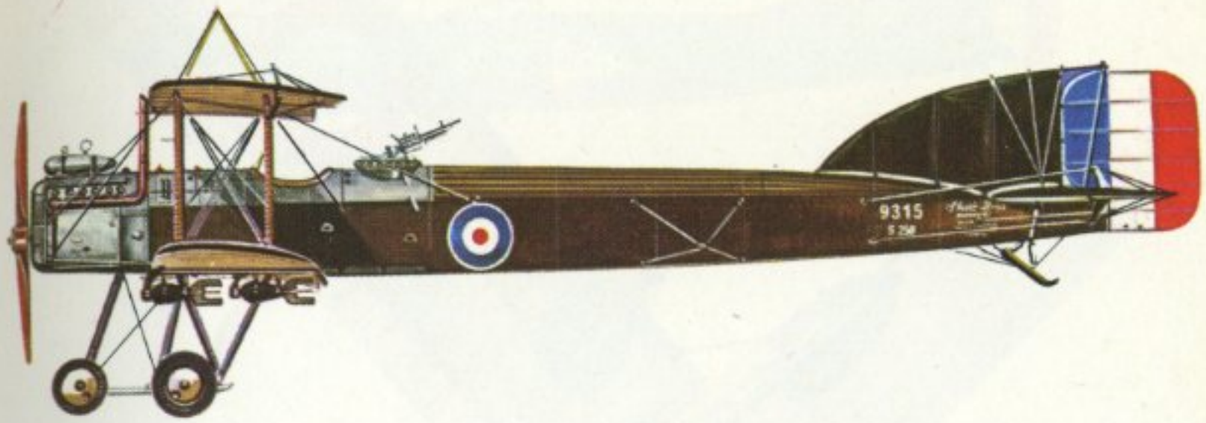
48

Spad XIA.2 of the French *Aviation Militaire,* early 1918. *Engine:* One 235 h.p. Hispano-Suiza 8 Bc water-cooled Vee-type. *Span:* 36 ft. $10\frac{1}{8}$ in. (11·23 m.). *Length:* 25 ft. $5\frac{1}{8}$ in. (7·75 m.). *Wing area:* approx. 307·8 sq.ft. (28·60 sq.m.). *Take-off weight:* 2,310 lb. (1,048 kg.). *Maximum speed:* 109·4 m.p.h. (176 km./hr.) at 6,562 ft. (2,000 m.). *Service ceiling:* 22,966 ft. (7,000 m.). *Endurance:* 2 hr. 15 min.

BREGUET 14 (France)

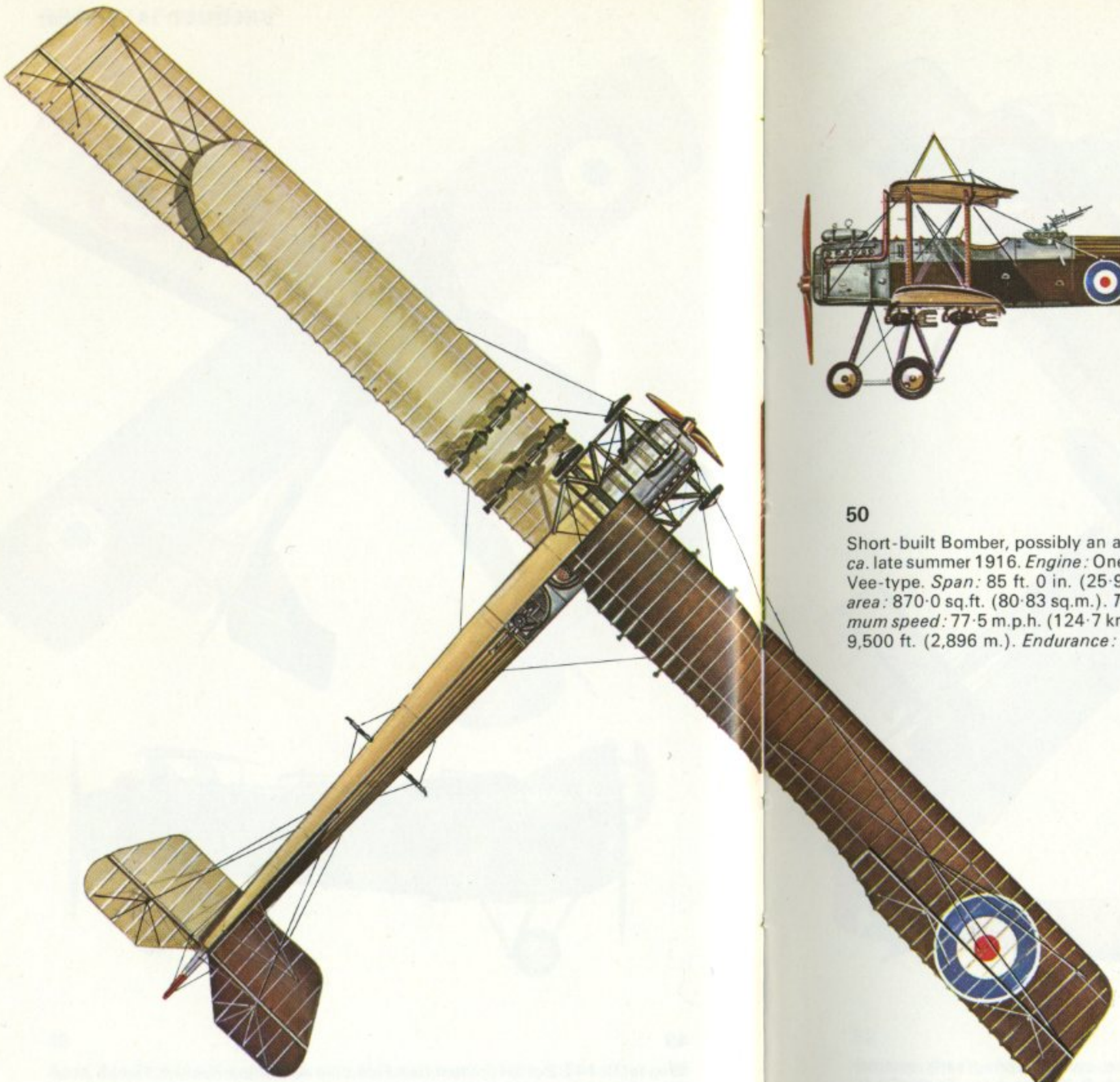
49

Breguet Br.14B.2 of an unidentified *Escadrille de Bombardement,* French *Aviation Militaire,* late 1917/early 1918. *Engine:* One 300 h.p. Renault 12 Fcx water-cooled Vee-type. *Span:* 47 ft. $1\frac{1}{2}$ in. (14·364 m.). *Length:* 29 ft. $1\frac{1}{4}$ in. (8·87 m.). *Wing area:* 540·3 sq.ft. (50·20 sq.m.). *Take-off weight:* 3,891 lb. (1,765 kg.). *Maximum speed:* 110 m.p.h. (177 km./hr.) at 6,562 ft. (2,000 m.). *Service ceiling:* 19,029 ft. (5,800 m.). *Endurance:* 2 hr. 45 min.

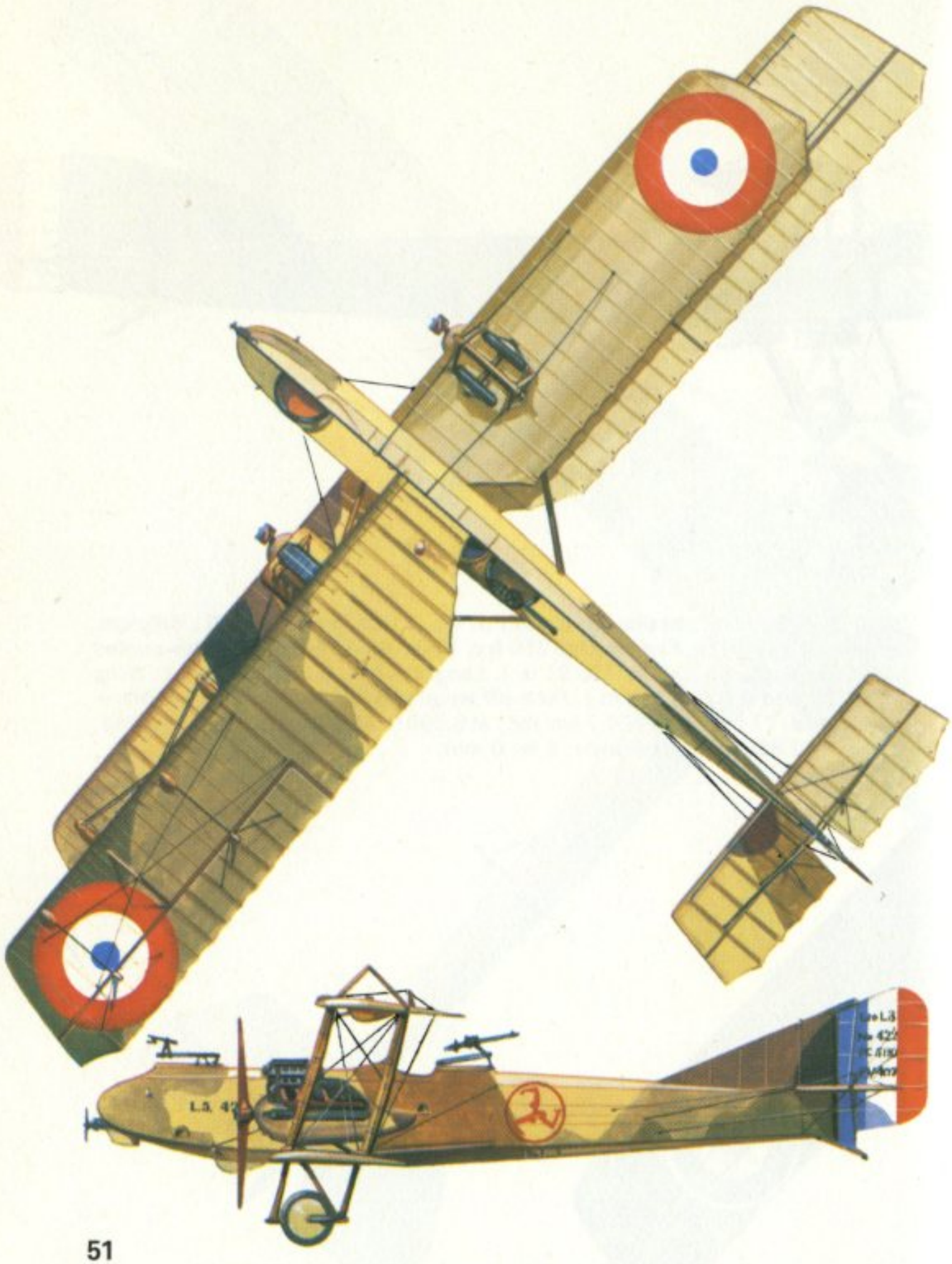


50

Short-built Bomber, possibly an aircraft of No. 7 Squadron R.N.A.S., Belgium, *ca.* late summer 1916. *Engine:* One 250 h.p. Rolls-Royce Eagle III water-cooled Vee-type. *Span:* 85 ft. 0 in. (25·91 m.). *Length:* 45 ft. 0 in. (13·72 m.). *Wing area:* 870·0 sq.ft. (80·83 sq.m.). *Take-off weight:* 6,800 lb. (3,084 kg.). *Maximum speed:* 77·5 m.p.h. (124·7 km./hr.) at 6,500 ft. (1,981 m.). *Service ceiling:* 9,500 ft. (2,896 m.). *Endurance:* 6 hr. 0 min.



LETORD TYPE 5 (France)



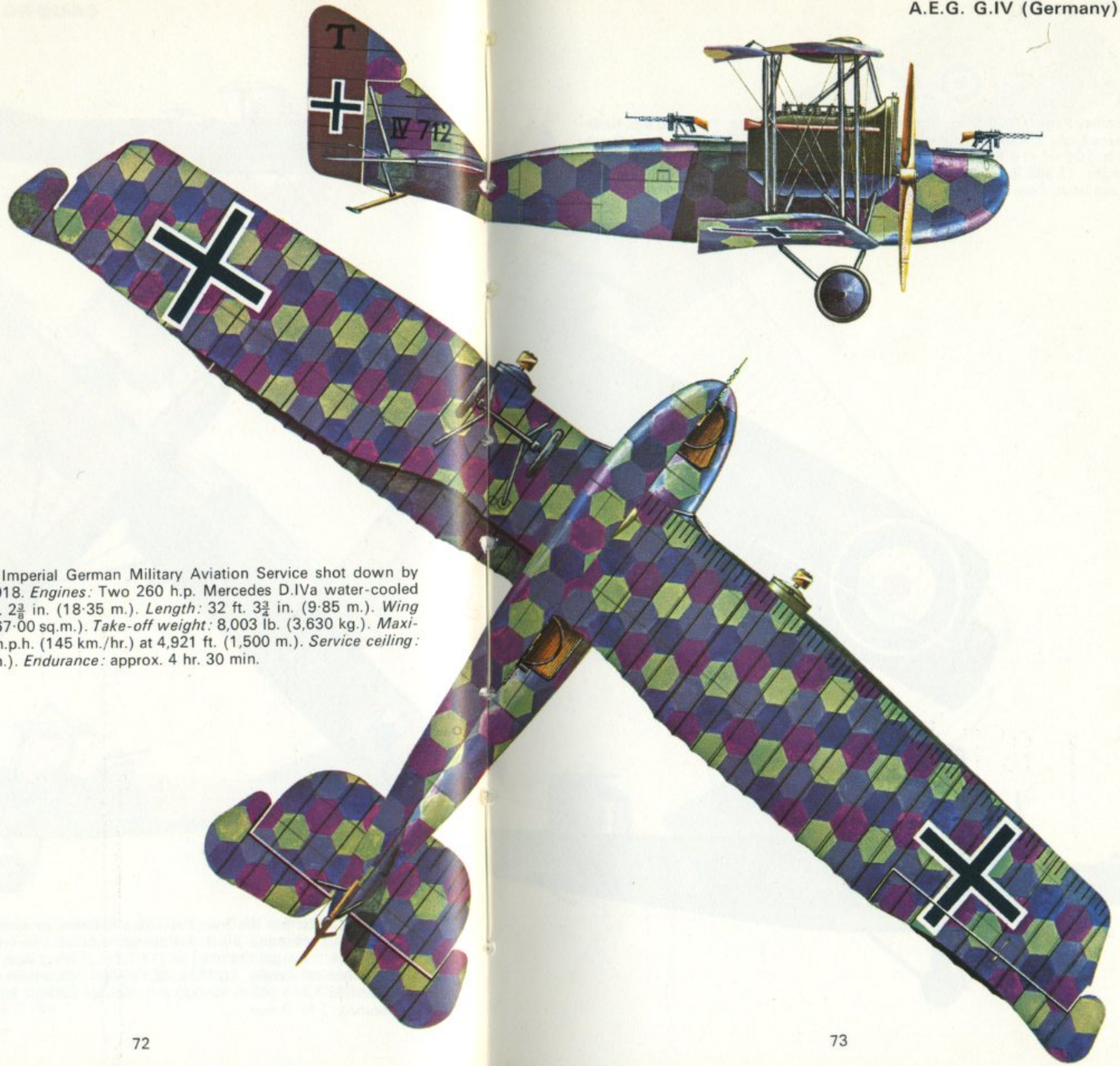
51

Letord Type 5 of the French *Aviation Militaire, ca.* late spring/early summer 1917. *Engines:* Two 220 h.p. Lorraine-Dietrich 8 Fb Vee-type. *Span:* 59 ft. 0¾ in. (18·00 m.). *Length:* 36 ft. 7¾ in. (11·17 m.). *Wing area:* 669·5 sq.ft. (62·20 sq.m.). *Take-off weight:* 5,390 lb. (2,445 kg.). *Maximum speed:* 99·4 m.p.h. (160 km./hr.) at 6,562 ft. (2,000 m.). *Service ceiling:* 16,404 ft. (5,000 m.). *Endurance:* 3 hr. 0 min.

CAUDRON R.11 (France)

52

Caudron R.11 Bn.3 of the French *Aviation Militaire, ca.* summer 1918. *Engines:* Two 215 h.p. Hispano-Suiza 8 Bdawater-cooled Vee-type. *Span:* 58 ft. 9½ in. (17·92 m.). *Length:* 36 ft. 9¾ in (11·22 m.). *Wing area:* 583·9 sq.ft. (54·25 sq.m.). *Take-off weight:* 4,773 lb. (2,165 kg.). *Maximum speed:* 113·7 m.p.h. (183 km./hr.) at 6,562 ft. (2,000 m.). *Service ceiling:* 19,521 ft. (5,950 m.). *Endurance:* 3 hr. 0 min.



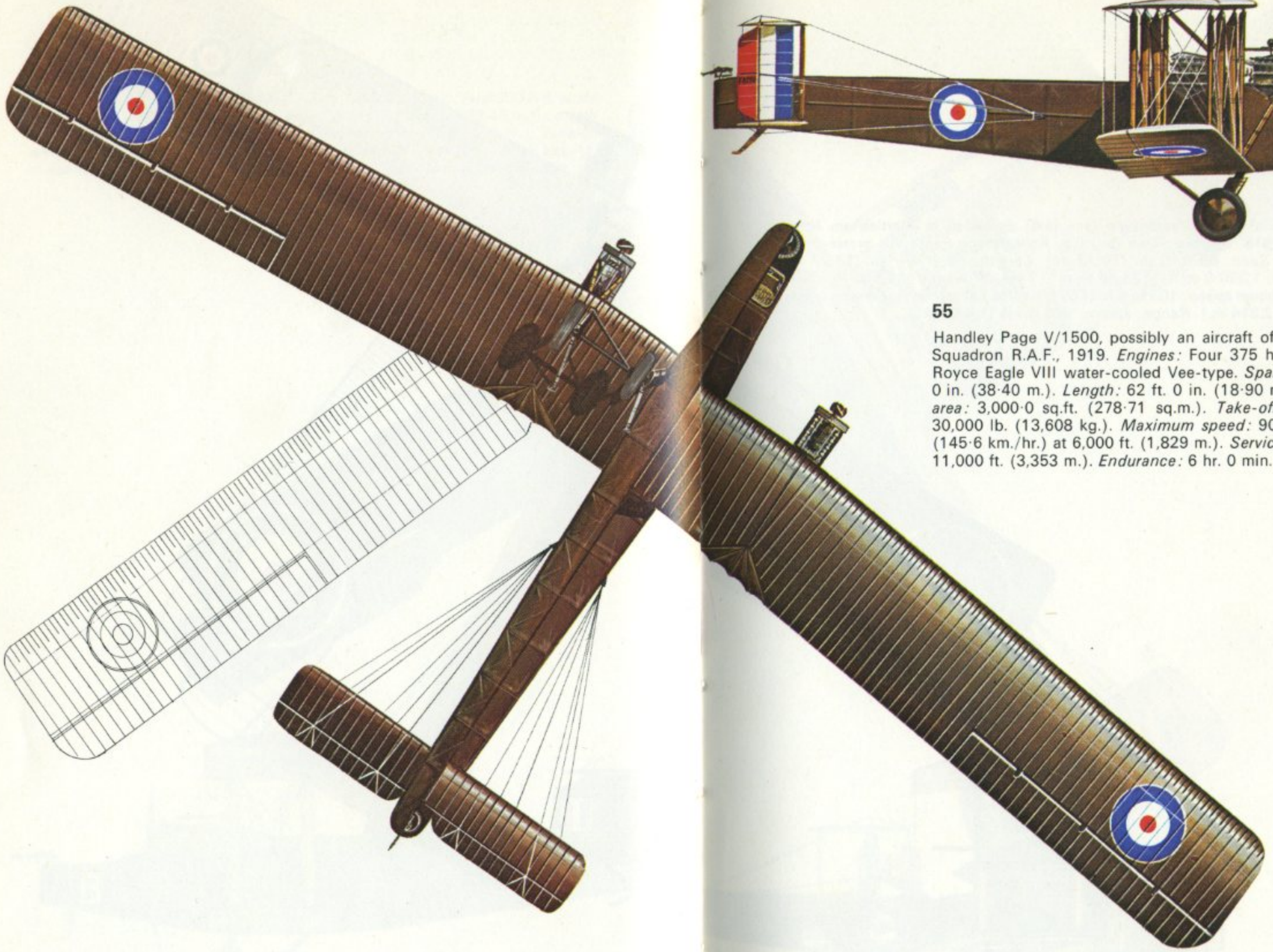
53

A.E.G. G.IV of the Imperial German Military Aviation Service shot down by the French, May 1918. *Engines:* Two 260 h.p. Mercedes D.IVa water-cooled in-line. *Span:* 60 ft. $2\frac{3}{8}$ in. (18·35 m.). *Length:* 32 ft. $3\frac{3}{4}$ in. (9·85 m.). *Wing area:* 721·2 sq.ft. (67·00 sq.m.). *Take-off weight:* 8,003 lb. (3,630 kg.). *Maximum speed:* 90·1 m.p.h. (145 km./hr.) at 4,921 ft. (1,500 m.). *Service ceiling:* 13,123 ft. (4,000 m.). *Endurance:* approx. 4 hr. 30 min.

54

Handley Page O/400 of the R.N.A.S., early 1918. *Engines:* Two 360 h.p. Rolls-Royce Eagle VIII water-cooled Vee-type. *Span:* 100 ft. 0 in. (30·48 m.). *Length:* 62 ft. 10¼ in. (19·16 m.). *Wing area:* 1,648·0 sq.ft. (153·10 sq.m.). *Take-off weight:* 13,360 lb. (6,060 kg.). *Maximum speed:* 97·5 m.p.h. (156·9 km./hr.) at sea level. *Service ceiling:* 8,500 ft. (2,591 m.). *Endurance:* 8 hr. 0 min.

V/1500 (U.K.)

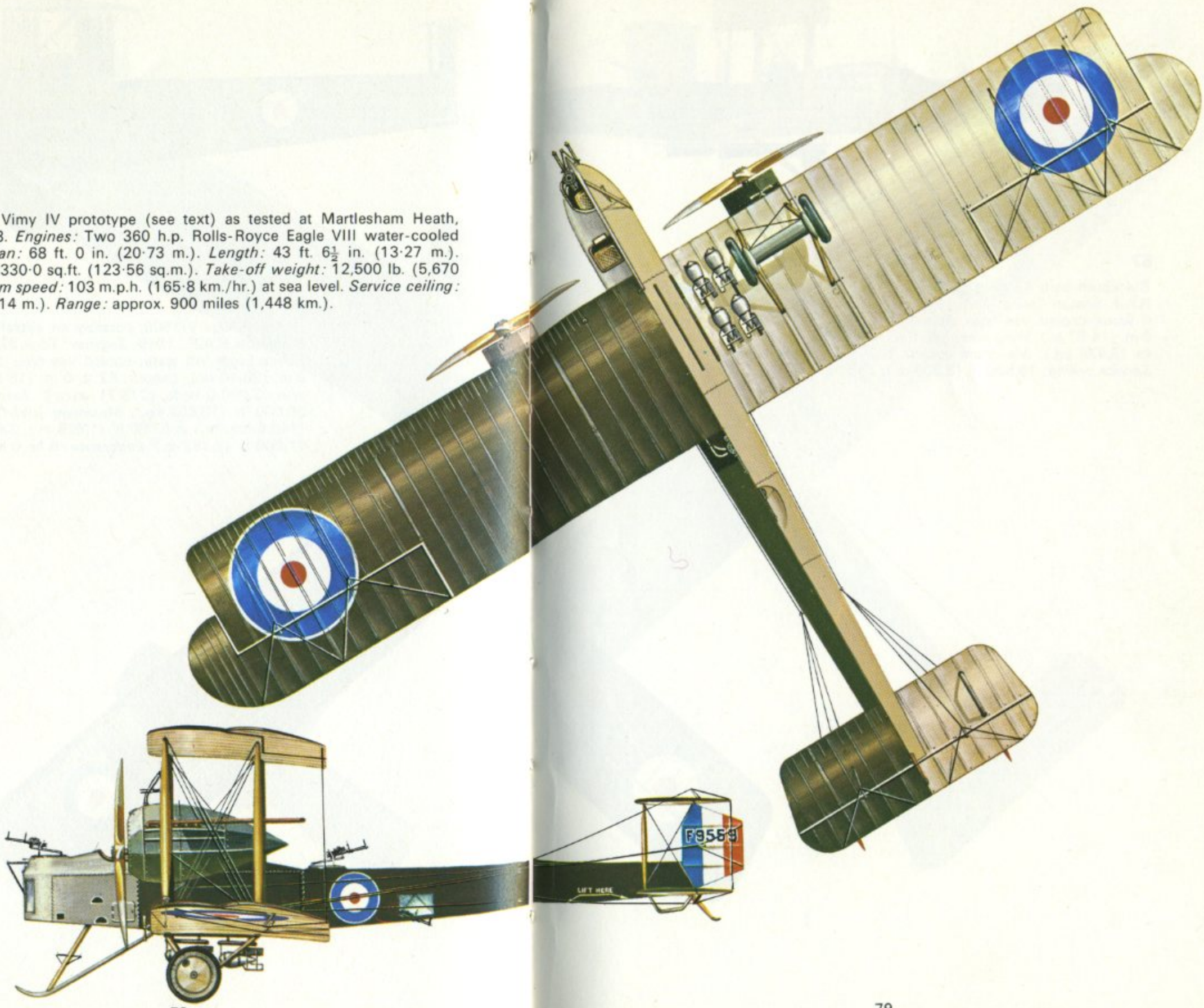


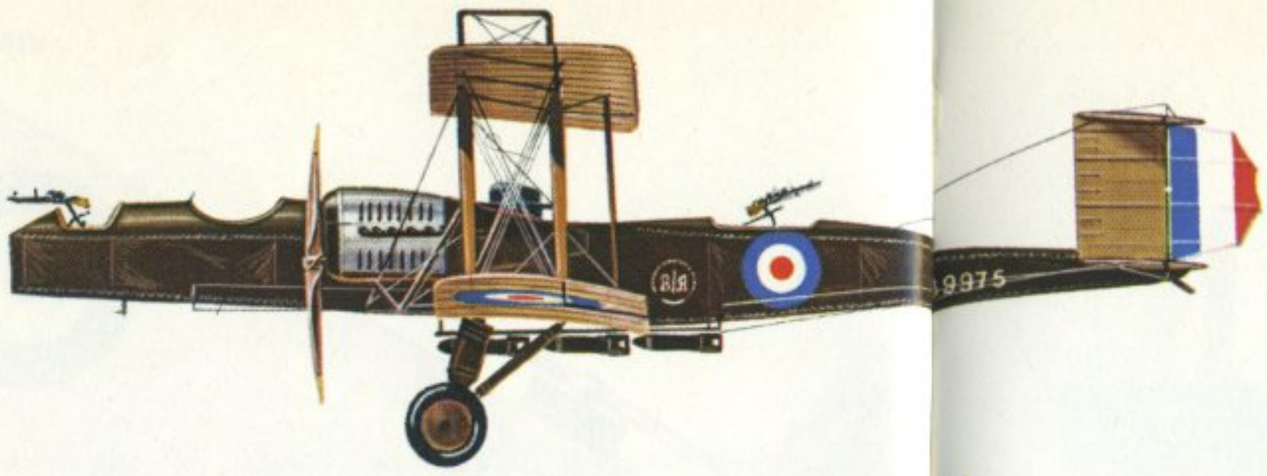
55

Handley Page V/1500, possibly an aircraft of No. 274 Squadron R.A.F., 1919. *Engines:* Four 375 h.p. Rolls-Royce Eagle VIII water-cooled Vee-type. *Span:* 126 ft. 0 in. (38·40 m.). *Length:* 62 ft. 0 in. (18·90 m.). *Wing area:* 3,000·0 sq.ft. (278·71 sq.m.). *Take-off weight:* 30,000 lb. (13,608 kg.). *Maximum speed:* 90·5 m.p.h. (145·6 km./hr.) at 6,000 ft. (1,829 m.). *Service ceiling:* 11,000 ft. (3,353 m.). *Endurance:* 6 hr. 0 min.

56

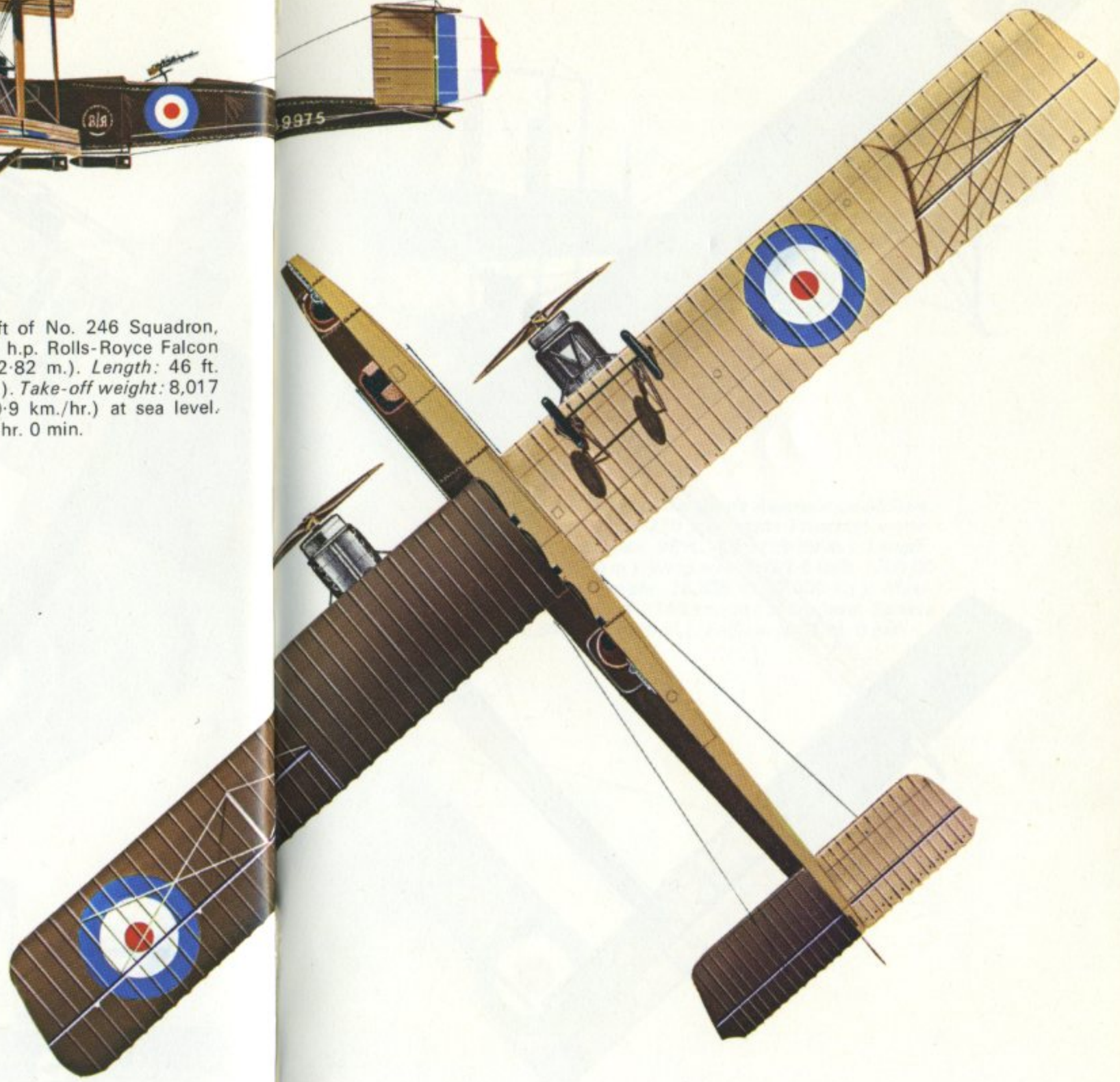
Vickers-built Vimy IV prototype (see text) as tested at Martlesham Heath, October 1918. *Engines:* Two 360 h.p. Rolls-Royce Eagle VIII water-cooled Vee-type. *Span:* 68 ft. 0 in. (20·73 m.). *Length:* 43 ft. 6½ in. (13·27 m.). *Wing area:* 1,330·0 sq.ft. (123·56 sq.m.). *Take-off weight:* 12,500 lb. (5,670 kg.). *Maximum speed:* 103 m.p.h. (165·8 km./hr.) at sea level. *Service ceiling:* 7,000 ft. (2,314 m.). *Range:* approx. 900 miles (1,448 km.).

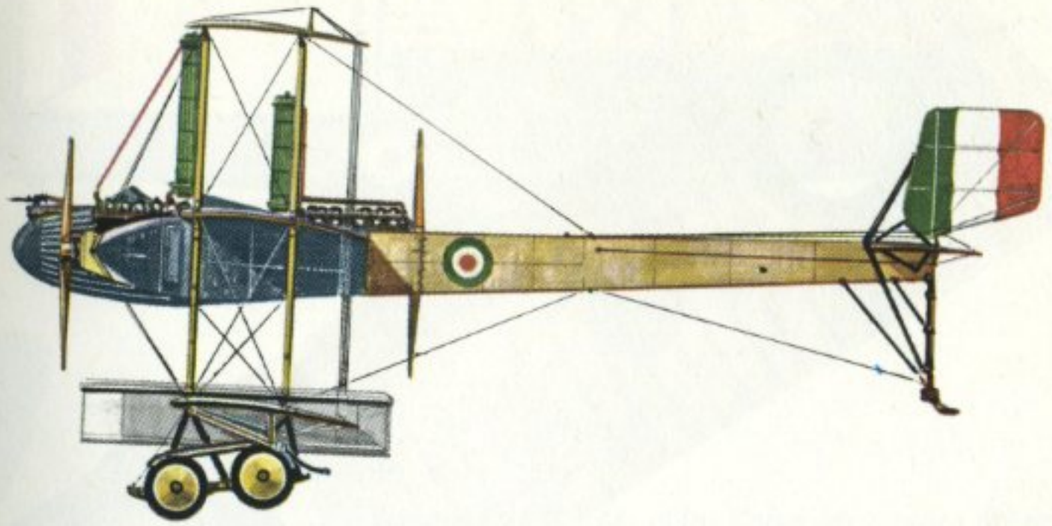




57

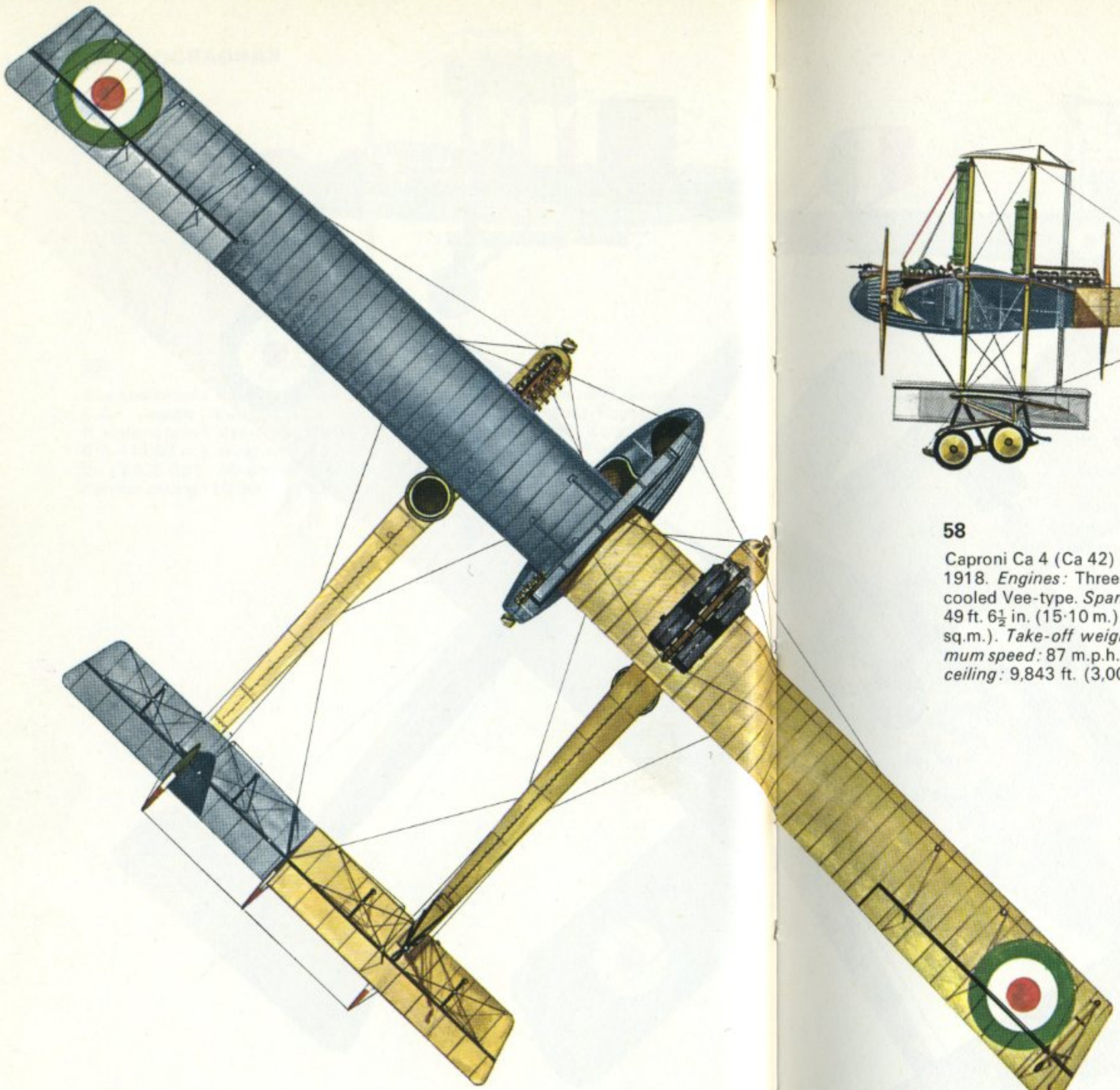
Blackburn-built Kangaroo, believed to be an aircraft of No. 246 Squadron, R.A.F. Seaton Carew, April 1918. *Engines:* Two 255 h.p. Rolls-Royce Falcon II water-cooled Vee-type. *Span:* 74 ft. $10\frac{1}{4}$ in. (22·82 m.). *Length:* 46 ft. 0 in. (14·02 m.). *Wing area:* 880·0 sq.ft. (81·75 sq.m.). *Take-off weight:* 8,017 lb. (3,636 kg.). *Maximum speed:* 100 m.p.h. (160·9 km./hr.) at sea level. *Service ceiling:* 10,500 ft. (3,200 m.). *Endurance:* 8 hr. 0 min.





58

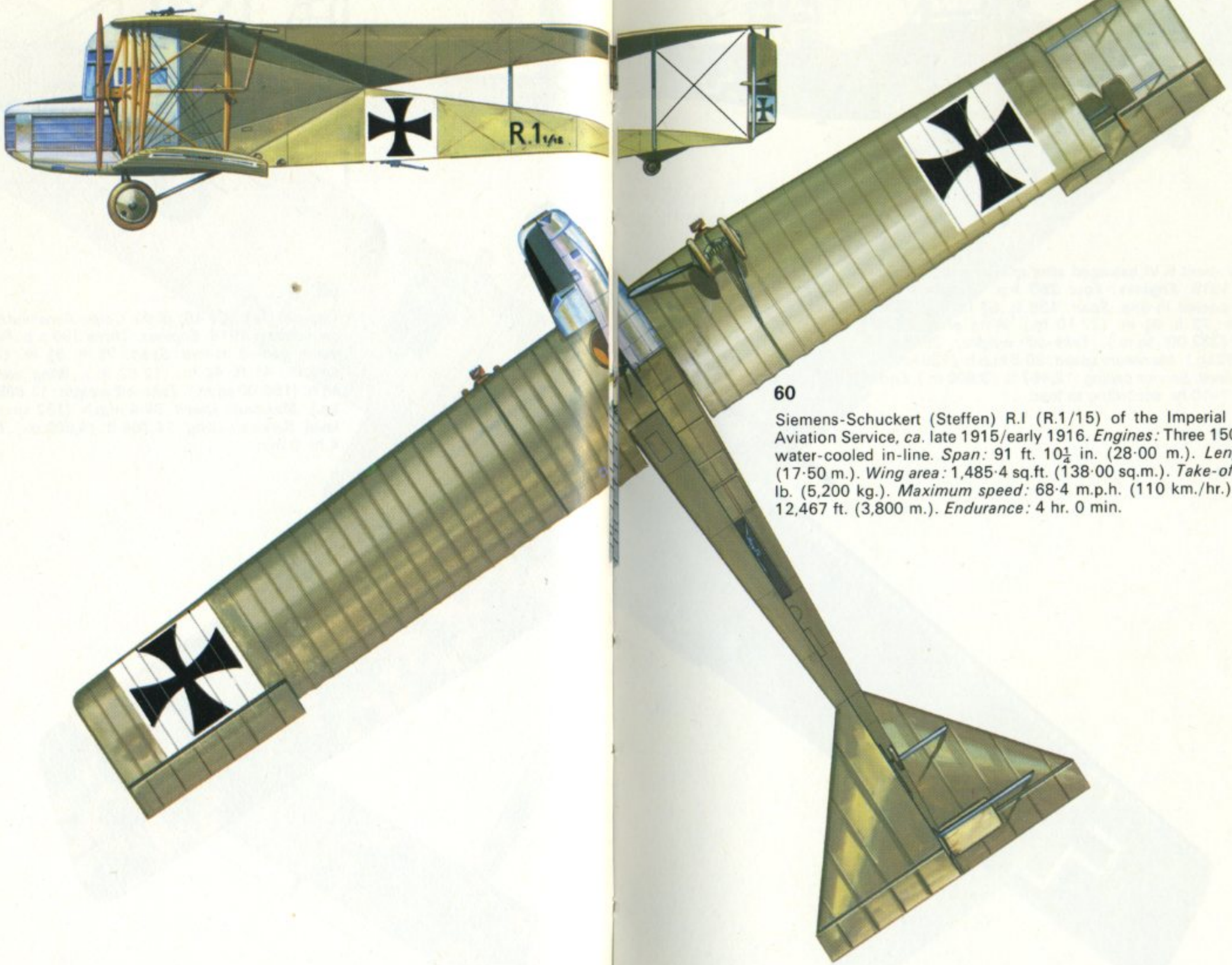
Caproni Ca 4 (Ca 42) of the *Corpo Aeronautica Militare,* 1918. *Engines:* Three 270 h.p. Isotta-Fraschini water-cooled Vee-type. *Span:* 98 ft. $1\frac{1}{8}$ in. (29·90 m.). *Length:* 49 ft. $6\frac{1}{2}$ in. (15·10 m.). *Wing area:* 2,152·8 sq.ft. (200·00 sq.m.). *Take-off weight:* 16,535 lb. (7,500 kg.). *Maximum speed:* 87 m.p.h. (140 km./hr.) at sea level. *Service ceiling:* 9,843 ft. (3,000 m.). *Endurance:* 7 hr. 0 min.



59

Caproni Ca 5 (Ca 46) of the *Corpo Aeronautica Militare, ca.* summer 1918. *Engines:* Three 300 h.p. Fiat A-12*bis* water-cooled in-line. *Span:* 76 ft. $9\frac{1}{4}$ in. (23·40 m.). *Length:* 41 ft. $4\frac{7}{8}$ in. (12·62 m.). *Wing area:* 1,614·6 sq.ft. (150·00 sq.m.). *Take-off weight:* 11,685 lb. (5,300 kg.). *Maximum speed:* 94·4 m.p.h. (152 km./hr.) at sea level. *Service ceiling:* 14,764 ft. (4,500 m.). *Endurance:* 4 hr. 0 min.

SIEMENS-SCHUCKERT R.I (Germany)



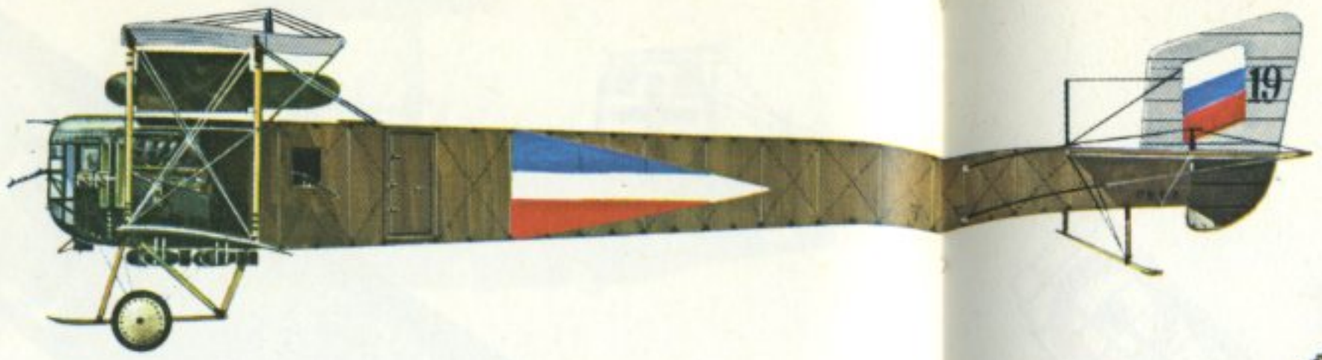
60

Siemens-Schuckert (Steffen) R.I (R.1/15) of the Imperial German Military Aviation Service, *ca.* late 1915/early 1916. *Engines:* Three 150 h.p. Benz Bz.III water-cooled in-line. *Span:* 91 ft. 10¼ in. (28·00 m.). *Length:* 57 ft. 5 in. (17·50 m.). *Wing area:* 1,485·4 sq.ft. (138·00 sq.m.). *Take-off weight:* 11,464 lb. (5,200 kg.). *Maximum speed:* 68·4 m.p.h. (110 km./hr.). *Service ceiling:* 12,467 ft. (3,800 m.). *Endurance:* 4 hr. 0 min.

61

O.A.W.-built R.VI salvaged after crashing at Betz on 1 June 1918. *Engines:* Four 260 h.p. Mercedes D.IVa water-cooled in-line. *Span:* 138 ft. $5\frac{3}{8}$ in. (42·20 m.). *Length:* 72 ft. $6\frac{1}{8}$ in. (22·10 m.). *Wing area:* 3,573·6 sq.ft. (332·00 sq.m.). *Take-off weight:* 25,265 lb. (11,460 kg.). *Maximum speed:* 80·8 m.p.h. (130 km./hr.) at sea level. *Service ceiling:* 12,467 ft. (3,800 m.). *Endurance:* 7–10 hr. according to load.

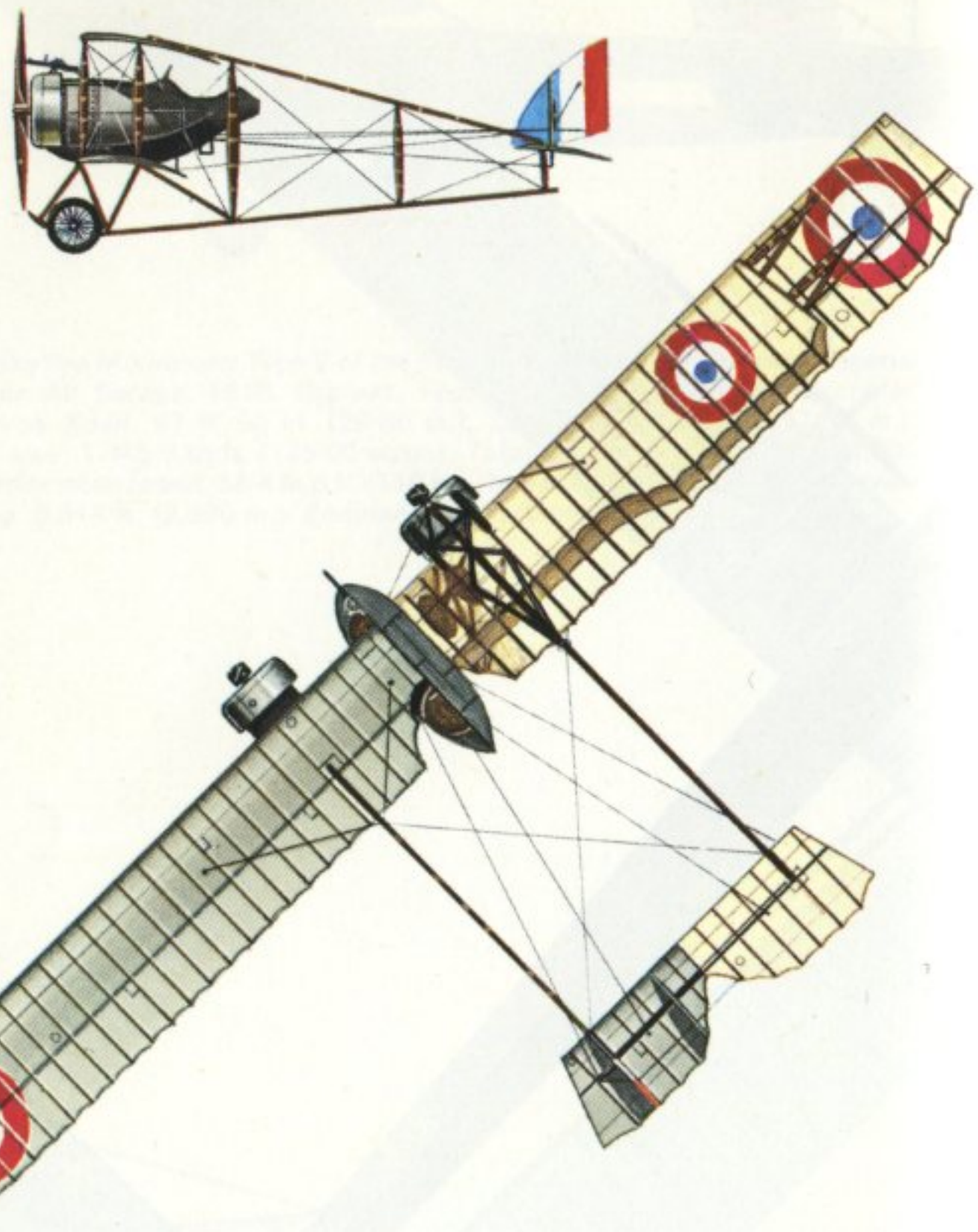
ILYA MOUROMETS (Russia)



62

Sikorsky *Ilya Mouromets* Type V of the *Eskadra Vozdushnykh Korablei,* Imperial Russian Air Service, 1916. *Engines:* Four 150 h.p. Sunbeam water-cooled Vee-type. *Span:* 97 ft. 9⅛ in. (29·80 m.). *Length:* 57 ft. 5 in. (17·50 m.). *Wing area:* 1,345·5 sq.ft. (125·00 sq.m.). *Take-off weight:* 10,141 lb. (4,600 kg.). *Maximum speed:* 68·4 m.p.h. (110 km./hr.) at 6,562 ft. (2,000 m.). *Service ceiling:* 9,514 ft. (2,900 m.). *Endurance:* 4 hr. 0 min.

CAUDRON G.IV (France)



63

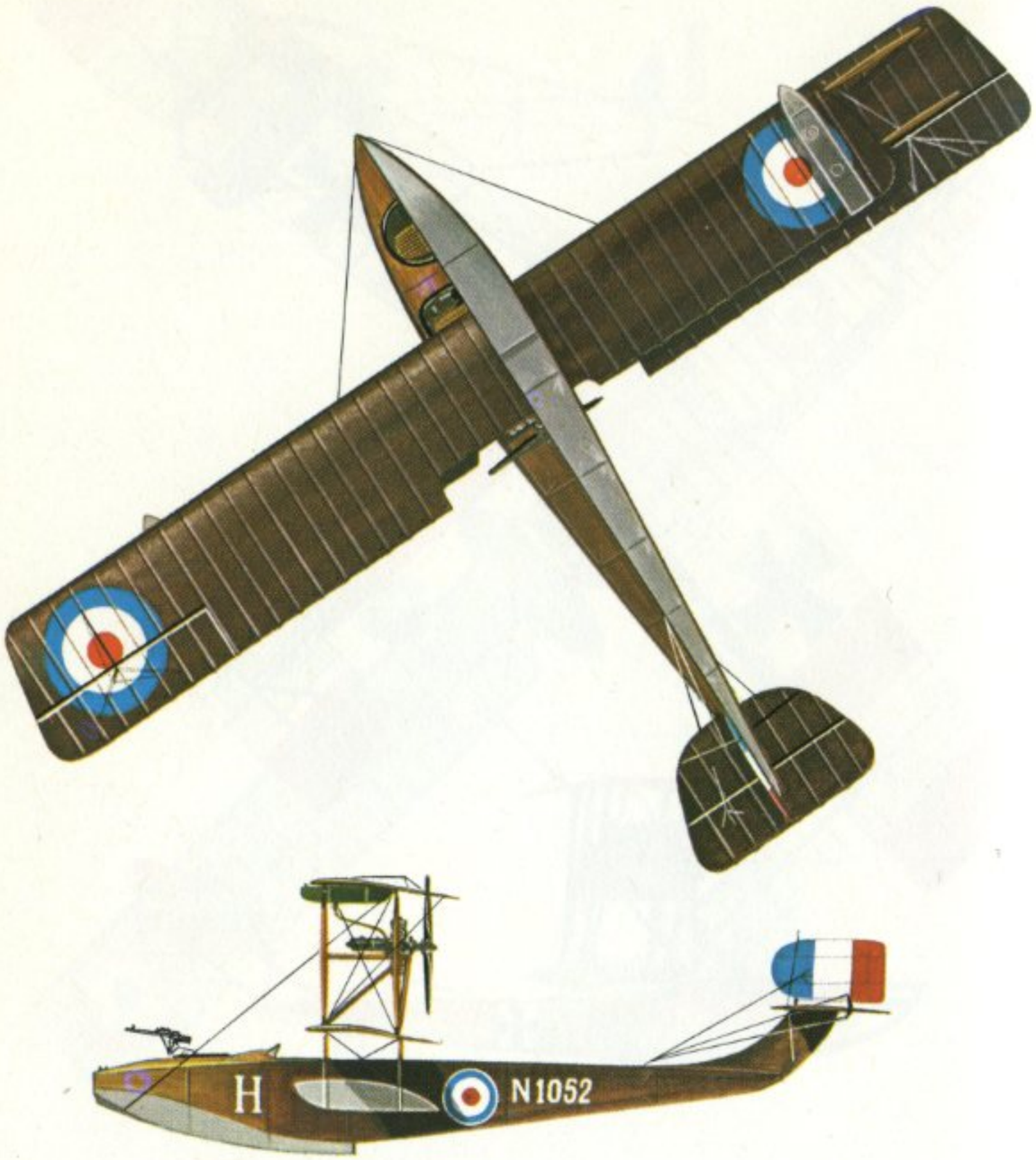
Caudron G.IVA.2 of the French *Aviation Militaire, ca.* spring 1916. *Engines:* Two 80 h.p. Le Rhône 9 C rotaries. *Span:* 55 ft. $4\frac{1}{2}$ in. (16·88 m.). *Length:* 23 ft. $7\frac{1}{2}$ in. (7·20 m.). *Wing area:* 396·1 sq.ft. (36·80 sq.m.). *Take-off weight:* 2,910 lb. (1,320 kg.). *Maximum speed:* 81 m.p.h. (130 km./hr.) at sea level. *Service ceiling:* 13,123 ft. (4,000 m.). *Endurance:* 4 hr. 0 min.

LOHNER L (Austro-Hungary)

64

Lohner L flown by Sub-Lt. Walter Zelezny of the Austro-Hungarian Navy, September 1916. *Engine:* One 160 h.p. Austro-Daimler water-cooled in-line. *Span:* 53 ft. $1\frac{3}{4}$ in. (16·20 m.). *Length:* 33 ft. $7\frac{7}{8}$ in. (10·26 m.). *Wing area:* 570·5 sq.ft. (53·00 sq.m.). *Take-off weight:* 3,748 lb. (1,700 kg.). *Maximum speed:* 65·2 m.p.h. (105 km./hr.) at sea level. *Service ceiling:* 16,404 ft. (5,000 m.). *Endurance:* approx. 4 hr. 0 min.

F.B.A. Type C (France)



65

Norman Thompson-assembled F.B.A. Type C of the R.N.A.S., spring 1916. *Engine:* One 130 h.p. Clerget rotary. *Span:* 44 ft. 11⅜ in. (13·70 m.). *Length:* 28 ft. 10⅛ in. (8·79 m.). *Wing area:* 322·9 sq.ft. (30·00 sq.m.). *Take-off weight:* 2,072 lb. (940 kg.). *Maximum speed:* 68·4 m.p.h. (110 km./hr.) at sea level. *Service ceiling:* approx. 11,483 ft. (3,500 m.). *Range:* 186 miles (300 km.).

BABY (U.K.)

66

Blackburn-built Baby of the R.N.A.S. coastal air station, Felixstowe, late 1917. *Engine:* One 130 h.p. Clerget 9 B rotary. *Span:* 25 ft. 8 in. (7·82 m.). *Length:* 23 ft. 0 in. (7·01 m.). *Wing area:* 240·0 sq.ft. (22·30 sq.m.). *Take-off weight:* 1,715 lb. (778 kg.). *Maximum speed:* 98 m.p.h. (157·7 km./hr.) at sea level. *Service ceiling:* approx. 7,600 ft. (2,316 m.). *Endurance:* 2 hr. 0 min.

FF33 (Germany)

67

Friedrichshafen FF33J of the Royal Swedish Naval Aviation, 1919. *Engine:* One 150 h.p. Benz Bz.III water-cooled in-line. *Span:* 54 ft. 11½ in. (16·75 m.). *Length:* 34 ft. 3⅜ in. (10·30 m.). *Wing area:* 565·1 sq.ft. (52·50 sq.m.). *Take-off weight:* approx. 3,704 lb. (1,680 kg.). *Maximum speed:* 72·1 m.p.h. (116 km./hr.) at sea level. *Service ceiling:* approx. 11,485 ft. (3,500 m.). *Endurance:* 5 hr. 0 min.

1 **Blériot XI**

The frail-looking tractor monoplane in which Louis Blériot crossed the English Channel in July 1909 was developed, with more powerful Gnome rotary engines in place of the original 25 h.p. Anzani, into one of the foremost military and civil aeroplanes of the period before World War 1. Blériot XIs established various speed, height and endurance records during 1910–11, and their aerobatic capabilities were well demonstrated by Alphonse Pégoud, who successfully looped an aeroplane of this kind in 1913. Military Blériot XIs were in service in France and Italy from 1910, the latter seeing action with the Italian forces in North Africa in 1911. The R.F.C.'s Military and Naval Wings and, later, the R.N.A.S. received their first Blériots in 1912.

During the first year of World War 1 the Blériots were among the most widely used of Allied observation types. They served with at least eight escadrilles of the French Aviation Militaire, with Nos. 1, 3, 6, 7, 9 and 16 Squadrons R.F.C. in France, and when Italy entered the war in May 1915 her air force had six squadriglie equipped with Blériot XIs. There were five basic variants of the standard shoulder-wing monoplane. Two of them, the XI Militaire and XI Artillerie, were single-seaters with 50 h.p. Gnome engines; the XI-2 Artillerie and XI-2 Génie were 2-seaters with 70 h.p. Gnomes; and the 3-seat XI-3 had a 140 h.p. Gnome. They differed in such matters as undercarriage, elevators, rudders and control pylons. The single-seat XI Militaire and the XI-2 Génie also served with the Belgian Aviation Militaire. Some single-seat Militaires were flown as 'nuisance' bombers with up to 25 kg. (55 lb.) of small bombs carried along the sides of the fuselage. Rifles or revolvers were the only armament carried by the crew. In addition to those in front-line service, many Blériot XIs were used by the French, British and Italian air forces as training aircraft.

A parasol-winged version was designated XI-B.G.: this was flown by French escadrilles and by both British air services. A few floatplane Blériots are believed to have served with the British and Italian Navies.

Known British serial number allocations indicate that twenty-one parasol Blériots and up to forty-eight Blériot XIs of other kinds were in R.F.C. service; and sixteen parasols and twenty-six Blériot XIs with the R.N.A.S. In addition, there were allocations for ten (R.N.A.S.) and eleven (R.F.C.) 'Blériot tractor' aircraft, which may be assumed to have been aircraft of one type or the other.

2 **Ago C types**

The Ago Flugzeugwerke, formed in 1912 from the former Aerowerke Gustav Otto, produced its first C type biplane, the C.I, in mid-1915. This, and the later C.II and C.III, shared a similar configuration, being pusher-engined 2-seaters with two slender oval-section fuselage booms supporting the tail unit. The C.I, originally powered by a 150 h.p. Benz Bz.III and later by a 160 h.p.

Mercedes D.III, entered service in summer 1915 in small numbers on the Western Front. Designed by the Swiss engineer August Haefeli, it was characterised by having small, comma-type rudders and prominent H. & Z. side radiators on the nacelle, in the nose of which was mounted a free-firing Parabellum machine-gun for use by the observer. For a pusher type the C.I was quite fast and had an operational endurance of 4 hours. One example of a twin-float version, the C.IW, was delivered to the German Navy for evaluation. Late in 1915 the C.I was superseded by the C.II, which had the more powerful Benz Bz.IV engine with a wing radiator, small triangular fins and plain rudders and various other aerodynamic improvements. This remained in service throughout 1916 and the first half of 1917 and, like its predecessor, was a useful aeroplane with good handling qualities. A variant of the Ago C.II was built by Haefeli, at Thun in 1915–16, as the DH-1 for the Swiss Air Force. For reasons that remain unexplained, the Ago pushers seem to have acquired an early reputation for being much larger and more heavily manned and gunned than in fact they were. A version did exist, however, with an enlarged wing span of 18·30 m. (60 ft. 0½ in.), and a few of these were built in landplane and C.IIW floatplane forms for use by the German Navy. Conversely, the Ago C.III was a smaller edition, powered by a Mercedes D.III, but only a few of these were built.

Ago's next C type was the C.IV, and this departed completely from the previous designs in being a tractor biplane with equal-tapered, equal-span wings of identical pattern, double ailerons and very slight wing stagger. The C.IV was powered by a 220 h.p. Bz.IV engine, had a synchronised forward-firing Spandau gun for the pilot and a ring-mounted Parabellum gun in the observer's cockpit. The prototype bore a comma-type rudder only, but a small fixed fin was introduced on production aircraft, giving a continuously rounded tail contour. The Ago C.IV was a fast and efficient aeroplane of its type, but it entailed long and costly constructional methods that limited the number built. The maximum number of C.IVs in service at any time was seventy in September 1917; this is thought to represent little more than a quarter of the total output, some of which were subcontracted to Schütte-Lanz and Rathgeber. The C.VII and C.VIII were experimental developments of the C.IV with, respectively, revised wing bracing and a different engine installed. Neither went into quantity production.

3 Breguet 4 and 5

After a series of tractor aeroplanes Louis Breguet designed his BU3 (later BR54) prototype in mid-1914 as a pusher biplane in deference to official insistence that French 2-seater aircraft should carry their observers in front, where they had the maximum possible field of view and of fire. Powered originally by 200 h.p. Canton-Unné, and later

by 220 h.p. Renault engines, one hundred aircraft of a slightly modified type were built by André and Edouard Michelin at their Clermont-Ferrand factory and presented to the Aviation Militaire. They were known as BUMs (with Canton-Unné engines), BLMs (with Renault engines) or simply as Breguet-Michelins, this last name also being applied to later developments from the design. In summer 1915 the French government issued a specification for a bomber capable of carrying a 300 kg. (661 lb.) load over a range of 600 km. (373 miles), and to meet this Breguet developed the BU3 into the SN3. The SN3 differed from the BU3 in having unequal-span wings and a modified undercarriage. It won the competition, which was held in October 1915, and in its production form was known as the Breguet Concours; military designations, applied later, were Type 4B.2 and Type 5Ca.2, the latter signifying a cannon armament. Both entered production early in 1916 at the Breguet and Michelin factories, with the 220 h.p. Renault 12 as their standard powerplant. The 4B.2 was armed with a single Hotchkiss or Lewis machine-gun in the front cockpit, and could carry up to forty 7·25 kg. bombs in Michelin automatic bomb racks beneath the lower wings outboard of the main landing wheels. The Breguet 5Ca.2 was basically similar, but mounted a 37 mm. cannon in the front cockpit and a rearward-firing machine-gun over the top wing. Its purpose was to act as escort for the 4B.2 bombers, but in practice the heavy cannon was usually replaced by a standard machine-gun. The Breguet Type 6 was a further development of the Type 4 with a 225 h.p. Salmson A9 radial engine and smaller radiators.

The Breguet pushers had a good range with a useful load, but required a long take-off, were difficult to land and were far too slow for day bombing. They were transferred to night operations from October 1916. The type served with at least five Escadrilles de Bombardement, one of which was still equipped with this type of Breguet in January 1918. The R.N.A.S. purchased approximately forty-six Breguets, of various models, from France; an additional thirty, with 250 h.p. Rolls-Royce engines, were ordered from Grahame-White Aviation under the designation G.W. XIX, but only ten of these were completed. British Breguets served with No. 3 Wing in France, and in the Aegean area.

4 Voisin 1 to 6

In spite of their frail appearance, the Voisin pusher biplanes, first designed in 1914, were in fact extremely weather-worthy and battle-worthy aeroplanes, as was demonstrated convincingly by their continuous employment throughout the whole of World War 1. The basis of their success was the strongly made steel airframe and the ability to take advantage of successively more powerful engines as the war progressed.

The Voisin 1 (Type L) appeared early in 1914 and was powered by a 70 h.p. Gnome rotary engine. The

Voisin 2 was essentially similar except that it was fitted with an 80 h.p. Le Rhône. These two types were already in service with four escadrilles of the French Aviation Militaire in August 1914 and initially were employed for artillery observation on the Western Front. From November 1914, however, they began to be used for daylight bombing, carrying about 60 kg. (132 lb.) of bombs in or on the sides of the 2-seat crew nacelle.

Also a pre-war design, the Voisin 3 (Type LA) had flown in February 1914 and was to become the most widely built Voisin type. It differed from the earlier machines in having a 120 h.p. Salmson (Canton-Unné) 9 M radial engine and unequal-span wings. It also carried a Hotchkiss machine-gun in the front of the nacelle, for the use of the observer, and the first enemy aircraft to fall to a French crew was shot down by Voisin V.89 on 5 October 1914. Although used at first for daylight operations, the Voisin 3 was transferred to night bombing from September 1915 and some aircraft of this type were also in service with the Marine Nationale. About eight hundred Voisin 3s were built for the Aviation Militaire, and a small quantity, equipping one escadrille, was supplied to Belgium; substantial numbers were delivered to Russia, and in 1915–16 the Società Italiana Transaerea built one hundred and twelve Voisin 3s which served with five squadriglie of the Corpo Aeronautica Militare and were powered by Fiat, Isotta-Fraschini or Renault engines. Both British services purchased French-built Voisins locally, the R.N.A.S. having at least twenty-one and the R.F.C. at least twenty-three; a further fifty Voisins were built in the United Kingdom by Savages Ltd. for the R.F.C. Later-production aircraft were known as Type LA.S, the suffix letter indicating surélevé (raised), in which the engine was installed at a slight downward angle to improve its thrust properties. Two hundred examples were also completed of the Voisin 4 (Types LB and LB.S). This was basically similar to the Type 3, but had slightly staggered wings and a more rectangular nacelle, in the nose of which a 47 mm. Hotchkiss cannon was installed. This version was used primarily for ground strafing, and sometimes for escort duty. The LB version flew for the first time in March 1915 and the LB.S towards the end of the year. Both the Voisin 3 and 4 were also used in D.2 form as 2-seat dual-control trainers.

A more powerful version of the Type 3 LA.S was the Type 5 LA.S, which appeared late in 1915. It differed from the Voisin 3 in having a 150 h.p. Salmson radial engine, an enlarged cut-out in the upper trailing edge and a strengthened undercarriage. Three hundred and fifty Voisin 5s were built. The Voisin 6 was virtually identical to the 5 except in having a slightly modified 155 h.p. version of the Salmson engine.

5 Voisin 8 to 10

The second most widely built Voisin biplane was the Voisin 8, developed from the Voisin 7 and enlarged and strengthened in an attempt to sustain a viable performance in the later war years by using a 220 h.p. Peugeot engine. A ready point of distinction between the Voisin 8 and the earlier models was the installation of two streamlined fuel tanks beneath the upper wings. The Voisin 8 was produced initially in Type LA.P form as a night bomber, going into service late in 1916. It was armed with one or two machine-guns, and the bomb load was increased to 180 kg. (396 lb.), carried beneath the wings and in the nacelle. The LB.P was a 'canon' version, slightly smaller and heavier and mounting a 37 mm. or 47 mm. Hotchkiss cannon in the front cockpit. It entered service in August 1916 for ground-attack and escort duties, but was not employed in very great numbers. One thousand one hundred and twenty-three Voisin 8s were built; one of these was sent to the United States for evaluation in 1917 and was followed by the purchase of eight more in April 1918 for use as trainers. Twenty Voisin 8s were delivered to the Marine Nationale and the remainder to the Aviation Militaire, which still had fifty-one in service in August 1918. The Voisin 9 was a lighter-weight reconnaissance version of the Voisin 8 LA.P.

Early in 1918 the Voisin 10 appeared as a replacement for the Voisin 8. The latter's Peugeot engine had been somewhat unreliable, and in the Voisin 10 its place was taken by the 300 h.p. Renault, which gave much less trouble and more efficiently sustained the aircraft's performance at altitude. It also enabled the bomb load to be increased to about 300 kg. (661 lb.), although at some reduction in the aircraft's range. Nine hundred Voisin 10s were built, two of which were purchased by the A.E.F. in July 1918, the rest being delivered to the Aviation Militaire from the beginning of the year. A 'canon' version, with a 37 mm. Hotchkiss, was designated LB.R (the bomber version being known as the LA.R), but was not employed on any scale.

6 Farman HF.20 series

The Henry Farman HF.20, which first appeared in 1913, was based on the earlier HF.16 design and had been produced in some numbers for military service well before the outbreak of World War 1 together with the generally similar HF.21, HF.22 and HF.23. These were all wooden-framed, 2-seat pusher biplanes designed to the same basic configuration and varying chiefly in their dimensions. The HF.21 had a greater span but a shorter fuselage than the HF.20; while the HF.22 and HF.23 had a longer fuselage than either the HF.20 or HF.21.

In August 1914, aircraft of the HF.20/21/22 type were in service with Escadrilles 1, 7, 13, 19 and 28 of the French Aviation Militaire; with Escadrilles 1 and 2 of the Belgian Aviation Militaire; with Nos. 1, 2 and 3 Squadrons R.N.A.S.; Nos. 3, 5, 6 and 7 Squadrons R.F.C.; and with the air forces of Romania and Russia. They were built under licence in Belgium by

Jero; in Italy by Savoia, with float landing gear and 100 h.p. Colombo engines; and in the United Kingdom by the Aircraft Manufacturing Co. and Grahame-White Aviation among other manufacturers. Usual powerplant was a 70 h.p. or 80 h.p. Gnome, or 80 h.p. Le Rhône rotary, although Anzanis or other engines of different ratings were fitted occasionally. Six HF.22s were supplied to the Netherlands in 1913, where a further fourteen were built in 1915 by the Spijker motor-car company; one or two of these were allocated to the Dutch Navy, the remainder serving with the Dutch Army Air Service. British Farmans operated in France with both the R.F.C. and the R.N.A.S., and with No. 3 Wing R.N.A.S. in the Dardanelles. Many R.N.A.S. Farmans were also operated as floatplanes.

The major variant of the design was the HF.27, which had a steel-tube airframe, a shorter nacelle, equal-span wings and a simplified 4-wheel undercarriage without landing skids. It was a slightly bigger aeroplane than the previous Henry Farmans, and usually powered by a 140 or 160 h.p. Canton-Unné engine. It had a 4-hour endurance and could carry a maximum bomb load of about 250 kg. (551 lb.). Farman HF.27s were employed operationally on the Western Front, in the Dardanelles, Mesopotamia, East and South-West Africa. Those of the R.N.A.S. were used both in France and at Mudros in the Aegean (with No. 2 Wing). Several of the R.N.A.S. Farman HF.27s were transferred to the R.F.C., equipping Nos. 26 and 30 Squadrons. Six British-built HF.27s were supplied to Romania.

A precise breakdown of the Farmans in British service is almost impossible to achieve since many serial allocations did not specify the individual type. However, from known serial batches it can be confirmed that the R.N.A.S. received more than one hundred and fifty Henry Farmans, of which about half were French-built. Similarly, R.F.C. serial numbers can be traced for more than four hundred and seventy Henry Farmans, almost all of which were built in the United Kingdom, by Airco, Grahame-White or other manufacturers.

7 Farman F.40 series

Towards the end of 1915 Henry and Maurice Farman produced a joint design incorporating the better features of their earlier, separate designs. The basic model for this series was the F.40, a 2-seat pusher biplane with the crew nacelle mounted mid-way between the unequal-span wings. It was powered by a 160 h.p. Renault engine. The F.40 series was preceded in December 1915 by the F.30, a simplified version with more angular nacelle and flying surfaces and powered by a 160 h.p. Canton-Unné radial engine. The F.30 was produced primarily for Russia, where it was also built under licence, although an F.30B.2 version with a 260 h.p. Salmson radial may have been built in small numbers for the Aviation Militaire.

The F.41 differed from the F.40 in having shorter-span wings, a nacelle similar to that of the Maurice Farman MF.11bis and an 80 or 110 h.p. Renault. The F.60 and F.61 corresponded respectively to the F.40 and F.41 except for their 190 h.p. Renault powerplants. The other major production version was the F.56, which had a 170 h.p. Renault but was otherwise similar to the F.41; the F.46 was produced specifically for training, with large front skids like those on the MF.7.

The Farmans entered service early in 1916 and were used widely for reconnaissance and bombing, serving with forty-seven escadrilles of the Aviation Militaire on the Western Front and in Macedonia. Only a small bomb load could be carried by the Farmans, whose sole defence was a single Lewis gun in the front cockpit. The type was virtually outclassed from the time it entered service, but it was not declared obsolete until early 1917 and even then continued to be used for night bombing until the arrival of Breguet 14s at the end of the year. A few Farmans were employed for 'balloon-busting', armed with Le Prieur rockets carried on the interplane struts. During 1918 all Farmans were withdrawn from the front line to training establishments. Farman F.41s and F.60s served with two escadrilles of the Belgian Aviation Militaire: thirty F.40s were purchased by the A.E.F. for training purposes; and a small number of Farmans were used by No. 5 Wing R.N.A.S. in France.

The Farman F.50, despite its designation, was not a variant of the F.40 design. It was a twin-engined tractor biplane bomber, with a wing span of 75 ft. 0 in. (22·86 m.), two 250 h.p. Lorraine-Dietrich engines and a possible load of eight 75 kg. (165 lb.) bombs. The F.50 appeared in 1918, and a small number had been delivered to French Escadrilles de Bombardement, including F.114 and F.119, before the Armistice. Two others were purchased by the A.E.F. in March 1918. After the war two F.50s were supplied to the Marine Nationale, another went to Japan and a small batch were demilitarised and used for a short while as passenger-carrying aircraft.

8 Friedrichshafen G types

Although better known for its wartime series of naval seaplanes, the Flugzeugbau Freidrichshafen did produce during World War I a range of G type twin-engined bombers. They were slightly smaller than the contemporary and more widely used Gotha G types, from which they could be distinguished by the shape of their wingtips and horizontal tail surfaces. The first type to appear was the G.I (FF30), which was completed late in 1914. It was a 3-bay biplane with two 150 h.p. Bz.III pusher engines, a compound tail assembly, and was armed with a single Parabellum defensive machine-gun in the nose. This apparently did not go into production, and it was not until 1916 that the G.II (FF38) appeared, a 2-bay, single-tailed aircraft with two 200 h.p. Bz.IV pusher engines and a Parabellum gun in each of the

nose and rear cockpits. The G.II went into limited production by the parent company and the Daimler Motoren-Werke, entering service towards the end of 1916. It continued to serve throughout the following year, but its 150 kg. (330 lb.) bomb load was modest by current standards and it was supplanted by the G.III (FF45), a larger aeroplane capable of carrying a heavier load.

The G.III first appeared early in 1917, and was again a 3-bay design. All flying surfaces, including the double ailerons, were balanced, but only the elevators were overhung. A 3-man crew was carried, and the defensive armament consisted of single or twin Parabellum guns in each of the front and rear cockpits; the rear gunner was protected from the pusher propellers of the Mercedes D.IVa engines by wire mesh guards on either side of him. Bomb load of the G.III for normal ranges was 500 kg. (1,102 lb.), of which 100 kg. (220 lb.) was carried internally and the remainder on racks under the fuselage. The Friedrichshafen G.III was in service at about the same time as the Gotha G.V (i.e. from mid-1917 until the end of the war), operating chiefly as a night bomber against targets in France and Belgium, although some accompanied the Gothas in their attacks on the United Kingdom. From early 1918 they were joined by the G.IIIa, which differed principally in having a compound tail unit. Production of the G.III/IIIa was shared by Daimler and Hansa, who built two hundred and forty-five and ninety-three aircraft respectively.

Later variants, appearing in modest numbers during 1918, included the G.IVa, G.IVb and G.V. All were short-nosed developments without a front gun position, the G.IVa being a pusher type like the earlier Friedrichshafens, while the G.IVb and G.V had engines driving tractor propellers. The Friedrichshafen G types equipped Bombengeschwadern 1, 2 and 5, and served in Macedonia as well as on the Western Front.

9 **Gotha G.I to G.V**

The first Grossflugzeug (large aeroplane) built by the Gothaer Waggonfabrik A.G. was the G.I, evolved by Oskar Ursinus and Major Friedel of the German Army from a prototype flown for the first time in January 1915. A few of these were built by Gotha under licence, in simplified and improved form. They were intended for ground-attack and general tactical duties and were employed on the Western and Eastern Fronts. The G.Is were characterised by a slim fuselage attached to the upper wings, while the two 160 h.p. Mercedes D.III engines were mounted close together on the lower wings.

Although following the same basic concept, the Gotha G.II was an entirely new design, evolved at Gotha under the Swiss engineer Hans Burkhard and flown for the first time in March 1916. The fuselage and engines (220 h.p. Mercedes D.IVs) were mounted conventionally on the lower wings; overall span

was increased, and auxiliary front wheels were added to the landing gear to avoid the risk of nosing over. The Gotha G.II carried a crew of three and a defensive armament of two machine-guns; the first production example was completed in April 1916. The G.II entered service in the autumn, but was soon withdrawn from operations (on the Balkan Front) after repeated failures of the engine crankshafts. It was replaced by the G.III from October 1916 on the Balkan and Western Fronts, a new model with reinforced fuselage, an extra machine-gun and 260 h.p. Mercedes D.IVa engines. An initial twenty-five G.IIIs were ordered, and in December 1916 fourteen were in service at the Front.

First major production model was the G.IV, chosen to carry out raids on the United Kingdom: an initial fifty G.IVs were ordered from Gotha, and eighty were built by Siemens-Schuckert and about a hundred by L.V.G. The G.IV went into service about March 1917, and began to make daylight raids on southern England towards the end of May. The G.IV retained the Mercedes D.IVa, but differed appreciably in having a tunnel hollowed out of the rear fuselage so that the rear gunner could cover the 'blind spot' below and to the rear of the bomber. Normally this was done with the standard rear-mounted gun, but a fourth gun could be carried for the purpose at the expense of part of the bomb load. The G.IV, with an all-plywood fuselage, and ailerons on top and bottom wings, was stronger yet easier to fly than its predecessors, though its performance remained much the same as for the G.III, and Germany was obliged to switch it to night attacks against Britain from September 1917. By this time it was beginning to be replaced by the new G.V, which had entered service in August; this version continued the night bombing of England until the following May. At the peak of their employment, in April 1918, thirty-six Gotha G.Vs were in service. Their typical bomb load on cross-Channel raids was six 50 kg. (110 lb.) bombs – about half their maximum load. Final versions in service were the G.Va/Vb. These differed from one another only in internal details, but could be distinguished from the G.V by their biplane tail assembly and shorter nose. The G.Va/Vb went into production in March 1918 and into service in June; by August there were twenty-one G.Vbs at the Front.

In general, the Gotha bombers were agile for their size, well defended and difficult to shoot down. More were lost to anti-aircraft fire than in aerial fighting, but far more still were lost in landing accidents. Forty of the Siemens-built G.IVs were completed as trainers, most of them with 180 h.p. Argus As.III or 185 h.p. N.A.G. engines. About thirty of the L.V.G. G.IVs were later transferred to Austro-Hungary, where they were refitted with 230 h.p. Hieros and employed on the Italian Front. A seaplane development of the G.I, the Gotha-Ursinus UWD, was completed late in 1915.

It was handed over to the German Navy in January 1916 and used on operations.

10 D.F.W. B.I and C.I

In the years preceding World War 1 one of the types built by the Deutsche Flugzeug-Werke was the Etrich Taube, and some indication of its influence was apparent in the banana-shaped wings of D.F.W.'s own MD 14 design that appeared in mid-1914. This was an elegant, stable and pleasant-to-fly aeroplane, with 3-bay bracing of the modest-span wings and small, looped skids underneath the lower extremities. Other characteristics of the MD 14 included the large H. & Z. side radiators and a downward-pointing engine exhaust manifold on the starboard side.

Upon the outbreak of war the MD 14 was impressed for military service and given the military designation B.I. Powered by a 100 h.p. Mercedes D.I engine, it was employed during the early months of hostilities for observation work on both the Eastern and Western Fronts. Like all B types, it carried no fixed defensive armament, the only weapons being a rifle or revolver carried by the observer, who in the fashion of the time occupied the front seat. With the arrival in service of armed 2-seaters in 1915, the B.Is were reallocated to training duties, for which their pleasant flying qualities made them an excellent choice. The D.F.W. MRD biplane, which became the military B.II, was externally similar to the B.I; this may have been a dual-control model produced especially for the training role.

In 1915 the D.F.W. KD 15 (military designation C.I) entered service in replacement of the unarmed B types. It was powered by a 150 h.p. Benz Bz.III; the observer still occupied the front seat, but the centre-section of the top wing now incorporated a cut-out enabling him to stand up and operate a free-firing Parabellum machine-gun mounted over the top wing. Like its predecessor, the C.I served on the Eastern and Western Fronts, and about one hundred and thirty of these aircraft are thought to have been completed. The T 25, or C.II, was a rather smaller aeroplane with modified tail surfaces, straight-edged staggered wings and more conventional crew seating with a Schneider ring for a Parabellum gun in the rear cockpit. Reports indicate that the C.II was somewhat unstable, and it may not actually have entered service. Total production of B types by the Deutsche Flugzeug-Werke is thought to have reached about one hundred machines.

11 Lloyd C types

The C type 2-seat reconnaissance aircraft built by the Ungarische Lloyd Flugzeug und Motoren-fabrik are among the lesser-known aircraft of World War 1, despite the fact that between four and five hundred aircraft of this type were built and used quite extensively by both Austro-Hungarian air serivces during the first half of the war.

They originated before the outbreak of war with the C.I (Series

41), one example of which was flown to an altitude of 6,170 m. (20,243 ft.) at Vienna in the summer of 1914. Aircraft of this type were already in military service when the war commenced. They were followed early in 1915 by the Lloyd C.II (Series 42), whose general appearance was typical of the Lloyd machines up to the time of the C.V. One hundred C.IIs were completed, fifty by Lloyd and fifty by W.K.F. They were powered by 145 h.p. Hiero engines and had a communal cockpit for the 2-man crew; the wing span was slightly larger than that of the C.I. The C.IIs were at first unarmed, but later aircraft in service were fitted with a Schwarzlose machine-gun for the observer. In 1916 the C.III appeared, being basically similar to the C.II except for its more powerful 160 h.p. Austro-Daimler engine in a somewhat deeper cowling. W.F.K. built fifty C.IIIs (Series 43.51), and they were employed on the Italian and Romanian Fronts in 1916–17. Some were fitted with a second machine-gun mounted on top of the wings. Little is known about the C.IV: it is thought to have been a single-bay version of the C.III, built by Lloyd and W.K.F. as Series 44 and 44.51, but its operational employment has not been confirmed.

The final Lloyd C type was the C.V (Series 46), with smaller dimensions, an aerodynamically refined airframe including a spinnered propeller and a taller fin with a rounded rudder. Powered by 185 h.p. Austro-Daimlers in the first fifty aircraft and 220 h.p. locally built Benz Bz.IVs in the second fifty, the C.V was some 32 km/hr. (20 m.p.h.) faster than the C.III. It was also built in Series 82 form by W.K.F. with 200 h.p. Bz.IV engines, but by the time the C.V appeared, later and more efficient reconnaissance aircraft were in service, and the Lloyd C types were transferred to training duties.

12 Hansa-Brandenburg C.I

Although it was employed almost exclusively by the Austro-Hungarian air services during World War 1, the Hansa-Brandenburg C.I or Type LDD was designed by Ernst Heinkel of the parent company in Germany, and may have owed something to the earlier Brandenburg FD (B.I) of 1914, three of which were supplied to Austro-Hungary. A characteristic of both designs was the inward-sloping interplane bracing struts.

The Brandenburg C.I was a 2-seat armed reconnaissance biplane of conventional appearance, having the typical communal cockpit favoured in Austrian aircraft at that time, in which the observer occupied the rear position and was provided with a free-firing Schwarzlose machine-gun. On later production C.Is a synchronised Schwarzlose was installed in front of the cockpit on the port side for use by the pilot. From the early spring of 1916 until the end of World War 1 the Brandenburg C.I was employed widely on reconnaissance, artillery observation and light bombing. Its normal war load was 60 kg. (132 lb.),

but some aircraft were operated with a maximum load of 100 kg. (220 lb.), consisting of one 80 kg. (176 lb.) and two 10 kg. (22 lb.) bombs. Visual and photographic reconnaissance missions were undertaken. The C.I was simple and stable to fly, had good take-off and landing qualities and a gradually improving performance in the air as successive production batches were fitted with engines of increased power.

In all, one thousand three hundred and eighteen C.Is were built, in eighteen series, by Brandenburg (eighty-four), Phönix (four hundred) and Ufag (eight hundred and thirty-four). Phönix built C.Is with 160 h.p. Austro-Daimlers (Series 23 and 26), 185 h.p. Austro-Daimlers (Series 27), 210 h.p. Austro-Daimlers (Series 29), 200 h.p. Hieros (Series 29·5, 129, 229 and 329) and 230 h.p. Hieros (Series 429). The Ungarische Flugzeugfabrik A.G. (Ufag) built Brandenburg C.Is with 160 h.p. Austro-Daimlers (Series 61, 64, 67 and 68), 160 h.p. Mercedes D.IIIs (Series 63), 200 h.p. Austro-Daimlers (Series 269), 200 h.p. Hieros (Series 69), 220 h.p. Benz Bz. IVas (Series 169) and 230 h.p. Hieros (Series 369).

13 **Albatros B types**

The unarmed 2-seat Albatros biplanes that served Germany in one capacity or another throughout World War 1 were probably the best reconnaissance machines in German service at the outbreak of war. Their design had been undertaken by Ernst Heinkel early in 1914, and the original version had entered production in a small way before the war started. They were impressed for war service, given the military designation B.I and allocated to Feld Flieger Abteilung (Field Reconnaissance) units in August 1914. Production was not especially standardised, and the B.I appeared in 1-, 2- and 3-bay forms with either a 100 h.p. Mercedes D.I or 120 h.p. D.II engine, the radiator for which was mounted above the cylinder block. As was the fashion at the time, the pilot sat in the rear cockpit while the observer occupied the front seat under the cabane trestle. No fixed defensive armament was carried, but during the early months of the war the observer usually armed himself with a rifle or carbine. Two batches of Albatros B.Is (Series 23 and 24) were built in Austro-Hungary by Phönix.

A second Albatros 2-seater had also flown during 1914, and in the summer it set an altitude record of 4,500 m. (14,764 ft.). A 2-bay biplane with a shorter span than the B.I, the B.II, as this version became known, was powered at first by a 100 h.p. Mercedes D.I. The Albatros B.II was one of the most widely used reconnaissance and observation types during the first year of the war, and was the subject of an extensive production programme. To improve the downward view for both pilot and observer, small cut-outs were made in the lower-wing roots. A small batch of B.Is and B.IIs (Series 21) was supplied to Austro-Hungary, and it is thought that some or all of these may have been

fitted with a rudimentary mounting for a machine-gun in the front cockpit. Later production B.IIs were of the B.IIa model, with a strengthened and aerodynamically improved airframe, dual controls and a 120 h.p. engine – either the Mercedes D.II or the Argus As.II.

The final Albatros B type was the B.III, which was built in small numbers in 1915 for reconnaissance work with both the German Army and Navy. This retained more or less the same fuselage as the B.II, but had shorter-span wings and a new, high-aspect-ratio vertical tail and curved tailplane similar to those later employed on the C.III.

With the introduction of the C category of armed 2-seaters in summer 1915, the B types became obsolete as observation aircraft. However, the Albatros machines' excellent flying qualities made them ideally suited to a training role, and they were extensively employed in this capacity throughout the remainder of the war. Production of the Albatros B series was undertaken by the B.F.W., L.F.G., Linke-Hofmann, Merkur, Kondor and Refla companies in Germany, in addition to those built by the Ostdeutsche Albatros Werke. Some Albatros B types were in military service in Sweden in 1918–19.

14 **Austrian Aviatik B.II and B.III**

In 1914–15 the German Automobil und Aviatik A.G. of Leipzig built a small, 2-seat reconnaissance aircraft designated B.I, powered by a 100 h.p. Mercedes D.I engine, which was employed in small numbers on the Western Front for observation during the early months of World War 1. The company's Austrian subsidiary, the Oesterreichische-Ungarische Flugzeugfabrik Aviatik of Vienna, in 1915 built a variation of this design with similar-pattern fuselage and wings, a characteristic of which were the strut-braced outer sections. Chief points of distinction between the German and Austrian Aviatiks were the horn-balanced, overhung elevators and rudder of the latter. The Austrian B.II was built in a small series (Series 32) in 1915, powered by a 120 h.p. Austro-Daimler engine. It carried no defensive armament other than the observer's rifle or revolver, but was able to carry a pair of 10 kg. bombs for 'nuisance' raids.

It was followed by the B.III (Series 33), which was ostensibly an improved version. This was powered by a 160 h.p. Austro-Daimler, with a box radiator mounted over the engine instead of the B.II's side radiators. The wings were of increased span, with raked-back tips; the fin was strut-braced; and instead of the B.II's separate cockpits, the B.III featured a long, communal cockpit in which the pilot now sat in the front seat and the observer at the rear had a Schwarzlose machine-gun on a flexible mounting. Like the B.II, the B.III had an excellent range, and was used in some numbers for long-distance reconnaissance on the Russian Front. It could carry three 10 kg. bombs. Unfortunately, the B.III's flying qualities were nowhere near as good as those

of its predecessor: it did not respond very quickly to its flight controls, and this caused it to swing about when flying in windy conditions, earning it such nicknames as 'gondola' and 'rocking-chair'.

Because of its unsatisfactory flying tendencies, a second series of B.II aircraft were built – the Series 34. These retained the former basic B.II airframe, but incorporated the 160 h.p. Austro-Daimler engine with its box radiator and the machine-gun installation of the B.III. Bomb load was increased to three 20 kg. bombs. In its Series 34 form the B.II was considerably more stable in flight, faster than the B.III and could climb to twice the altitude of the original B.II. Though they were not outstanding machines, the Austrian Aviatiks performed useful service in theatres where their long range was an asset, but by early 1916 they had been withdrawn from the front line and relegated to training duties.

15 Lohner B and C types

The Jakob Lohner Werke of Vienna is best known for the range of marine aircraft that it produced during 1914–18, but, like its lesser-known compatriot, Lloyd, it also produced a range of 2-seat reconnaissance biplanes during the early part of the war. The first of these, the Lohner Type B, was in fact a 1913 design, several of which had been built before the outbreak of war with 100 h.p. Austro-Daimler engines. Some of them were given individual names, all beginning with the letter B. After the outbreak of war, production was increased, and the type was designated B.I. It was built by Lohner (as Series 11) and by the government factory at Fischamend (as Series 73), some aircraft having 120 h.p. engines. Although unarmed, the B.Is were used in some numbers during the early months of hostilities for observation and communications work. The Lohner Type C, or B.II, differed chiefly in having a longer fuselage, balanced rudder and an 85 h.p. Hiero engine. This type was built by Lohner, Fischamend and Ufag with Series numbers 12, 74 and 12.41 respectively.

The third B type to enter service was the B.IV (Lohner Type E), which equipped several Fliegerkompagnien in 1915. It was powered by a 100 h.p. Mercedes D.I engine, had a further-extended fuselage and a neater undercarriage. It was the first B type to be properly armed, having a Schwarzlose machine-gun in the rear for use by the observer. Built by Lohner (Series 15) and Ufag (Series 15.51), the B.IV was of limited value to the Austro-Hungarian air service since it could only maintain its performance effectively at altitudes below 2,000 m. (6,562 ft.). Later, in 1915, the B.IV was followed by the B.VII (Lohner Type I), which had a much more powerful engine and a far better performance. This version was built by Lohner as Series 17 with the 150 h.p. Austro-Daimler, and by Ufag as Series 17.51 with the 160 h.p. Austro-Daimler. The rear-mounted Schwarzlose machine-gun was retained as standard equipment.

Although numerically earlier, the Lohner B.VI (Type H) did not enter service until 1916, after the appearance of the B.VII. Powered by a 145 h.p. Rapp engine, the B.VI had a shorter fuselage than its predecessors and lower wings of extended span. The sweepback of both upper and lower planes was reduced, and the interplane bracing simplified. The B.VI was built by Lohner as Series 16.10. The same basic airframe, with a 160 h.p. Austro-Daimler engine, was used in the construction of the Lohner C.I, or Type K. This entered service early in 1916 and remained in use throughout that year, being built by Lohner only as Series 18.

16 Albatros C.I

For the first few months of World War 1 the opposing forces in France carried out reconnaissance and observation of one another's troop movements and artillery concentrations by means of aircraft that carried no formal armament either for offence or defence. At best, they could defend themselves if attacked only by revolvers or rifles carried by the observer, and since he customarily occupied the front cockpit in tractor-type biplanes, he was prevented by the surrounding engine cylinders, wing struts and bracing wires from making very effective use of such weapons. However, in the spring of 1915 Germany introduced a new category of warplane, the armed 2-seat C class, which not only had more powerful engines but also transferred the observer to the rear position, where he had a much more effective field of fire to the sides, rear and above the aircraft, and armed him with a free-firing machine-gun.

One of the first such types to appear in service was the Albatros C.I. This aeroplane was, essentially, a slightly scaled-up version of the unarmed B.II, powered in its prototype form by a 150 h.p. Benz Bz.III engine. Apart from being better defended, by its ring-mounted Parabellum gun, the C.I also offered a better field of view to both crew members by virtue of a distinctive dual-curve cut-out in the upper trailing edge and rectangular cut-outs in the lower-wing roots. Standard production C.Is were 2-bay biplanes with 160 h.p. engines – either the Mercedes D.III or the Argus As.III. They were strongly built, and inherited the same fine stability and flying qualities that had characterised the earlier B.II. From late spring 1915 the Albatros C.I was used in substantial numbers, both on the Western Front and in Russia, chiefly for photographic or visual reconnaissance and artillery observation duties. It could also be used for light bombing, with a load of some 70 kg. (154 lb.) of bombs stowed vertically in a space between the two cockpits. The Albatros C.I's performance, for its time, was sufficiently good to permit it to be used aggressively, as well as on more passive duties, and among those who gathered valuable early fighting experience in Albatros-built C.Is were Oswald Boelcke and Manfred von Richthofen. Albatros-built C.Is could be distinguished by the prominent side radiators flanking the

front cockpit; the C.Ia, built by B.F.W. and L.F.G. (Roland), replaced these by a single leading-edge box-type radiator. Comparatively few C.Ias were built, as by this time the improved C.III was ready for production. However, a dual-control variant, the C.Ib, appeared in 1917, built by Merkur for the training role. It is not certain whether these were newly built aircraft or conversions of C.I/Ias, but after their replacement by more up-to-date Albatroses and other C types the C.I series continued to give useful service in the training role.

One C.I was built with an experimental 3-bay enlarged wing cellule and a long, communal cockpit; a standard C.I wing unit and undercarriage were also used in the construction of the experimental C.II early in 1916. This was a pusher type with a 150 h.p. Benz Bz.III, but did not go into production.

17 Lebed'-XI, XII and XIII

Vladimir Alexandrovich Lebedev learned to fly in France in 1909, and three years later became head of the PTA (Petersburg Aviation Company). Later, while still at St. Petersburg, the company was renamed as the Aktsionernoe Obitsestvo Vozdukhoplavaniya V.A. Lebedeva (V.A. Lebedev Aeronautics Company), its early products including licence-built versions of Deperdussin, Farman, Morane, Nieuport, Sopwith and Voisin designs for the Imperial Russian Air Service. Among these early aircraft was also the Lebed'-VII of 1915, a small 2-seat scout with a close resemblance to the Sopwith Tabloid; two examples of the Lebed'-VIII, of similar appearance to the Albatros B.II; and the Lebed'-IX, based on an L.V.G. design. During 1915 a captured Albatros B.II was sent to the Lebedev factory for evaluation, and from an amalgamation of the best features of this and the Lebed'-VIII there first emerged the Lebed'-XI, a 2-seat reconnaissance aircraft having a 47 ft. 6¾ in. (14·50 m.) wing span and, initially at least, a 150 h.p. Sunbeam engine.

Apart from a tendency to 'float' when landing, it was pronounced superior in most respects to the Albatros design, and it was presumably this criticism which led to the development of the Lebed'-XII, which first flew on 28 December 1915 and had the wing span reduced to 43 ft. 1¾ in. (13·15 m.). An order for two hundred and twenty-five Lebeds was placed on 19 April 1916, by the Central Military Technical Board, and it is known that two hundred and sixteen Lebed'-XIIs (plus a substantial quantity of spares) were completed. The remainder, possibly, were either Lebed'-XIs (or LM I twin-float equivalents), in which 150 h.p. Benz or Salmson engines were installed as powerplants.

The first production Lebed' (Type XI?) was flown on 4 August 1916, and service acceptance trials were completed some two months later. The Lebed'-XII was a 2-seat reconnaissance aircraft, armed with a single 7·62 mm. Colt machine-gun on a pillar mounting in the rear (observer's) cockpit and with

four racks for small bombs beneath the lower wings. Bomb load was of the order of 165–220 lb. (75–100 kg.), according to whether a 140 or 150 h.p. Salmson engine was installed. Both the bomb racks and the gun mounting of the early production aircraft were the work of Lebedev's chief designer, Schulnik, but were found unsatisfactory in service and were later replaced by fittings of Kolpakov design. Unfortunately, these were not the Lebed'-XII's only unsatisfactory features. The centre of gravity, especially when carrying a bomb load, was badly positioned, and combined with excessive wing flexing to create a marked tendency to go into dives from which recovery was often impossible; and the occupants were repeatedly overcome by fumes from the side-mounted radiators.

Modifications made during the summer of 1917, at which time about eighty Lebed'-XIIs had been delivered, led to the Lebed'-XIIbis (140 h.p. Hispano-Suiza V8 engine) and Lebed'-XIII (150 h.p. Salmson). The former offered no great improvement over its predecessor, but a contract for two hundred Lebed'-XIIIs was placed, though it is uncertain whether all were completed. Other 1917 variations on the Albatros/Lebed'-XII theme included the Lebed'-XVII, mounting a fixed, forward-firing gun for the pilot; and the Lebed'-XXIV, with either a 200 h.p. Hispano-Suiza or 230 h.p. Fiat engine. Between 1914 and 1917 inclusive the Lebedev factories (including new ones opened in 1917 at Penze and Taganrog) produced a total of six hundred and seventy-four aircraft of all types, including foreign designs and prototypes of the indigenous Lebed'-XIV and Lebed'-XVI twin-engined bombers.

18 Albatros C.III

Well and widely as the Albatros C.I series of biplanes served the Flieger Abteilungen, the C.IIIs which followed them were even more successful. As the C.I had been evolved from the B.II unarmed 2-seater, so the C.III was a similarly scaled-up version of the Albatros B.III, repeating the latter's curved tailplane and low-aspect-ratio fin. These revised tail surfaces improved the already excellent flying qualities of the aircraft, making it more stable longitudinally and better able to manoeuvre in combat with Allied fighters.

The C.III prototype, like that of the C.I, was powered by a 150 h.p. Bz.III engine, and this unit was installed in some production C.IIIs. The standard powerplant was the well-tried and thoroughly reliable Mercedes D.III of 160 h.p. The Albatros C.III was the most widely built Albatros C type, the production programme being shared between Albatros, O.A.W., D.F.W., Hansa, Linke-Hofmann, L.V.G. and Siemens-Schuckert. The Parabellum gun on a Schneider ring mounting in the observer's cockpit was a standard installation; most C.IIIs were also provided with a synchronised forward-firing Spandau gun on the starboard side of the engine block. The C.III went into service late in 1915, and it continued to serve on

the Western Front, in Macedonia and in Russia throughout 1916 and the early part of 1917. Its duties included visual and photographic reconnaissance; it could undertake light bombing duties with about 90 kg. (198 lb.) of bombs stowed internally between the cockpits. Without a bomb load, radio equipment could be installed in the C.III for use in artillery co-operation work. In addition to its pleasant handling qualities, the C.III was a compact, sturdily built aeroplane whose ply-covered fuselage enabled it to withstand a considerable amount of battle damage. After its withdrawal from front-line operations early in 1917 it continued to render useful service as a trainer until the end of the war.

Single examples were built in 1916 of the C.IV, which was basically a C.III airframe with a completely new single-bay wing cellule, and of the W.2, a twin-float version of the C.III, which was handed over to the German Navy in June. No series production of either version was undertaken. A few Albatros C.VIs were built: these had stronger but lighter C.III-type airframes fitted with 180 h.p. As.III engines, giving a slight improvement in overall performance.

19 **Dorand AR types**

Designed in 1916 by Capitaine Georges Lepère, chief designer of the Section Technique de l'Aéronautique, the AR 2-seat reconnaissance biplane was named after the S.T.Aé's director, Lt. Col. Dorand, who had issued the requirement for its development as a replacement for the Aviation Militaire's ageing Farman F.40s. Referred to variously as the AR.1 or ARL.1, the interpretation of its designation is obscure. The 'L' has been taken by some to indicate manufacture by the Letord company, though evidence to support this is conflicting, to say the least; an alternative, and plausible, explanation is that the prefix letters originally stood for 'Avion Renault' and later for 'Avion Renault ou Lorraine'. Major production was undertaken by the government-owned factory of the S.T.Aé. at Chalais-Meudon, near Paris; additional quantities are believed to have been produced by Farman Frères and, possibly, others. Flight testing was completed in the autumn of 1916, and the first AR.1A. 2s began to join operational French squadrons on the Western Front in the following spring, serving there until early 1918.

In all, AR.1s and/or AR.2s served with some eighteen French escadrilles, five of which also flew their Dorands on the Italian Front. The indications are that both aircraft warranted only a low priority in the demand for available powerplants, and Lt. Col. Dorand is on record as saying that they 'performed as well as could be expected, considering the engines installed'.

Normal powerplants of the AR.1 and AR.2 were, respectively, the 190 h.p. Renault 8 Bd or the 200 h.p. Renault 8 Gdy, with the 185 or 240 h.p. Lorraine-Dietrich (ARL.1 and ARL.2) as the usual alternatives, although other Renault

variants were also employed. Frontal radiators were fitted to the AR.1/ARL.1, and wing radiators to the AR.2/ARL.2. Both types had the pronounced backward wing stagger that characterised aircraft bearing the Dorand name, the AR.2 being somewhat smaller with a wing span of only 39 ft. 4½ in. (12·00 m.) and area of 484·4 sq. ft. (45·00 sq. m.). Bomb load of either type, carried in the fuselage, was of the order of 176 lb. (80 kg.), and armament comprised a single synchronised forward-firing Vickers machine-gun for the pilot and one or two Lewis guns, on a movable mounting in the rear cockpit, for the observer.

In 1917 the American Expeditionary Force ordered twenty-two AR.1s and a hundred and twenty AR.2s, delivery of these beginning in December 1917 and February 1918 respectively. From the beginning of 1918 until May or June of that year the Dorands flew on operational service with the 12th Aero Squadron of the A.E.F., until replaced by Salmson 2s; thereafter they were employed almost entirely for training duties, and were redesignated Type X in 1919. Many AR.1s and AR.2s gravitated to the French civil register after the war, some as 2/3-passenger transports with Compagnie Aérienne Française in France (which had about two dozen) and Réseau Aérien Transafricain (which had four); others were used for joy-riding or training flights.

20 **Rumpler C.I**

Although mainly concerned with the production of Taube monoplanes in the periods immediately before and after the outbreak of World War 1, the Rumpler Flugzeug-Werke also produced a 2-seat reconnaissance biplane, the B.I, with a 100 h.p. Mercedes D.I engine; about two hundred of these aircraft were built by Rumpler and Pfalz and served on the Eastern and Western Fronts in 1914–15. Early in 1915 Rumpler was one of the first German companies to produce a C type, the C.I, which was to become one of the longest-serving C types of the whole war. It was a well-built aeroplane, and intelligently designed to enable the crew to carry out their various duties with the maximum efficiency. The C.I went into production and service in 1915, its standard engine being the 160 h.p. Mercedes D.III with a semicircular radiator in the centre of the upper leading edge. Its 2-bay wings were slightly swept back, and had cut-outs in the lower wing roots to improve the view downward. An extensive production programme was undertaken by the parent company and the Germania, Hannover, Märkische and Albert Rinne factories. Early production C.Is were armed only with a Parabellum gun on a Schneider ring mounting in the rear cockpit, but a synchronised Spandau was fitted on later aircraft on the port side of the front fuselage. A subsequent version designated C.Ia was powered by the 180 h.p. Argus As.III.

The Rumpler C.I served on the Eastern and Western Fronts, in Macedonia, Palestine and Salonika. In all theatres it was an extremely

efficient machine, both for reconnaissance and for light 'nuisance' bombing raids with up to 100 kg. (220 lb.) of small bombs. Visual and photographic reconnaissance was carried out, except in the Middle Eastern theatres where the climate affected the photographic materials. In October 1916 there were two hundred and fifty Rumpler C.Is in service on all Fronts; the type was still in production for part of 1917 and some C.Is were still with front-line units as late as February 1918. Thereafter they were used on training duties, for which their pleasant handling and flying qualities made them eminently suitable; one batch was built especially for the training role by the Bayerische Rumpler-Werke with 150 h.p. Bz.III engines and no gun ring in the rear cockpit. A development, the Rumpler C.II, was projected, but apparently none were actually built.

21 D.F.W. C.V

The Deutsche Flugzeug-Werke's C.V, one of the finest German 2-seat types to be used during World War 1, was preceded in service by the C.IV of generally similar appearance. Authorities differ in regard to the extent in which the C.IV was produced, and its operational record was certainly overshadowed by that of the more widespread C.V. However, it is certain that among the two thousand three hundred and forty C types produced by D.F.W. during the war period the C.IV and C.V were the predominant models. The basic airframe, designed by Heinrich Oelerich, was common to both aircraft, the C.IV having a neatly installed 150 h.p. Benz Bz.III engine with a radiator mounted flush in the top wing. Its rudder and elevator surfaces were non-balanced, and the fin and tailplane structures were more triangular than those of the C.V. The C.IV first appeared in spring 1916 and was subsequently built by both D.F.W. and Aviatik for both German air services.

The C.V (factory designation T 29) was built by Aviatik, Halberstadt and L.V.G., in addition to the parent company. It differed principally in having the uprated Bz.IV engine (some later aircraft were fitted with 185 h.p. N.A.G. C.IIIs) and was at first fitted with Windhoff side radiators. A single box-type leading-edge radiator was fitted to later C.Vs, and the propeller was fitted with a small spinner. Tail contours were more rounded, and the elevator and rudder surfaces balanced. The C.V went into service on the Western Front in late summer 1916, subsequently appearing in Italy, Macedonia and Palestine. It continued to be used in France throughout 1917 and the early part of 1918, and about six hundred C.Vs were still in service on all Fronts when the war ended. The type handled well and was very popular with its crews, and its performance, at high or low level, was excellent for an aeroplane in its class. Its duties included artillery co-operation and infantry contact patrol, and visual and photographic reconnaissance. The C.V possessed a high degree of

manoeuvrability, and with an experienced crew aboard could outmanoeuvre even the late-war Allied fighters. Major J. T. McCudden, V.C., in his book *Five Years in the Royal Flying Corps*, admits having to give best to a D.F.W. that evaded his every attempt in his S.E.5a to shoot it down in 1917.

Of the C.Vs that fell into Allied hands at the time of the Armistice some twenty-five to thirty were acquired by Belgium, where the type was used for some time for pilot training. On 17 June 1919 a D.F.W. C.V established a world altitude record for an aeroplane of its class by flying to 9,620 m. (31,561·7 ft.). The C.VI, which appeared in 1918, remained a prototype only. This aircraft had a 220 h.p. Bz.IVa engine, overhung, balanced ailerons and a redesigned tail unit.

22 A.E.G. C and J types

In 1914–15 the Allgemeine Elektrizitäts Gesellschaft built a small series of unarmed reconnaissance and training biplanes under the designations B.I, B.II and B.III. The first C type (armed 2-seater) was the C.I, based on the B.II, powered by a 150 h.p. Benz Bz.III and having a Bergmann machine-gun in the rear cockpit. In autumn 1915 this was followed by the smaller C.II, a more compact aeroplane capable of carrying four 10 kg. (22 lb.) bombs. The C.III, which also appeared late in 1915, was apparently influenced by the Roland C.II, for it had a deep, clumsy fuselage that completely filled the interplane gap. No production of the C.III was undertaken.

The principal A.E.G. C type to appear was the C.IV, produced in 1916 to meet the need to expand German field reconnaissance and contact patrol units. Externally it generally resembled the C.II, but had wings of much greater span. Its 160 h.p. Mercedes D.III was enclosed in a typical A.E.G. cowling, with the cylinders exposed and a large 'rhino horn' exhaust manifold rising well clear of the top wing. More attention was evidently paid to its structure than to its streamlining, for Allied reports on captured machines commented favourably on the high standard of welding in its steel-tube airframe. The C.IV entered service in early spring 1916, mainly on escort and reconnaissance duties, and a small number were still operational when the war ended. They were armed with a single Spandau gun offset to starboard in front of the cockpit, with a Parabellum gun on a Schneider ring mounting for the observer; the latter could accommodate up to 90 kg. (198 lb.) of bombs in his cockpit. The only figures available apply collectively to all A.E.G. armed 2-seaters; these record a total output of six hundred and fifty-eight C types, and a peak employment of one hundred and seventy at the Front in June 1917. Probably about five hundred of these would have been C.IVs. Variants included the C.IVN night bomber with longer-span wings, a Bz.III engine and a carrying capacity of six 50 kg. (110 lb.) bombs; it

appeared in 1917. The C.V and C.VII both appeared in 1916, the former having a 220 h.p. Mercedes D.IVa and the latter a Mercedes D.III and sweptback upper wings of smaller span. The C.VIII, appearing in July 1917, had an even shorter span, an improved cowling for its Mercedes engine and redesigned tail surfaces. It was also seen in triplane form later in the year.

The major variant, based on the standard C.IV airframe, was that produced for armoured ground-strafing duties from early 1918. The engine and crew positions were encased in some 390 kg. (860 lb.) of armour plating, and to power this heavier machine a 200 h.p. Bz.IV was installed. Initial version was the J.I; with small, lower-wing ailerons added this became the J.Ia; and with balanced, overhung top ailerons, elevators and rudder it was known as the J.II Six hundred and nine A.E.G. J types were built, but they were not an outstanding success. Instead of the normal forward-firing gun, these aircraft had twin Spandaus mounted in the floor of the rear cockpit to fire forward and downward at about 45 degrees; but the guns were difficult to aim properly when the aircraft was flying low. At least one machine flew experimentally as a single-seater, with six of these downward-firing guns.

Production of the C.IV was subcontracted to Fokker, who may have built some of the C.IVa machines reported to have had 180 h.p. Argus As.III engines.

23 **Halberstadt C.V**

Two principal types were employed by the German Air Force in 1918 for photographic reconnaissance work: of these, the Rumpler C.VII was undoubtedly the superior machine, but its companion, the Halberstadt C.V, was also built and used in substantial numbers. The Halberstadt company's previous C types began with the C.I, a 1916 adaptation, with a rotary engine, of the unarmed B.II. It is doubtful whether this went into production. The C.III, which appeared late in 1917, was the first long-range photographic type designed by Karl Theiss. It was powered by a 200 h.p. Benz Bz.IV and an unusual feature of its design was the attachment of the lower wings to a small 'keel' on the underside of the fuselage. The C.III formed the basis for the C.V, in which a simpler and more conventional attachment was employed for the lower wings.

Powerplant of the C.V was the high-compression version of the Bz.IV developing 220 h.p. and giving a much better performance at altitude. The wings were of wide span, with 2 bays of bracing struts and overhung, balanced ailerons on the upper sections. The fuselage was essentially a scaled-up version of that used in the C.IV, but with separate cockpits for the 2-man crew. Reconnaissance cameras were aimed downward through a trap in the floor of the rear cockpit; the top of the cockpit was built up with the traditional ring mounting for a Parabellum machine-gun. The pilot was furnished with a synchronised

Spandau gun immediately in front of his cockpit on the port side; C.Vs also normally carried wireless equipment. The prototype C.V appeared early in 1918, undergoing its official trials in the spring. Its front-line career lasted from summer 1918 until the Armistice. Production was undertaken by the Aviatik, B.F.W. and D.F.W. companies in addition to those built by Halberstadt.

Variants appearing during 1918 included the C.VII, C.VIII and C.IX. The C.VII (245 h.p. Maybach Mb.IV) and C.IX (230 h.p. Hiero) remained in the prototype stage, though the latter may have been intended for Austro-Hungarian production. The C.VIII, officially tested in October 1918, was a single-bay biplane, slightly smaller than the C.V and powered by an Mb.IV engine; it had a ceiling of 9,000 m. (29,528 ft.), which it could reach in 58 minutes, and was probably intended for series production if the war had continued; however, only the prototype had been completed when the war ended.

24 **Rumpler C.IV to C.VII**

The C.IV, the second of Dr. Edmund Rumpler's C type designs to go into large-scale production, was preceded by the generally similar C.III, seventy-five of which were recorded in service in February 1917. The C.III was a 1916 design, powered by a 220 h.p. Benz Bz.IV. When the more powerful Mercedes C.IVa became available it was developed into the C.IV, which was one of the most efficient, as well as most elegant, German 2-seaters to appear on the Western Front. It had the staggered, sweptback wings of 'libellule' planform that characterised subsequent Rumpler C types, and its horizontal tail surfaces were of 'wing-nut' shape. The fuselage was reasonably well streamlined, with attention paid to nose-entry in the neat cowling of the 260 h.p. D.IVa engine and the small conical spinner over the propeller hub. In place of the small, comma-type rudder of the C.III, the C.IV's vertical tail surfaces were of the triangular fin and plain rudder form used on the earlier C.I. The Rumpler C.IV carried the normal 2-seater armament of the period, i.e. a forward-firing synchronised Spandau gun and a ring-mounted Parabellum. The reconnaissance cameras were aimed through a trap in the floor of the rear cockpit. Light 'nuisance' raids were often undertaken, with a small load usually consisting of four 25 kg. bombs on underwing racks. The C.IV had an excellent performance for an aeroplane in its class, especially at high altitude; it could climb to 5,000 m. (16,404 ft.) in 38 minutes, and at its maximum altitude was still fast enough to elude Allied fighters. Rumpler C.IVs saw service in Italy and Palestine as well as on the Western Front; they were built by the Bayerische Rumpler-Werke and Pfalz Flugzeugwerke, those built by the latter concern having linked double ailerons.

The Rumpler C.V was a variant of the C.III airframe fitted with a Mercedes D.IVa, but apparently it did not go into production. There

is no record of a C.VI, the next production version being the C.VII, which appeared late in 1917. The C.VII had a 240 h.p. Maybach Mb.IV engine which, although of a lower nominal rating, had a higher compression ratio than the Mercedes D.IVa that enabled it to maintain its output at greater heights. The C.VII was slightly smaller than the C.IV; it was built in two standard forms, the long-range reconnaissance version with radio equipment and a normal 2-gun armament and the C.VII (Rubild). In the latter version the front gun was dispensed with, and instead the aircraft carried additional photographic gear and oxygen breathing apparatus for the crew members, who were also provided with electrically heated flying suits. These assets were extremely necessary, for the C.VII (Rubild) could fly to, and maintain its speed at, even greater heights than those reached by the C.IV. Service ceiling of the C.VII (Rubild) was 7,300 m. (23,950 ft.), which it could reach in 50 minutes. At heights in the region of 20,000 ft. (6,000 m.) it could fly as fast as such Allied fighters as the S.E.5a. Both the Rumpler C.IV and C.VII remained in German Air Force service until the Armistice.

25 L.V.G. C types

Like many other German manufacturers, the Luft-Verkehrs Gesellschaft built a small series of B type unarmed 2-seaters during the early part of World War 1 which formed the basis for armed reconnaissance aircraft when the C category was introduced in spring 1915. The L.V.G. C.I, based on the B.I, has the distinction of being the first 2-seat operational German aircraft in which the observer was provided with a Schneider ring mounting and a Parabellum machine-gun. The first four L.V.G. C types were designed by Franz Schneider. Only limited production was undertaken of the C.I (150 h.p. Bz.III), this being followed late in 1915 by the C.II, the basis for which was the unarmed B.II. The L.V.G. C.II was produced in substantial numbers by the parent company, and by the Ago and Otto works, and was powered by a 160 h.p. Mercedes D.III. It was used extensively for visual and photographic reconnaissance work, and also for light bombing. One aircraft of this type made an audacious daylight raid on London on 28 November 1916, dropping six 10 kg. bombs on Victoria railway station. The raid was not an unqualified success, since the aircraft was obliged to force-land in Allied territory on the return journey. In spring 1916 there were some two hundred and fifty C.I/C.II types in service and some late-production C.IIs had a forward-firing Spandau gun in addition to the usual Parabellum. It is thought that only one example of the C.III was completed, a smaller but slightly heavier version of the C.II in which the observer occupied the front seat. An enlarged version of the C.II appeared in 1916: this was the C.IV, powered by a neatly cowled 220 h.p. Mercedes D.IV and having a balanced rudder.

A major step forward in design and performance was made with the appearance in mid-1917 of the L.V.G. C.V. This was later to serve in considerable numbers alongside the D.F.W. C.V; the external resemblance of these two types to one another is explained by the fact that the engineer responsible for the L.V.G. machine was formerly the chief designer of D.F.W. Among the largest German 2-seaters to be used during the war, the L.V.G. C.V was a neat, compact aircraft with 'libellule' shaped wings and overhung upper ailerons. It had a neatly installed 200 h.p. Benz Bz.IV engine with a leading-edge box-type radiator, and a spinnered propeller. Armament consisted of a single forward-firing Spandau gun and a rear-mounted Parabellum, and up to 115 kg. (254 lb.) of bombs could be carried beneath the lower wings. The C.V was in widespread use by autumn 1917, eventually serving in Palestine as well as on the Western Front. It was an excellent all-rounder, being used for artillery observation, photographic reconnaissance and light bombing. It usually operated with an escort, although it was quite able to give a good account of itself in combat when necessary.

In 1918 the C.V was joined by the C.VI, of which about one thousand were built by L.V.G. The C.VI incorporated a number of modifications, apparently designed both to improve performance and to simplify production. It had a deeper, slightly smaller fuselage, in which the engine was less neatly cowled, and the propeller had no spinner. The wings, which were slightly staggered, had plain ailerons and a flush-mounted centre-section radiator. This last feature, which could be hazardous for the occupants if punctured during combat, was replaced in some aircraft by Windhoff radiators on the sides of the fuselage. The crew members' view from their respective cockpits was considerably better in the C.VI than in the C.V, where their outlook was restricted by a confusion of cabane struts, engine cylinders and radiator. Larger and rounder horizontal tail surfaces were also fitted to the C.VI. A variant of the C.VI which appeared in 1918 was the C.VIII; apparently only one was completed, with a high-compression Bz.IVü engine of 240 h.p., linked double ailerons and other minor improvements.

26 Albatros C.V, C.VII, C.X and C.XII

Up to and including the C.IV, the early Albatros C types were fundamentally descendants of the unarmed B series designed by Ernst Heinkel. The first entirely newly designed C type was the C.V, the joint handiwork of Thelen and Schubert. Appearing in spring 1916, it utilised a wing cellule resembling, but slightly larger than, that of the Albatros C.III, but the new cigar-shaped fuselage, spinnered propeller and rounded tail unit reflected the same approach to streamlining as that practised on the early Albatros single-seat fighters. The C.V was powered by an almost fully cowled

220 h.p. Mercedes D.IV with, in the original C.V/16 form (i.e. built in 1916), prominent Windhoff radiators on either side of the front fuselage. It was fitted with a synchronised Spandau machine-gun for the pilot, mounted on the starboard side of the engine, with a ring-mounted Parabellum gun in the observer's cockpit. A bomb load of up to 175 kg. (386 lb.) could be carried. The C.V/16 was not a particularly elegant aeroplane, and was a cumbersome one to fly; in this respect the C.V/17 was some improvement, having a flush-mounted wing radiator, balanced and tapered ailerons on the top wings and elliptical tips to the lower ones. Four hundred and twenty-four C.Vs were completed by Albatros, but only a fraction of these were in service at any one time between early spring 1916 and the beginning of 1917. Apart from their indifferent flying qualities the C.Vs were repeatedly beset by engine crankshaft failures, and when production of the D.IV engine was abandoned, that of the Albatros C.V also came to an end. One C.V/16 was built experimentally with clumsy I-type interplane struts, but these did not improve the type's performance.

The next production Albatros C type was the C.VII, which went into service late in 1916. Albatros had in mind a C.V development using the 260 h.p. Mercedes D.IVa engine, but pending the availability of this powerplant the C.VII was produced as an interim measure for long-range reconnaissance and artillery observation. It was powered by a 200 h.p. Benz Bz.IV, installed in typical Germanic fashion with the cylinder heads exposed, and the airframe was a mixture of C.V/16 and C.V/17 components. The lower wings and side radiators of the C.V/16 were combined with the upper wings of the C.V/17. Like other compromise designs before it (and since), the C.VII flew and fought very well, and was successful enough to be built in considerable numbers. It was still in service late in 1917, its peak period of employment having been in February of that year when three hundred and fifty were in service on all Fronts. Production of the C.VII was shared between Albatros, O.A.W. and B.F.W.

In mid-1917 the fully developed version of the C.V appeared in the form of the C.X, powered by the long-awaited Mercedes D.IVa engine. The C.X was appreciably larger than its predecessors, and showed even greater similarity of outline to the Albatros D types. The flush-mounted wing radiator was reinstated in new wings of increased span with double ailerons. With these aerodynamic improvements and the greater power and reliability of the D.IVa engine, the C.X had an excellent altitude performance and usually carried oxygen equipment for the crew in addition to wireless and/or a light bomb load. Production was shared between the parent company, O.A.W., Linke-Hofmann, B.F.W. and L.F.G. (Roland), and by October 1917 there were three hundred C.Xs in service. The type remained with front-line reconnaissance and artillery co-operation units until mid-1918.

The Albatros C.XII (the C.XI remained a project only) appeared early in 1918 as a successor to the C.X, and continued to serve until the Armistice. In this ultimate form it could probably claim to be the most handsome German 2-seater on the Western Front, its elegant, rakish lines and the addition of a small fin beneath the rear fuselage emphasising still more the design resemblance between the Albatros C and D types. The final production Albatros C type was the C.XV, evolved from the C.XIV prototype of 1917. This was a smaller and much less elegant aeroplane, with a hump-backed fuselage, short-span staggered wings and a 220 h.p. Bz.IVa engine. It went into production in 1918, but only a few had entered service when the war ended.

Post-war designations of the C.V, C.VII, C.X, C.XII and C.XV were, respectively, L.14, L.18, L.25, L.27 and L.47.

27 L.F.G. (Roland) C.II

The Roland C.II 2-seater was an extremely advanced design, and one of the best German aircraft on the Western Front during the second half of 1916. It was the smallest C type used by Germany during the war period, being less than 50 kg. (110 lb.) over the weight limit for the lighter CL category. The design, by Dipl. Ing. Tantzen, featured an extremely strong, ply-covered semi-monocoque fuselage, beautifully streamlined and completely filling the interplane gap. The wings had a single 'I' srut and a minimum of external bracing wires. An excellent view of the upper hemisphere was enjoyed by both crew members, but the view downward past the nose, already poor, was restricted further by the large side radiators, and made the C.II a difficult aeroplane to land.

The first C.II was flown in October 1915, but the first handful of production aircraft were not delivered until March 1916 and had only a rearward-firing Parabellum gun in the observer's cockpit. Some squadrons met the need for a forward-firing gun by installing captured Lewises above the centre-section, but on later C.IIs a fixed, synchronised Spandau was provided. The first C.IIs in service were flown by the Kampfgeschwadern involved in the fighting at Verdun and the Somme in spring 1916, and their performance was well above that of contemporary German 2-seaters. In fact, the Roland C.II was as fast as the opposing Nieuport and Pup fighters, although it was less manoeuvrable and took half an hour to reach its fighting altitude of 3,000 m. (9,843 ft.). A number were lost in landing accidents due to the poor frontal view, and some weakness was found in the outer wing sections. This led to the introduction, from August 1916, of the C.IIa, with revised and reinforced wingtips. Late in 1916 the C.II was used for night bombing with four 12·5 kg. (28 lb.) bombs beneath the fuselage. In mid-year Capt. Albert Ball, who scored his first confirmed victory over a Roland

C.II, had called it 'the best German machine now', yet it never served at the front in outstanding numbers; the Roland's meticulous streamlining demanded careful and therefore costly constructional methods, which restricted the total built. Peak employment of the C.II/IIa came in December 1916, when sixty-four were at the Front. It was withdrawn slowly during the first half of 1917, after which the majority were employed for training, though some were retained for combat duty on quieter sectors of the Western Front and in Russia. Total production is estimated at between two hundred and fifty and three hundred, some two hundred of these by the parent company and the remainder by Linke-Hofmann. Some late-production aircraft had an enlarged vertical tail. In 1916 a single C.III was produced: this was a C.II development with 2-bay wings, parallel interplane struts, revised tail surfaces and a 200 h.p. Benz Bz.IV engine.

28 **Phönix C.I**

As explained in the description of the Ufag C.I (page 125), that aircraft and the Phönix C.I 2-seaters which appeared in Austro-Hungarian service in 1918 shared a common descent from the Hansa-Brandenburg C.II 'star-strutter' designed by Ernst Heinkel in Germany. Both were chosen for production, the Phönix machine in Series 121, and aircraft 121.01 and 121.02 were utilised as prototypes. They differed principally in their cabane strutting and radiator positions, and 121.02 was subsequently brought up to production standard with a centrally mounted 'Hifa' radiator in the top leading edge. Production Series 121 aircraft were powered by 230 h.p. Hiero engines and, except for the additional crew position, bore a strong resemblance to the Phönix D.I fighter. The unequal-span wings had distinctive, backward-curving tips and were braced by parallel pairs of 'V' struts. The deep, narrow fuselage left a minimum of gap below the top wing, thus giving the pilot an excellent view forward and upward. From the elevated gun position in the rear cockpit the observer also had a first-class field of view and of fire. Armament consisted of a synchronised forward-firing Schwarzlose machine-gun under the port-side engine panels, firing through an aperture in the front of the cowling; a second free-firing Schwarzlose gun was installed in the rear cockpit. A modest bomb load of 50 kg. (110 lb.) could be carried beneath the lower wings. The Phönix C.I went into service in spring 1918 and was used until the end of the war on both visual and photographic reconnaissance work. About one hundred and ten were built for the Fliegerkompagnien. They were somewhat slower than the Ufag 2-seaters, but had better take-off characteristics, climbing powers and performance at altitude.

After the war thirty aircraft of this type were built in Sweden by the Army Aircraft Workshops at Malmslatt, with 220 h.p. Benz Bz.IV engines in place of the Austrian powerplants. They went into service early in 1919 with the Royal Swedish Army Aviation under the title S 21 Dront and continued to be used until well into the 1920s.

29 **Ufag C.I**

Examples of the Hansa-Brandenburg C.II 2-seat 'star-strutter' designed by Ernst Heinkel were completed in Austro-Hungary in 1916 by both the Phönix Flugzeugwerke and the Ungarische Flugzeugfabrik A.G. Each company developed its own C.I derivative of this aeroplane, which were flown in comparative trials in January 1917. Both were powered by 230 h.p. Hiero engines; the Ufag C.I differed from its compatriot in having parallel interplane struts, equal-span, round-tipped wings with a moderate stagger and a squarish, balanced rudder. Each aircraft had an elevated gun ring in the rear cockpit for a single Schwarzlose machine-gun.

Flight trials revealed that each aircraft had some features superior to the other, and it was finally decided to put both into production. The Ufag C.I had a somewhat poorer ceiling and take-off than the Phönix, but it was appreciably faster and more manoeuvrable. Consequently, in service, while both types carried out general observation duties, the Ufag was used for lower-level missions such as artillery co-operation, while the Phönix C.I, with its higher ceiling, was chosen for photographic reconnaissance. In its production form the Ufag C.I had a smaller tailplane, and a plain rudder with a triangular fixed fin that improved the aircraft's directional stability. One or two synchronised forward-firing guns could be mounted in the front of the fuselage. Possibly because of production priority afforded to the Phönix single-seat fighters, the two C types did not go into service much before spring 1918, but for the remaining period of the war they carried out useful work and a small batch of Ufag C.Is were supplied to Romania after the war ended. It may be supposed that the Ufag was considered the better machine, since it was also manufactured under licence by Phönix as well as by the parent company. Phönix-built Ufag C.Is, at least thirty-six of which were completed, were designated Series 123, while Ufag's own machines were known as Series 161; more than one hundred were built by Ufag.

30 **Anatra D and DS**

The first major task of the Anatra aircraft factory at Odessa was the production of Voisin-type bombers. Based on the Voisin LA.S, with local modifications designed by Lt. V. Ivanov of the Imperial Russian Air Service, up to one hundred and fifty of these aircraft were built with the designation VI (Voisin Ivanov) with 150 h.p. Salmson (Canton-Unné) engines between March 1915 and March 1916. Unfortunately they were a wretched failure, many crashes occurring due to extremely poor stability and a lack of lateral control; a modified version was test-flown by Ivanov early in 1917 and

received qualified approval, but the crashes continued and the VI was finally dismissed as 'quite unfit for fighting purposes'.

Early in 1916 Anatra produced a design of its own, the Type D, a 2-seat reconnaissance tractor biplane with a 100 h.p. Gnome Monosoupape engine. An initial order for eighty Anatra Ds, placed in April 1916, was supplemented by later orders for a further seven hundred. The first of them went into service that summer, when inevitably they inherited the unfortunate reputation of the VI. This they did not deserve, although they were variously reported as being nose-heavy and liable to lose power due to inefficient engine cooling. A shortage of raw materials, particularly good-quality timber, led to makeshift constructional methods which caused many machines to break up in the air when flown under combat conditions. Production was curtailed after only two hundred and five Anatra Ds had been completed. Their peak period of employment came in spring 1917: seventy-six were at the Front in April, but this figure had dwindled to forty by June and the type disappeared from front-line service by the end of the year. Despite its shortcomings, a well-built Anatra D in the hands of a competent pilot was by no means an unsatisfactory aeroplane. It could climb to 2,000 m. (6,560 ft.) in 15 minutes, and was armed with one or two defensive machine-guns.

The Russian aircraft industry was always hampered by aero-engine supply problems, and some Anatra Ds were fitted with 130 h.p. Clerget rotary engines.

A developed version which appeared in service from mid-1917 was the Anatra DS, with a 150 h.p. Salmson (Canton-Unné) radial engine (which gave it its popular name of 'Anasal'). The DS was armed with a synchronised forward-firing gun and a ring-mounted gun in the rear cockpit. Production of the DS was curtailed by the November Revolution, by which time about a hundred had been completed.

31 Junkers J.I

The J.I, which must vie with the Airco D.H.6 as the most angular aeroplane of World War 1, was the only one of Hugo Junkers' many all-metal aircraft of the war period to be completed as a biplane. It was evolved to replace the interim A.E.G. and Albatros J types for infantry contact patrol and support duties with the Flieger Abteilungen, and made its first flight early in 1917. As such, its function was to fly at low level over the trenches and forward infantry positions to report troop concentrations and movements by means of a W/T link; and its metal construction afforded it excellent protection from ground fire, which was often heavy. The 5 mm. armoured shell which enclosed the 200 h.p. Benz Bz.IV engine and the crew positions alone weighed some 470 kg. (1,036 lb.), and in later examples the rear fuselage section was also metal-skinned. Other distinctive features of the design included the enormous span

of the upper wings and the uncommonly short-legged undercarriage.

Production J.Is differed from the prototype in having overhung, balanced ailerons and rudder and a redesigned vertical fin. The airscrew spinner was frequently omitted from aircraft in service, some of which carried a camera in the rear of the fuselage. Manufacture of J.Is was shared between the Junkers and Fokker factories: a total of two hundred and twenty-seven were built, the first being completed in October 1917. They entered service at the beginning of 1918, and soon proved efficient at their job. Frequently the J.Is would drop ammunition and food supplies to their own forward troops during the course of a mission. The J.I's size and weight necessitated long take-off and landing runs, and it was rather heavy to handle – factors which led the J.I to be nicknamed Möbelwagen (Furniture Van). Nevertheless, its crews appreciated its strength and the protection it offered, and it was generally regarded as the best German armoured type to appear during the war. Usual armament consisted of two Spandau machine-guns installed under the front engine decking, with a single ring-mounted Parabellum gun in the rear cockpit. Early in their service some J.Is carried, instead of W/T equipment, two extra downward-firing Parabellum guns, manned by the observer, but it was found difficult to aim these successfully at low level while the aircraft was flying fast, and the practice was soon abandoned. At the peak of their employment one hundred and eighty-nine Junkers J.Is were in service at the Front.

32 Ansaldo S.V.A. series

The outstanding S.V.A. biplanes that rendered such excellent service to the Italian Air Force in the final year of World War 1 were largely the handiwork of Umberto Savoia and Rudolfo Verduzio. The design was begun in 1916 as a single-seat fighter, its development being undertaken by Ansaldo as a private venture. However, it showed such promise that, with massive backing from the Italian government, the Ansaldo company was able to expand to such an extent that the S.V.A. series became the second most widely built Italian type of 1914–18.

The S.V.A. prototype, which flew for the first time on 3 March 1917, was an elegant machine with a slender, ply-covered fuselage and thin-section wings braced with a Warren-type interplane truss. It had a range, speed and climb far in excess of any other aircraft in Italian service at that time, but because it lacked the manoeuvrability of the contemporary Hanriot HD.1 the Italian Air Force decided instead to employ it in the reconnaissance and light bombing roles. Production began in autumn 1917, the first Ansaldo-built version apparently being the S.V.A.4, which entered service in February 1918. (A short-span version built by A.E.R. was designated S.V.A.3; it was used in small numbers for home defence and occasional reconnaissance from spring 1918.) The

S.V.A.4 was powered by a 220 h.p. S.P.A. 6A engine and carried a usual armament of twin forward-firing synchronised Vickers guns; one of the guns could be omitted when a reconnaissance camera was installed. A seaplane version was known as the I.S.V.A.

The major single-seat version was the S.V.A.5, with minor variations and the same powerplant as the S.V.A.4. The two types were soon in use, both for bombing raids across the Alps to Austria and Germany and along the length of the Adriatic. They also provided much extremely valuable photographic intelligence during the summer and autumn campaigns in 1918 which led to the Austrian surrender. A few S.V.A. landplanes formed part of the mixed equipment of one Italian naval squadron, being evaluated as potential torpedo bombers, and fifty twin-float I.S.V.As. were produced in 1918 for defending naval bases and patrolling the Italian coastline.

Alternative engines tested in the S.V.A. during 1917 included the 220 h.p. Lorraine-Dietrich and the 250 h.p. Isotta-Fraschini V-6. The latter unit was chosen for two 2-seat variants that appeared in 1918. These were the S.V.A.9, an unarmed trainer, and the S.V.A.10, for reconnaissance and bombing. The S.V.A.10, which entered service around August/September 1918, carried a single forward-firing Vickers gun and a Lewis gun on a flexible mounting in the rear cockpit.

The S.V.A.'s long-range capabilities were demonstrated repeatedly during the final months of the war; in September 1918 the prototype made a flight of 900 miles (1,448 km.) non-stop. In February 1919 two S.V.As. (of seven starters) completed an 11,250 mile (18,105 km.) flight from Rome to Tokyo in 109 flying hours. By the end of 1918, one thousand two hundred and fifty had been built (including I.S.V.As.), and this total had increased to two thousand before production ended in 1928. The S.V.As. remained in Italian service for many years, both at home and in North Africa. In 1923 six squadrons were still equipped with them, and they did not finally pass out of service until the mid-1930s. Many were used by Italian civil flying schools and clubs in the 1920s; others were flown as sporting and racing aircraft in Italy and the United States; and military S.V.As. were exported to Argentina, Ecuador, Peru and Latvia.

33 **S.I.A. 7 and 9 and Fiat R-2**

The Società Italiana Aviazione of Turin, a subsidiary of the famous Fiat motor-car building concern, was occupied during the first year or two of Italy's involvement in World War 1 with the production of foreign aircraft under licence. However, in 1917 it produced a native design, by Savoia and Verduzio (who also designed the Ansaldo scouts). This was the S.I.A. 7B, a 2-seat armed reconnaissance biplane powered by a 260 h.p. Fiat A-12 engine. As the S.I.A. 7B.1 it entered service with the Corpo

Aeronautica Militare in November 1917, and was armed with a Revelli machine-gun on a Nieuport-type mounting in the rear cockpit with a second gun of the same type mounted over the top wing to fire forward outside the propeller arc. A light bomb load of some 60 kg. (132 lb.) could be carried beneath the lower wings. The S.I.A. 7B.1 was a manoeuvrable aeroplane, with good level and climbing speeds, but its career was marred by a succession of structural failures of the wing cellule, which resulted in the type being withdrawn from front-line service in July 1918. Five hundred and one S.I.A. 7B.1s were built; two were sent to the United States for evaluation in 1917, and in February 1918 the A.E.F. purchased a further nineteen for use on the Italian Front.

A later and supposedly stronger version, the S.I.A. 7B.2, was powered by the 300 h.p. Fiat A-12bis, and had the rear fuselage deepened in order to bring the two cockpits on a level with the top of the engine cowling. This considerably improved the crew members' field of view compared with the S.I.A. 7B.1, in which the high engine decking seriously obstructed the view to the front. The S.I.A. 7B.2 inherited the same speed, climbing and endurance powers of its predecessor, and one aircraft of this type flew non-stop from Turin to London, a distance of some 1,200 km. (746 miles). Unfortunately it also inherited the same wing weaknesses that had plagued the 7B.1, and both types were withdrawn from the front line at the same time. The S.I.A. 7B.2 had been in service for only about two months, and only seventy-one of these aircraft were built.

An enlarged bomber/reconnaissance development flew for the first time late in 1917. This was the S.I.A. 9B, also a 2-seater, but powered by the large 700 h.p. Fiat A-14 and capable of carrying a 350 kg. (772 lb.) bomb load. The S.I.A. 9B was in service by February 1918, but despite its useful performance with a reasonable war load, it, too, was subject to the same structural weaknesses as the earlier models. The Italian Army air service refused to operate it, and only sixty-two S.I.A. 9Bs, of five hundred ordered, were completed. These flew with three squadriglie of the Italian Navy.

The weakness of the basic design was finally overcome in 1918, after S.I.A. had become Fiat Aviazione, and the airframe was redesigned by Celestino Rosatelli. The result was the Fiat R-2, a much improved and slightly smaller form of the S.I.A. 7B.2, retaining the same powerplant and having provision for single or twin Lewis guns in the rear cockpit in addition to the wing-mounted Revelli gun. Five hundred R-2s were ordered, entering production in autumn 1918, but only one hundred and twenty-nine were completed by the Armistice. The Fiat R-2 thus saw little operational service during World War 1, but it continued as a standard reconnaissance and bomber type with the post-war Italian Air Force until 1925.

34 Pomilio P types

The most widely produced aircraft of Italian design during World War 1 were the P series of armed 2-seaters built by the Fabbrica Aeroplani Ing. O. Pomilio of Turin during 1917–18. The first of these to enter service (in March 1917) was the PC, powered by a 260 h.p. Fiat A-12 in a rather Germanic cowling that left the cylinder heads exposed. Pilot and observer sat in close-mounted, separate cockpits, the former having a Revelli machine-gun fixed over the top wing to fire at an angle outside the propeller arc, and the latter with another Revelli on a Nieuport-type mounting. The PC was fast enough to dispense with fighter escort on its reconnaissance missions, but it suffered from pronounced instability, which was the cause of frequent accidents. To eliminate this the next model, the PD, introduced a small, curved underfin incorporating the tail-skid; other changes included a revised engine cowling, in which the cylinder heads were enclosed in louvred panels, and a box radiator in front of the top wing replacing the vertical radiator in front of the PC's cockpit.

By far the most successful variant was the PE, which went into service in February 1918. This had a 300 h.p. A-12bis engine with a frontal radiator, a slightly enlarged upper fin and a bigger tailplane. The PE was armed with a synchronised, forward-firing machine-gun and a Scarff ring in the rear cockpit for one or two Lewis guns. It could climb to 3,000 m. (9,843 ft.) in 16 minutes.

The Pomilio P types flew with thirty squadriglie of the Corpo Aeronautica Militare, of which eighteen squadriglie had PDs or PEs during 1918. One hundred and twelve PEs were marshalled for the Battle of Vittorio Veneto on 20 October 1918. Total output of the three types reached one thousand six hundred and sixteen: five hundred and forty-five PCs and PDs during 1917, and one thousand and seventy-one PDs and PEs during 1918. Final variant was the PY, generally similar to the PE but with squared-off top decking to improve the observer's field of fire; only seven PYs were built. The Pomilio brothers then sold their business to Ansaldo and emigrated to the United States, where they continued their aeronautical activities. They designed two types evaluated by the U.S. Signal Corps, the FVL-8 and BVL-12. The former was a single-seat fighter with a 280 h.p. Liberty 8 engine, the latter a 2-seat bomber with a 400 h.p. Liberty 12. Six FVL-8s and five BVL-12s were completed.

35 S.A.M.L. S.1 and S.2

The German Aviatik B.I armed 2-seater was the subject of extensive licence production in Italy during World War 1. The first three versions to appear were designated A.1 (100 h.p. Fiat A-10), A.2 (120 h.p. Le Rhône) and A.3 (110 h.p. Colombo). The majority, however, were powered with 140 h.p. Salmson (Canton-Unné) radial engines, but 160 h.p. Isotto-Fraschini V-4Bs were installed in some late-production examples. Five hundred and

sixty-eight Aviatiks were built in Italy during 1915–18, and four hundred and ten of these were completed by the Società Aeronautica Meccanica Lombarda of Monza. Until early 1917 these were employed extensively by the Italian reconnaissance squadrons; thereafter they were transferred to training duties, on which they continued to serve until 1930.

From the beginning of 1917 they began to be replaced in the reconnaissance role by an Italian product, the S.A.M.L. S.1, designed by the Swiss engineer Robert Wild, who had previously been responsible in Germany for the Aviatik B.I and B.II. The S.A.M.L. S.1 was basically an enlarged, 3-bay development of the Aviatik, with a 260 h.p. Fiat A-12 engine and a rotatable 6·5 mm. Revelli machine-gun on a tripod mounting in the rear cockpit. The S.1 was primarily a reconnaissance type, though it could carry up to 40 kg. (88 lb.) of small bombs. It served principally with the I Armata of the Corpo Aeronautica Militare at Trentino on artillery-spotting and occasional bombing duties. From the summer of 1917 it was joined in service by the S.2, which had shorter-span, 2-bay unstaggered wings with dihedral on the lower planes; a fully curved rudder in place of the flat-topped rudder of the S.1; and a second Revelli machine-gun mounted over the top wing to fire at an angle outside the propeller arc.

The S.A.M.L. 2-seaters were strongly built, reliable aircraft with good handling qualities, and were well liked by the crews who flew them. Between 1916 and 1918 six hundred and fifty-seven S.1s and S.2s were completed, serving with sixteen Squadriglie da Ricognizione in Italy, Albania and Macedonia. Some S.2s carried camera equipment instead of a bomb load, and others were fitted with dual controls and employed for training. The first S.2s had the same powerplant as the S.1, but in later machines the more powerful 300 h.p. A-12bis was installed. Some aircraft of this type survived the war and later saw action again during Italy's military campaigns in North Africa.

36 Royal Aircraft Factory B.E.2, B.E.2a and B.E.2b

The first B.E. type* produced by the Army Aircraft Factory was the B.E.1, designed by Geoffrey de Havilland and F. M. Green in the second half of 1911. Ostensibly, it was supposed to be a reconstruction of a Voisin biplane; in fact, almost its only connection with the Voisin was the latter's 60 h.p. Wolseley engine, and even this was changed for a 60 h.p. Renault some time after the B.E.1's first flight on 1 January 1912. The B.E.1 later served with the R.F.C., with the official serial number 201.

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* Under the Army Aircraft Factory designation system adopted in November 1911 the letters B.E. signified Blériot Experimental. However, this was merely to indicate that the B.E. types were general-purpose 2-seat tractor biplanes; they had no design or other connection with aircraft of Blériot origin.

The B.E.2, which appeared in February 1912, was a developed version with equal-span unstaggered wings and a 70 h.p. Renault; it was a 2-seater, with the pilot in the rear cockpit. On 12 August 1912 the B.E.2 was flown to a new British altitude record of 10,560 ft. (3,218·7 m.), and later that month it demonstrated its superiority to the Cody biplane that had officially won the Military Trials at Larkhill. A token order for four B.E.2s had been placed with Vickers nearly three months before this, and the first of these machines was delivered to the R.F.C. in February 1913. Other orders followed, and most production aircraft at this time were delivered as B.E.2as, with unequal-span wings, additional decking round the front cockpit and a modified fuel system. Before the outbreak of World War 1 the B.E.2/2a was in service with three R.F.C. squadrons, and at least one such aircraft was in the possession of the R.N.A.S. in September 1913.

Following the outbreak of war, the B.Es. served in France with Nos. 2, 4, 6, 8, 9 (Wireless) and 16 Squadrons R.F.C., and with the former R.N.A.S. Eastchurch Squadron in the Ostend/Dunkirk area. They were joined by the B.E.2b, which differed in its elevator and rudder controls and had redesigned top-decking and cockpit contours to give better protection to the crew. The first air V.C. of the war was awarded, posthumously, to Lt. W. B. Rhodes-Moorhouse of No. 2 Squadron, who, despite his wounds, brought his B.E. back successfully from a bombing attack on the railway station at Courtrai on 26 April 1915. Another officer of No. 2 Squadron had, on 13 August 1914, piloted the first British aircraft (a B.E.2a) to land in France after the outbreak of war. The B.Es. of the R.N.A.S. were used quite often for bombing, carrying a single 100 lb. bomb or three smaller ones under the fuselage. Early B.Es. carried no fixed defensive armament, their only protection being rifles or revolvers carried by the observer. These often fired incendiary bullets in efforts to shoot down enemy airships. The early B.Es. saw almost all of their operational service in France, although small numbers of R.F.C. machines were flown in Egypt and one or two R.N.A.S. aircraft took part in the Dardanelles campaign.

There are one hundred and sixty-four known serial number allocations for B.E.2/2a/2b aircraft, completed by nine British manufacturers; undoubtedly more than these were built, but surviving records make it impossible to give more precise figures. Final B.E.2b deliveries were made in late autumn 1916, by which time the type had been obsolete for at least a year. Late-production aircraft, and earlier machines withdrawn from front-line service, however, served a further useful period in a training capacity.

37 **Royal Aircraft Factory B.E.2c and B.E.2d**

Throughout its early existence the Royal Aircraft Factory and its antecedents were concerned – one might even say obsessed – with the evolution of an inherently stable aeroplane. They believed, quite rightly, that such an aeroplane would be easier and safer to fly; doubtless they were also influenced by the War Office's opinion that aircraft were only of use for reconnaissance, for which a steady-flying machine was even more desirable. Unhappily, while combat experience in France was almost every day proving this attitude to be wrong, from an operational standpoint, the Factory either was not told (or, if it was, it chose to ignore) the fact that it was the very stability of the B.E. that was contributing to its downfall. Against the nimble, front-gunned Fokker monoplane fighters the B.E.2 was virtually helpless: it was far too stable to outmanoeuvre the enemy, too slow to run away from him and, since it needed 45 minutes to reach its modest ceiling of 10,000 ft. (3,048 m.), had no hope at all of outclimbing him.

The B.E.2 type had been the principal mount of one of the Factory's leading experimental fliers, Edward Busk, during his researches into the matter of inherent stability. The main results of his findings took expression in the B.E.2c, which was first flown in early summer of 1914. This version had equal-span wings with marked forward stagger and double ailerons in place of the warp control of the earlier B.Es.; vertical fin area was also increased. A few B.E.2cs reached France late in 1914, but the first unit fully equipped with them (No. 8 Squadron) did not arrive until April 1915. By this time the R.A.F.1a engine (developed from the Renault of earlier B.E.2cs) had become the standard powerplant, and a plain Vee-type undercarriage replaced the earlier wheel-and-skid arrangement. Bomb load of Renault-powered B.E.2cs comprised four 25 lb. Cooper bombs suspended beneath the nose; R.A.F. 1a-engined aircraft carried two 112 lb. or ten 20 lb. bombs under the wings; with the heavier load they were usually flown solo from the rear cockpit. The B.E.2c ultimately served on the Western Front with No. 1 Wing R.N.A.S. and with more than a dozen R.F.C. squadrons. It was also flown as a bomber or reconnaissance type in Macedonia and the Middle East, and Naval B.E.2cs served as bombers and anti-submarine aircraft in the Dardanelles and the Aegean. From spring 1916 the B.E.2d began to join it in service. This had a large gravity fuel tank beneath the top wing, which increased its range with a similar load to the B.E.2c, but it took nearly twice as long as the B.E.2c to reach 10,000 ft. The new version was somewhat better defended, the observer occupying its rear cockpit armed with a free-firing Lewis gun. A few B.E.2ds were supplied to Escadrille 6 of the Belgian Aviation Militaire, being fitted with 150 h.p. Hispano-Suiza engines.

Notwithstanding its unhappy reputation as 'Fokker fodder' in France, the B.E.2c enjoyed rather more success at home. Here its stability made it a good gun platform for night fighting, and, flown

solo from the back seat, with an upward-firing Lewis gun above the top wing, it achieved some success as a Home Defence fighter, including the destruction of seven airships. The lesson of the losses in France, however, was not learned: its only result seemed to be to step up production, and the type was still in front-line service when the last B.E.2c was delivered in July 1917. A precise figure cannot be given, but a total output of B.E.2c/2d in the region of one thousand three hundred aircraft seems likely. These two models remained in service until the Armistice, latterly in a training capacity.

38 **Royal Aircraft Factory B.E.2e**

The final production model in the ill-starred B.E.2 series, the B.E.2e, was a little faster and was lighter on the controls than its predecessors, but was no real improvement. Indeed, it had a poorer climb than the B.E.2c and, inexplicably, reverted to the outmoded back-to-front seating arrangement, thus severely limiting the use that the observer could make of his defensive machine-gun. Structurally, it differed appreciably from previous models, having single-bay wings with blunt, raked tips and a pronounced difference in span between the upper and lower planes. The tailplane and elevator tips were also raked back, and a larger, more curved vertical fin was fitted.

Some B.E.2c/2d contracts were amended to specify B.E.2es, the first examples of the new model being delivered to the R.F.C. in July 1916. They subsequently served in virtually all of the squadrons that had flown earlier B.E.2 variants, and served in Macedonia and India as well as on the Western Front. About ninety-five R.F.C. B.E.2es were transferred to the R.N.A.S. for training duties; some of these were powered by 75 h.p. Rolls-Royce Hawk engines. In August 1918 the U.S. Navy bought twelve B.E.2es for use as trainers.

It is well-nigh impossible to give a production breakdown for the B.E.2 series. The building programme was so widespread, and many contracts either remain unconfirmed or specified a mixture of two or more variants. In addition to the Royal Aircraft Factory, at least twenty-two other British manufacturers are known to have participated in the production programme, the major contributors being the British & Colonial Aeroplane Co., Ruston Proctor & Co., Vickers Ltd., Vulcan Motor & Engineering Co., and G. & J. Weir. Serial allocations can be confirmed for three thousand five hundred and thirty-five B.E.2-type aircraft, but almost certainly more than this number were built. This suggests that a B.E.2e figure upward of one thousand eight hundred, of which about half are believed to have been employed on training duties, is a reasonable approximation.

39 **Royal Aircraft Factory R.E.5**

The R.E.5 was the first of the Royal Aircraft Factory's Reconnaissance Experimental biplanes to be put into production, twenty-four being built with the money received by the War Office from the Admiralty in autumn 1913 as payment for the Army airships taken over by the Navy. The R.E.5 appeared in 1914 as a large 2-seat, 2-bay biplane with wings of equal span, chord and profile and a marked dihedral. Ailerons were fitted to both top and bottom wings. The R.E.5 was powered by the Beardmore version of the 120 h.p. Austro-Daimler engine, enclosed in a long, bull-nosed cowling. The observer, who had nothing but small-arms for protective armament, occupied the front cockpit, and a normal bomb load of 60 lb. (27 kg.) could be carried.

The R.E.5 was flown operationally in France by No. 2 Squadron R.F.C. from September 1914 and by No. 7 Squadron from April 1915. Capt. J. A. Liddell of the latter squadron was awarded the V.C. for bringing back a badly damaged R.E.5 in July. One R.E.5 bomber was also used by the R.N.A.S., operating from Dunkirk, in September 1914. The keynote of the previous R.E. designs had been stability in the air, and one of the R.E.1s was flown extensively by Edward Busk at Farnborough during his researches into the nature of inherent stability. The R.E.5 inherited the reliability and straightforward handling qualities of its predecessors, and was sturdily built. Unfortunately this lack of agility and the absence of a protective armament detracted seriously from the R.E.5's operational value, and its career was short-lived.

The sixth production R.E.5 was converted to a single-seater and given extended-span wings for high-altitude flying trials: this aircraft reached a height of 17,000 ft. (5,182 m.) in June 1914. Another machine, similarly modified, was employed at Farnborough for flight trials of the Factory's 336 lb. bomb and its carrying gear, and formed the basis for the subsequent R.E.7.

40 **Royal Aircraft Factory R.E.7**

Shortly after the outbreak of World War 1 the Royal Aircraft Factory designed a new 336 lb. bomb, and this weapon, and its carrying gear, were air-tested on a modified R.E.5 in 1915. The R.E.7, whose design was also completed in 1915, was designed primarily as a carrier for this weapon. Its prototype was similar to the R.E.5 test aircraft, but had an even greater wing span and area.

Orders were placed for five hundred R.E.7s, but only just over half of this total were built: one hundred by Siddeley-Deasy, fifty each by Napier and Coventry Ordnance Works and fifty-two by the Austin Motor Co. As a temporary measure early production R.E.7s were fitted with 120 h.p. or 160 h.p. Beardmore engines, but as soon as supplies of the 150 h.p. R.A.F.4a became available this was adopted as the standard powerplant. Deliveries began late in 1915, and the first unit to be equipped fully with R.E.7s, No. 21

Squadron R.F.C., arrived with them in France in January 1916. No. 21 remained the only squadron to be equipped wholly with R.E.7s, although a few were also flown by No. 12 Squadron, and at least one (a 3-seater) was on the strength of No. 20 Squadron. For most of their service in France the R.E.7s were misemployed on escort or reconnaissance duties, for which they were too slow and inadequately armed. They did not undertake bombing until early summer 1916, and by August their replacement by B.E.12s had already begun. As an alternative to the large Farnborough bomb, the R.E.7 could carry two 112 lb. weapons and a few small bombs to an equivalent total weight. It was armed with only a single Lewis machine-gun on a makeshift mounting in the front cockpit.

After their withdrawal from front-line duty the R.E.7s were employed at training establishments until 1918, their work including target towing. A few were converted into 3-seaters, with a ring-mounted machine-gun in the third cockpit, and others were used in experimental installations of the 190 h.p. Falcon I, 200 h.p. R.A.F.3a and 225 h.p. Sunbeam engines. Six R.E.7s were allocated to the R.N.A.S.

41 Royal Aircraft Factory R.E.8

The design of the R.E.8, undertaken late in 1915, was to provide the R.F.C. with a better-defended replacement for the later B.E.2 variants. In its production form it certainly carried a more effective armament, but the stubborn adherence by the Royal Aircraft Factory to the concept of inherent stability meant that the R.E.8, like its predecessors, could easily be outmanoeuvred by the more nimble German fighters. Two prototypes (7996 and 7997) were completed, the first flying on 17 June 1916 and the second about three weeks later. They were powered by R.A.F.4a engines, which remained the standard installation in production R.E.8s, and had B.E.2e-type wings with marked stagger and dihedral.

Production began in August 1916, the first few machines having, like the prototypes, a drum-fed Lewis gun mounted low down in the cockpit and firing between propellor blades fitted with bullet deflector plates. A ring-mounted Lewis was provided in the rear cockpit. Standard front armament of the R.E.8 soon became a Vickers gun, mounted under the port-side engine panels and synchronised at first with Challenger and later with Constantinesco gear. Deliveries began in November 1916, the first aircraft arriving in France later that month with No. 56 Squadron R.F.C. Due to the inexplicable reduction in fin area on production R.E.8s, the aeroplane made a catastrophic start to its career when several were lost in spinning and other accidents or from fires that broke out when they crash-landed. As a result, the upper and lower fin areas were enlarged slightly on later machines.

The R.E.8 was the most widely used British 2-seater on the Western Front, four thousand and ninety-nine being completed by seven British manufacturers. These included twenty-two supplied to Escadrille 6 of the Belgian Aviation Militaire that were later re-engined with 150 or 180 h.p. Hispano-Suizas. R.E.8s equipped sixteen R.F.C./R.A.F. squadrons in France, and the type was in service throughout 1917–18. Their duties included observation, reconnaissance, ground-support patrols, night bombing (with two 112 lb. bombs or equivalent smaller bombs) and ground attack (with four 65 lb. bombs). Despite the fact that they were outclassed by enemy fighters, they served the Allied cause well for a much longer period than should have been necessary, and fifteen R.A.F. squadrons still had R.E.8s at the time of the Armistice. They were used by two British squadrons in Italy, two in Mesopotamia and four in Palestine; three Home Defence units also had some R.E.8s. A few remained in R.A.F. service for a short time after the war.

Variants included the R.E.8a, with a 200 h.p. Hispano-Suiza and its Vickers gun on top of the front fuselage; it is thought that only one R.E.8a was built. The R.E.9 and R.T.1 were both potential R.E.8 replacements, utilising many components of the latter aircraft. Several R.E.8s were converted to R.E.9s with equal-span wings and variously modified control surfaces; Siddeley-Deasy built six R.T1s with a variety of powerplants, unequal-chord wings and a Lewis gun over the top plane.

42 Sopwith 1½-Strutter

The 1½-Strutter was used widely during World War 1 by British, French and other Allied air forces on a range of duties that included fighter / reconnaissance, bombing, ground strafing, coastal patrol, anti-submarine work and photographic reconnaissance. Its capable performance of all these activities, often in the face of superior opposition, is its own tribute to a remarkable aeroplane. Historically, the 1½-Strutter is significant on two counts: it was the first British service aircraft with an efficient synchronised forward-firing armament, and it was chosen to equip the first-ever strategic bombing force.

The prototype (3686), completed in December 1915, was a 2-seat biplane with a 110 h.p. Clerget 9 Z engine. It went into production for the R.N.A.S. at the beginning of 1916, the 2-seat version being known as the Admiralty Type 9400. Initially the 1½-Strutter was armed with a Vickers machine-gun for the pilot and a Lewis gun in the rear cockpit. Various synchronising gears were installed, one of the most common being the excellent Scarff-Dibovsky. Later 1½-Strutters had a Scarff ring for the observer's gun in place of the original Nieuport mounting. The 1½-Strutter entered service in April 1916 with No. 5 Wing R.N.A.S. in France, where its first task was to escort French bombers. Later that year it was used as a bomber in its own right, with No. 3 Wing R.N.A.S. This unit was formed in spring 1916 with aircraft converted as single-seaters

(Admiralty Type 9700) carrying four 65 lb. bombs internally and having an excellent combat radius. At about this time the R.F.C. made heavy demands on 1½-Strutter production, with the result that No. 3 Wing did not make its first raids until the summer, and did not really get going until October 1916. Meanwhile No. 70 Squadron had become the R.F.C.'s first Strutter unit, employing them in the Battle of the Somme in summer 1916. Additional War Office orders for 1½-Strutters were placed, and the type subsequently flew with Nos. 43 and 45 Squadrons in France.

Between fourteen and fifteen hundred 1½-Strutters were built by eight British manufacturers; these included fifty-eight 'Ship Strutters' that served aboard H.M.S. *Argus*, *Furious*, *Vindex* and other major Naval vessels. Some of these aircraft also performed useful experimental work in trials of ditching and deck arrester gear and in taking off from platforms aboard Naval vessels. A small batch (later increased to over fifty aircraft) supplied to the French government early in 1916 was the prelude to an extensive French building programme in which some four and a half thousand 1½-Strutters were completed by four French manufacturers. They served extensively with the Aviation Militaire, most of them as single-seat bombers at first. French-built machines were supplied to three Belgian escadrilles, and to Russia. In spring 1918 the largest purchase from the French production line was made by the A.E.F., which bought five hundred and fourteen, primarily for use as trainers, but a few were used operationally. Twenty-one were later transferred to the U.S. Navy. Five aircraft which 'strayed' into Holland were interned and later served with the Dutch Army Air Service, and others found their way to Japan, Lithuania and Romania.

During the middle months of 1917 the R.F.C. 1½-Strutters were replaced by Camels, and many were brought back for Home Defence night-fighter duties. In these single-seaters the pilot occupied the rear cockpit and was provided with one or two Lewis guns on an over-wing Foster mounting in place of the Vickers front gun. British and French Strutters served in Macedonia, Italy and the Aegean area, and in spring/summer 1917 the R.N.A.S. employed some at home and in the Mediterranean for coastal patrol and anti-submarine work.

The 1½-Strutter was not an easy aeroplane to service, and its Clerget engines (130 h.p. in later aircraft) gave quite a lot of trouble, but these good-looking aeroplanes were straightforward to fly and achieved an impressive operational record.

43 **Sopwith Cuckoo**

The Admiralty, and especially the then Capt. Murray F. Sueter, were convinced well before the outbreak of World War 1 of the potential value of the aeroplane as a torpedo carrier. Prior to 1916 all such activities had been carried out by seaplanes, which depended upon calm water in order to operate; but in October 1916 Sueter officially asked Sopwith to investigate the possibility of a single-seat land-based aircraft carrying one or two 1,000 lb. torpedoes and having a 4-hour endurance.

The Sopwith prototype carried the factory designation T.1 (it was serialled N74 later) and flew for the first time in June 1917. (The single-seat B.1 bomber was developed concurrently with the T.1 and flew two or three months earlier, but did not go into production.) The Sopwith T.1 had 3-bay fold-back wings, with its cockpit located aft of the trailing edge, and a short-legged undercarriage between whose Vees the torpedo was slung close under the fuselage. The T.1 underwent official trials in July 1917, an order for one hundred following in August and another, for fifty, in November. The prototype was originally powered by a 200 h.p. Hispano-Suiza, but these engines were required urgently for S.E.5a fighters; N74 was therefore re-engined with a 200 h.p. Sunbeam Arab, and this became the standard unit for production Mk.I aircraft. The two original contractors, Fairfield and Pegler, had had no previous aircraft manufacturing experience, and did not deliver their first aircraft until September and October 1918; to overcome these delays, additional orders were placed with Blackburn early in 1918; the first machine from this company was delivered in July, by which time the type had been named Cuckoo. A total of three hundred and fifty Cuckoos were ordered, but with the curtailment of some contracts after the Armistice only about one hundred and fifty were actually completed, ninety of them by November 1918. Sixty-one of these were on R.A.F. charge on 31 October.

The first squadron of Cuckoos had embarked in H.M.S. *Argus* only twelve days before this, and hence was too late for combat service. Three other Cuckoos were aboard H.M.S. *Furious*. After the Armistice the Cuckoo served aboard H.M.S. *Eagle* and with Nos. 185, 186 and 210 Squadrons. Some aircraft were built as Mk.IIs with 200 h.p. Wolseley Viper engines, and in October 1919 Cuckoo N7990 was flown with a 275 h.p. Rolls-Royce Falcon III. This gave the best performance of any Cuckoo variant, but no further development was undertaken. In 1921 six Mk. II Cuckoos formed part of the equipment taken by the British Air Mission to Japan, where they laid the foundations of that country's later pre-eminence in the production of torpedo-carrying aircraft. The Cuckoo finally disappeared from R.A.F. service in April 1923.

44 **Airco D.H.4**

The D.H.4 was the first British aeroplane to be designed from the outset for high-speed day bombing, although as its career progressed it was employed on a variety of other duties as well. It was designed by Geoffrey de Havilland around the 160 h.p. B.H.P. engine, which powered the first prototype when it flew in August 1916. Before this took place, however, fifty D.H.4s had already been ordered with 250

h.p. Rolls-Royce III or IV (later Eagle III or IV) engines, and an engine of this kind was installed in the second prototype which flew later that summer. The D.H.4 proved to be a comfortable aeroplane, light on the controls and easy to fly; its main operational drawback was the installation of the fuel tank between the two cockpits, where it was vulnerable to enemy gunfire and inhibited communication between the pilot and observer.

Detail airframe improvements, including a ring mounting for the observer's Lewis gun, were made on the second prototype and retained in production aircraft, which were delivered from early 1917. The pilot had a forward-firing Vickers synchronised with Constantinesco gear. The fifty D.H.4s ordered from Westland for the R.N.A.S. had twin Vickers front guns and an elevated Scarff ring to improve the observer's field of fire. Subsequent D.H.4 production was on such a large scale that insufficient Rolls-Royce engines could be supplied; among the alternatives installed were 200 h.p. Puma or Adriatic engines (variations of the B.H.P.), the 200 h.p. R.A.F.3a, 260 h.p. Fiat A-12 and 375 h.p. Eagle VIII. With the last-named powerplant the D.H.4 had a superlative performance, including a maximum speed of 143 m.p.h. (230 km/hr.). Later production aircraft, irrespective of powerplant, had larger-diameter propellers and correspondingly longer-legged undercarriages.

First R.F.C. deliveries were made to No. 55 Squadron, which arrived in France in March 1917 and carried out its first raid during the following month. The first R.N.A.S. unit of D.H.4s was No. 2 Squadron, which became operational at about the same time, and D.H.4s eventually served with Nos. 18, 25, 27, 49, 55 and 57 Squadrons of the R.F.C./R.A.F., and Nos. 2, 5, 6, 11 and 17 Squadrons of the R.N.A.S./R.A.F. on the Western Front. Maximum bomb load of the D.H.4 was two 230 lb. or four 112 lb. bombs or an equivalent weight of smaller weapons. The R.N.A.S. on the whole made more varied use of its D.H.4s' ability to out-fly and climb above enemy fighters, and hence to be capable of operating without an escort. They were used for artillery spotting, anti-submarine patrol and photographic reconnaissance in addition to bombing. Apart from their employment in France, D.H.4s of one or other British service were operated in Russia, Macedonia, Mesopotamia, the Aegean and the Adriatic, and also at home for coastal patrol and training duties. Experimental British variants included two long-range D.H.4s, fuelled for 14 hours flying, which were intended to photograph shipping in the Kiel Canal; they were not after all used for such a mission, but later became night fighters with twin over-wing Lewis guns. Two other D.H.4s were fitted, although not tested, with 1½-pdr. Coventry Ordnance Works guns. One seaplane version was tested, and other landplane D.H.4s carried out trials with flotation gear and parachutes.

The D.H.4 was withdrawn from

R.A.F. service soon after the Armistice, when several were supplied to Belgium, Canada, Chile, Greece, Iran, New Zealand, South Africa and Spain. With some of these countries they remained in service until the early 1930s. British civil D.H.4s included the D.H.4A 2-passenger cabin transport and the D.H.4R racer of 1919, which had a 450 h.p. Napier Lion engine that gave it a top speed of 150 m.p.h. (241·4 km/hr.). One thousand four hundred and forty-nine British-built D.H.4s were built by seven manufacturers; fifteen others were built by SABCA in Belgium in 1926.

The largest D.H.4 production, however, took place in the United States, and it was the only American-built British warplane to see combat service during World War 1. A pattern aircraft was sent to America in July 1917, where it was fitted with a 400 h.p. Liberty 12 engine and flown on 29 October. Four thousand eight hundred and forty-six 'Liberty Planes', designated DH-4A, were built in the United States: three thousand one hundred and six by Dayton-Wright, one thousand six hundred by the Fisher Body Division of General Motors and one hundred and forty by Standard Aircraft Corporation. Contracts for a further seven thousand five hundred and two DH-4As were cancelled after the Armistice. Only some 30 per cent of the American-built machines reached France before hostilities ended, but they served with thirteen squadrons of the A.E.F. from August 1918 and with four squadrons of the U.S. Naval Northern Bombing Group. The Americans were never happy with the DH-4A: it was semi-obsolete by the time it entered service with them, and had had to be considerably redesigned and reworked to adapt it to American production methods. The improved DH-4B was ready too late (October 1918) to replace it in France, but during the 1920s a considerable building and conversion programme (of DH-4As) kept the DH-4B, DH-4M and other variants in U.S. service until 1932. Two hundred and eighty-three DH-4As were transferred to the U.S. Navy and Marine Corps during and after World War 1. American-built DH-4As were armed with two Marlin or Browning machine-guns in front and two Lewises in the rear cockpit; their maximum bomb load was 332 lb. (151 kg.).

45 Airco D.H.9 and D.H.9A

The D.H.9 arose from a decision taken in 1917 to more than double the number of squadrons in the R.F.C., most of the new units being intended to undertake the daylight bombing of Germany. Basically it was a good design, with pleasant handling qualities, but it was beset by troubles from the engines installed, all derivatives of the B.H.P. As a result, its performance was inferior to the D.H.4 it was meant to replace. In November 1917 the prototype (A7559), a modified D.H.4, was tested concurrently with the first production D.H.9. The prototype was flown 'clean' with a 230 h.p. Galloway Adriatic engine, whereas the first production machine

was tested under full military load conditions with a 230 h.p. Siddeley Puma, installed in rather Germanic fashion with its cylinder heads exposed. During autumn 1917 contracts for nine hundred D.H.4s were amended to specify D.H.9s, and subsequent large-scale production of the new bomber was ordered. By the end of 1918 three thousand two hundred and four D.H.9s had been completed, and ultimate production reached more than four thousand, with fifteen British manufacturers taking part in the programme. The majority of D.H.9s had Siddeley Puma engines, although a small batch of Short-built aircraft were fitted with the 260 h.p. Fiat A-12. Armament consisted of a forward-firing Vickers gun with Constantinesco synchronising gear, and a Scarff-mounted Lewis gun in the rear cockpit. Camera or wireless equipment was also installed, and the D.H.9 could (though it seldom did) carry its load of two 230 lb. or four 112 lb. bombs internally; they were more often suspended from racks beneath the fuselage or lower wings.

The first unit to re-equip with D.H.9s was No. 103 Squadron, which began to receive its first aircraft in December 1917; but D.H.9 operations in France were first carried out, in March 1918, by No. 6 Squadron. Over the next few months there was a rapid build-up of D.H.9 squadrons on the Western Front, and they put in a lot of hard work. However, their effectiveness, already hampered by a mediocre performance, was restricted still further by repeated engine failures which rendered many attempted raids abortive. The fact that the D.H.9 achieved as much as it did was due more to the perseverance and initiative of its air and ground crews than to the aeroplane itself. On the credit side it must be admitted that, once free of its bomb load, the D.H.9 was quite a good fighting aircraft. In this respect at least it was better than the D.H.4, chiefly because the pilot's and observer's cockpits were placed closer together, permitting closer collaboration. As early in the D.H.9's career as November 1917 Trenchard had appealed for its cancellation, but his plea was already too late: production was then well advanced, and it was the D.H.9 or nothing. The type ultimately equipped twelve R.F.C./R.A.F. squadrons in France, and others in the Mediterranean, Middle East and Russian theatres, remaining in service until the Armistice. In 1917–18, D.H.9s were used in many different ways as testbed aircraft. Some flew with the 430 h.p. Napier Lion or the high-compression 290 h.p. version of the Puma, or other engines; others tested engine control, cooling, fuel and silencer systems; parachutes; and at least one was used in deck-landing trials. In 1918 two engine-less D.H.9s were supplied to the United States, where a vast production programme was planned using the 400 h.p. Liberty 12 engine. In fact, only four USD-9s were completed, the remainder of the fourteen thousand that had been ordered being cancelled after the Armistice.

Eighteen D.H.9s were supplied to the Belgian Aviation Militaire in 1918. After the end of the war the D.H.9 continued in R.A.F. service in modest numbers, and at least one aircraft was refitted as an ambulance; another nine aircraft, interned in Holland, were also returned to the R.A.F. Extensive D.H.9 sales were made to nearly a score of countries in Europe, South America and the Far East; in the early 1920s thirty were built by SABCA in Belgium, and several hundred were completed later in Spain with 300 h.p. Hispano-Suiza engines. The D.H.9 also figured prominently on the commercial front as a mail and passenger transport, and one, as G-EAAA, became the first aircraft on the new British civil register.

Proof that the basic airframe design was a sound one was provided by the D.H.9A, which was fundamentally a refined version fitted with a dependable powerplant. Following the installation of a 400 h.p. Liberty 12 in C6122, three thousand Liberty engines were ordered from the United States in 1917. Only one thousand and fifty of these actually reached Britain, early in 1918, but these were sufficient to power the eight hundred and eighty-five D.H.9As completed during the war period. The D.H.9A had wings of larger area to offset the bigger, heavier engine, and its fuselage was appropriately redesigned, with the engine fully cowled and given a frontal radiator. Armament and bomb load were the same as for the D.H.9. The first squadron deliveries of D.H.9As were made in June 1918 to No. 110, although they did not become operational in France until the end of August. By the time of the Armistice four squadrons in France were flying D.H.9As, but two of these only received their aircraft in November and hence the type saw little combat service during World War 1, although two squadrons on the Russian Front also had D.H.9As. The type remained in widespread production after the war, nearly two thousand five hundred being built by a dozen British manufacturers, among whom Westland and de Havilland predominated. D.H.9As served with the R.A.F. at home, in the Middle East and India as general-purpose aircraft, and remained in service until 1931, latterly in a training role.

46 **Armstrong Whitworth F.K.3 and F.K.8**

The F.K.3, proposed by Frederick Koolhoven as a simplified alternative to the B.E.2c for reconnaissance/bombing duties, was evolved in the late summer of 1915 and accepted by the War Office for substantial production. The production version reversed the crew position from those in the prototype, so that the observer could occupy the rear cockpit with a spigot-mounted machine-gun. In this respect, and in its speed and ceiling, the F.K.3 was undoubtedly superior to the B.E.2c, although it carried a smaller bomb load and had a poorer rate of climb. Its flying qualities were far

superior to those of the Factory machine. Four hundred and ninety-nine production F.K.3s were built, four hundred of them by Hewlett & Blondeau and the rest by the parent company. The only operational squadron to employ F.K.3s was No. 47 in Macedonia, which used them from September 1916 until early 1918, primarily on patrol and reconnaissance duties but sometimes in the bombing role. For the latter purpose it had to be flown as a single-seater in order to carry a war load of 112 lb. (51 kg.). Standard powerplant of the F.K.3 was the 90 h.p. R.A.F.1a Vee-type engine. Most F.K.3s were employed as trainers, for which they were ideally suited, and they were used by several training establishments in the United Kingdom and Egypt.

The F.K.8 was basically a scaled-up version of the F.K.3, making its maiden flight in May 1916 and being delivered to R.F.C. units towards the end of that year. First operational F.K.8 squadron was No. 35, which arrived in France with them in January 1917; Nos. 2, 8, 10 and 82 Squadrons also received F.K.8s, and they partially equipped Nos. 17 and 47 Squadrons in Macedonia and No. 142 Squadron in Palestine. At home the F.K.8 was flown by No. 50 Home Defence Squadron and several training establishments. The F.K.8 was a contemporary of the R.E.8, and was generally considered superior to the Factory design. Early F.K.8s were powered by 120 h.p. Beardmores, but the 160 h.p. model soon became the standard unit. The 'Big Ack', as it was known (the F.K.3 being the 'Little Ack'), was armed with a synchronised Vickers gun for the pilot and a Lewis gun on a Scarff mounting in the rear cockpit; it could carry a 160 lb. (72·6 kg.) bomb load. The F.K.8 was well built, well defended and regarded highly by its crews, and was used widely on reconnaissance, patrol, day and night bombing and ground attack throughout 1917 and 1918. The aircraft illustrated was attacked by eight Fokker Dr.Is on 27 March 1918, and its fuel tank and rear cockpit set ablaze while the aircraft was still loaded with bombs and ammunition. Although both crew members were seriously wounded, they accounted for four of the Fokkers before McLeod successfully brought the F.K.8 down in no man's land, a feat for which he received a well-earned V.C.

Known orders for the F.K.8 include six hundred and fifty from Armstrong Whitworth and nine hundred from Angus Sanderson & Co., but a hundred or more of the latter may not have been completed before production ended in July 1918. On 31 October 1918 there were six hundred and ninety-four F.K.8s on R.A.F. charge; over 40 per cent of these were then in store and less than two hundred in front-line service in France. The F.K.8 did not long survive the war, but a few appeared on the British civil register and others in Australia. During 1917–18, experimental installations were made in F.K.8s of the 150 h.p. Lorraine-Dietrich, 150 h.p. R.A.F.4a and 200 h.p. R.A.F.4d engines.

47 **Salmson 2**

The Société des Moteurs Salmson, as its name indicates, was formed primarily for the production of aero-engines, and in particular it built large numbers of the 9-cylinder water-cooled Canton-Unné radial which powered several types of aircraft in French, British and Russian service during the first half of World War 1. The company's first aeroplane venture, the Salmson-Moineau SM-1, was not a success, but early in 1917 it produced a 2-seat biplane known as the Salmson D with a 130 h.p. Clerget rotary engine. This did not go into production, but its derivative, the Salmson 2, using a Canton-Unné engine, became one of the more successful French types of the later war years.

Designed as a 2-seat 'heavy' observation aircraft, the Salmson 2 was of conventional appearance except that it had neither a vertical fin nor a fixed tailplane. It was a good-looking aeroplane, with a rounded fuselage and a distinctively louvred cowling for the radial engine; the equal-span wings had double ailerons. The Salmson 2 went into production towards the end of 1917 and entered service with the French Aviation Militaire in early 1918 with the military designation 2A.2. Three thousand two hundred Salmson 2s were built, and they served with twenty-two French escadrilles on the Western Front and two others in Italy. Seven hundred and five Salmsons were purchased by the A.E.F. as an interim type pending delivery of the DH-4A 'Liberty plane'. Eleven squadrons of the A.E.F. flew the Salmson 2 during the final months of the war. The duties assigned to the Salmson 2 were primarily those of visual and photographic reconnaissance, the rear cockpit having a trap in the floor for the aiming of cameras. The aircraft could carry two dozen small fragmentation bombs for ground strafing, and was occasionally used also as a light day bomber. Forward armament consisted of a single synchronised Vickers machine-gun mounted slightly to port on top of the engine cowling; some American machines were later fitted with Marlin guns instead. A Scarff ring in the rear cockpit could mount single or twin-yoked Lewis guns for the observer's use. Like the D.H.4, the Salmson 2's main drawback was the wide separation of the two cockpits, which made communication and collaboration between the crew members difficult when in combat. Nevertheless, the Salmson 2, although it did not possess a particularly outstanding performance, was a sturdily built machine with an extremely reliable engine and was capable of receiving and meting out considerable punishment. Lt. W. P. Erwin of the 1st Aero Squadron A.E.F. destroyed eight enemy aircraft using only the front gun of his Salmson 2. The Salmson was not especially fast, but it had a useful rate of climb, being able to reach 5,000 m. (16,404 ft.) in 27½ minutes.

48 **Spad XI**

The first 2-seater to be designed by Louis Béchereau, creator of the

Spad fighters, was the Spad VIII, although this did not proceed beyond the design stage. Its subsequent development, however, led to the Spad XI, which appeared in September 1916. Externally it resembled the Spad VII single-seater, except that the 2-bay wings had slight stagger and sweepback to balance the longer fuselage with its additional cockpit.

The Spad XIA.2 went into service in 1917, but its early production was affected by teething troubles with the reduction gear of its 235 h.p. Hispano-Suiza engine. It was armed with a single forward-firing synchronised Vickers gun, offset to starboard, in front of the pilot, while one or two Lewis guns could be installed on the ring mounting in the rear cockpit. A light bomb load of about 70 kg. (154 lb.) could be carried under the lower wings. Although sensitive on the controls, the Spad XI could have been a useful aircraft under the right conditions; unfortunately it was easily affected by uneven distribution of loads such as ammunition, cameras, photographic flares or bombs, and acquired a reputation for poor controllability. The same factor also affected its climbing powers, for in anything but a shallow climb the engine readily stalled. In 'clean' condition the Spad XI could climb to 4,000 m. (13,123 ft.) in 17½ minutes. At least one machine was fitted with a 220 h.p. direct-drive Renault engine, but the Hispano remained standard. Despite its shortcomings, the Spad XI served with at least fifteen escadrilles of the French Aviation Militaire and three Belgian escadrilles during 1917 and early 1918; the Belgian Spads remained in service until the Armistice.

In January 1918 a new version appeared. This was the Spad XVIA.2, powered by a 235 h.p. direct-drive Lorraine-Dietrich 8 Fb. The Spad XVI was faster, but had a poorer ceiling than the Spad XI and was no real improvement. With its introduction into service, however, the French government then sold thirty-five surplus Spad XIs to the A.E.F., two of whose squadrons flew the type during the summer of 1918. The A.E.F. also bought six Spad XVIs, and another was supplied to Belgium in 1918. A later version of the Spad XVI had twin guns fore and aft and a 250 h.p. Lorraine-Dietrich 8 Bb, but in March 1918 an explosion at the factory producing these aircraft seriously affected production, and in July all 2-seat Spads in French service were withdrawn from the Front.

49 **Breguet 14**

Louis Breguet began the design of his Type XIV in mid-1916, and himself flew the prototype at Villacoublay on 21 November. It was a big, capable-looking 2-seater, powered by a 220 h.p. Renault engine with a large frontal radiator and heavily louvred side panels. Another feature was the wide use of duralumin in its construction. Initial production version was the Br.14A.2 reconnaissance model, five hundred and eighty of which were ordered in March/April 1917; by this time a

prototype of the Br. 14B.2 bomber version had also been delivered. From then onward production of the Breguet 14 quickly gathered momentum: by the end of 1917 more than two thousand were on order from six French manufacturers; some five and a half thousand were ordered during the war period, and more than eight thousand were built before production ended in 1926.

The B.2 differed from the A.2 in having transparent side panels to the observer's cockpit, lower-wing flaps of nearly full span and Michelin bomb racks protruding from the lower leading edges. Both versions entered service in summer 1917, and carried a similar armament: a single, forward-firing Vickers gun for the pilot and twin Lewis guns on a ring mounting in the observer's cockpit. Some 14A.2s mounted an overwing Lewis in place of the forward Vickers gun, and an additional downward-firing Lewis could be mounted on the B.2 to protect the aircraft below and behind. Up to thirty-two 8 kg. bombs could be carried by the Br.14B.2; the A.2 could also carry a small load of four small bombs if required.

Breguet 14s served with seventy-one French escadrilles on the Western Front (including seventeen Escadrilles de Bombardement). They also equipped five escadrilles in Serbia, three in Greece, six in Morocco and eight in Macedonia. Two Belgian escadrilles and several A.E.F. squadrons also flew Breguet 14s. Aircraft supplied to the A.E.F. in 1918 included two hundred and twenty-nine Br.14A2s, forty-seven Br.14B.2s and one hundred Br.14E.2 unarmed trainers. As indicated by the numbers built, the Breguet 14 was widely used for day and night bombing during the final year of the war. Various alternative or experimental engine installations included improved versions of the Renault (one with a turbosupercharger), the Fiat A-12bis, Lorraine-Dietrich and Liberty 12. Variants included the unsuccessful Br.14H floatplane and the Br.14S ambulance, which was used in modest numbers in 1918 and extensively in the middle 1920s. The Br.16Bn.2 was an enlarged night-bomber development built in some numbers; also produced, but too late for war service, was the Br.17C.2, a 2-seat escort version with a 400 h.p. Renault 12K engine and twin forward-firing Vickers guns.

The Breguet 14 had a long and varied post-war career. The double crossing of the Mediterranean by Roget and Coli in January 1919 was the first of many endurance flights; other Br. 14s were used as mail and passenger transports; and in addition to a long post-war career with the French Aviation Militaire, the Breguet 14 was supplied to nearly a dozen foreign air forces in Europe, South America and the Far East.

50 **Short 184 and Bomber**

On 28 July 1914 a torpedo was successfully launched for the first time from a British aircraft, a 160 h.p. Short seaplane, and almost

immediately after this the Admiralty issued an official requirement to Short Bros. for an aeroplane designed specifically for this duty. The resultant prototype was given the serial number 184, from which the aircraft derived its official designation. It was powered by a 225 h.p. Sunbeam Mohawk engine, which caused it to be referred to often, but erroneously, as the 'Short 225', even when later-production examples were fitted with engines of greater power. The prototype was completed early in 1915, being a 3-bay biplane with fold-back wings and its 14 in. torpedo slung low between the twin floats. The second prototype, 185, was completed shortly afterwards, and both of these machines later served operationally aboard the seaplane carrier *Ben-my-Chree* in the Dardanelles from June 1915. On 12 August 1915 one of these aircraft, flown by Flt. Commander C. H. K. Edmonds, accomplished the first-ever sinking of a ship (a Turkish merchantman) by means of an air-launched torpedo.

The Short 184 was not one of the war's more spectacular aircraft; when loaded down with its torpedo it was difficult to take off in all but the calmest sea and was tricky to fly successfully; eventually the torpedo role was abandoned in favour of employment on reconnaissance, anti-submarine patrol and bombing. Nevertheless, the 184 served from mid-1915 until the end of the war, performing a great amount of humdrum but useful work in practically every combat theatre. About nine hundred Short 184s were built, by the parent company and nine other British manufacturers, and three hundred and twelve of them were still in service on 31 October 1918. By then nearly all of them were powered with Sunbeam Maori I, II or III engines, although the 225 h.p. Mohawk had been standard in early-production batches. Other powerplants used in lesser degree included the 240 h.p. Sunbeam Gurkha, 240 h.p. Renault or 250 h.p. Rolls-Royce Eagle. Short 184s were employed at U.K. coastal stations and aboard seaplane carriers of the Royal Navy in the North Sea, Mediterranean and Far East. One of the two 184s carried by H.M.S. *Engadine* made the only reconnaissance carried out during the Battle of Jutland on 31 May 1916. A typical bomb load for the 184 Type A, the standard Mohawk version, was four 100 lb. bombs. The Type D which appeared in 1917 was flown from the rear seat as a single-seater, with up to nine 65 lb. bombs in place of the observer. The Type B, first built by Mann, Egerton, had short-span lower wings, kingpost bracing above the outer-section top wings and reinforced strut bracing for the floats. A version known as the Improved 184 had modified aileron controls. Short 184s were armed with a single defensive Lewis gun in the rear cockpit on a Whitehouse or (later) a Scarff ring mounting. Two 184s were supplied to the French government for evaluation during the war, and in late 1917 and early 1918 two prototypes were

completed of the Short N.2B, a potential Maori-engined replacement; no production of this was, however, undertaken, and the Short 184 continued to serve until the end of the war. Indeed, it continued in service for a while after the war, carrying out mine-detection patrols in British waters. A small number were flown commercially for joy-riding by British civil owners, and others were sold to Chile, Estonia, Greece and Japan. Some of those in foreign service did not retire until the early 1930s.

In response to a bomber competition held in 1915, Short Bros. produced a landplane adaptation of the 184 (prototype serial number 3706). This also had a Mohawk engine and was a 2-bay machine with constant-chord top wings, a rather clumsy 4-wheel undercarriage and the observer situated in the front cockpit. Eighty-three production Short Bombers (they never received an official name) were built by Shorts and four other companies, earlier examples following the style of the 184 in having a short fuselage and later machines being given much extended rear fuselages. Production aircraft had 3-bay interplane bracing and a more conventional crew seating with the observer in the rear cockpit, armed with a free-firing Lewis gun. The 250 h.p. Rolls-Royce Eagle was the standard engine except in the fifteen aircraft built by Sunbeam, who installed their own 225 h.p. Mohawk. Typical bomb load comprised four 230 lb. or eight 112 lb. bombs, carried beneath the lower wings. Deliveries of Short Bombers began in early spring 1916 to No. 3 Wing R.N.A.S. – which, however, did not become operational with them until October. This was because, in answer to an urgent R.F.C. request, fifteen Short Bombers were handed over to that service in preparation for the Battle of the Somme. The remaining R.N.A.S. aircraft were employed operationally until April 1917, when they were replaced by Handley Page O/100s.

51 Letord Types 1 to 9

The Letord Type 1 originated in 1916 to meet a requirement issued by Lt. Col. Dorand, director of the Section Technique de l'Aéronautique at Chalais-Meudon, for a twin-engined 3-seat replacement for the Caudron R.4 reconnaissance aircraft. Although designed by the S.T.Aé's chief designer, Capitaine Georges Lepère, series production was entrusted to Établissements Letord, a company formed in 1908 to manufacture balloons and airships, which had aircraft factories at Lyon-Villeurbane and, conveniently, at Chalais. No fewer than seven aircraft types (three each for reconnaissance and night bombing and one escort fighter) stemmed from this basic design configuration, all having the characteristic 'trademark' of backward-staggered wings (with varying upper and lower spans) and most of them powered by variants of the Hispano-Suiza V8 engine.

All had a basic four-wheel main landing gear; the Types 1, 3 and 4 had an additional wheel under the

front of the fuselage to prevent a nose-over.

First to appear was the Let.1A. 3 reconnaissance version, with a pair of 150 h.p. Hispano-Suiza 8 A engines; one hundred and seventy-five of these were ordered in October 1916, entry into service beginning some six months later. Higher-powered Hispano-Suiza 8 Ba engines of 200 h.p. were generally fitted to the Let.2A. 3, though the 170 h.p. Lorraine-Dietrich 8 A was installed in some examples, and also in the third reconnaissance model, the Let.4A. 3. First of the night bombers was the Let.3Bn. 3 of 1917, similar to the 2A. 3 with Hispano-Suiza 8 Ba engines but having equal-span 4-bay wings of 55 ft. 9¼ in. (17·00 m.) span and greater area and an under-nose wheel. Gross weight was 5,291 lb. (2,400 kg.) and maximum speed 93 m.p.h. (150 km/hr.).

The Letord Type 3 was also built in a 3Ca. 3 escort fighter version, with a 'canon' armament, this in turn leading to a more definitive escort version, the Let.6Ca. 3, which had 220 h.p. Hispano-Suiza 8 Be engines and was flight tested in January 1918. The second and third bomber versions were the Types 5 and 7. Fifty-one Type 5s were built, these having unequal-span wings, two 220 h.p. Lorraine-Dietrich 8 Fb engines and no nosewheel. Normal armament consisted of single machine-guns on movable mountings in the front and rear cockpits and a maximum bomb load of 441 lb. (200 kg.); some Let.5Bn. 3 aircraft had an additional gun mounted under the nose to fire to the rear.

Only one Letord Type 7, first flown in 1918, is known to have been built. Developed from (and larger than) the Type 3, it had a 62 ft. 4 in. (19·00 m.) span, with two 275 h.p. Lorraine engines mounted on the lower mainplanes. At a gross weight of 6,305 lb. (2,860 kg.), its maximum speed was 89 m.p.h. (143 km./hr.). Letords of one type or another equipped at least eight escadrilles of the French Aviation Militaire, and some served also with Dorand or Caudron squadrons. A final wartime type, quite outside the foregoing family of designs, was the Letord Type 9, completed only shortly before the Armistice. Much larger than the Lepère-designed Types 1 to 7, it had non-staggered wings of 85 ft. 1¼ in. (25·94 m.) span and 1,453·1 sq. ft. (135·00 sq. m.) area, a biplane tail unit, and a crew of 2. Powered by two 400 h.p. Liberty 12 engines, it had a gross weight of 12,171 lb. (5,521 kg.) and could reach a speed of 90 m.p.h. (145 km./hr.), but it was too late to perform any war service.

52 **Caudron R.4 and R.11**

Compared with the frail-looking Farman and Voisin bombers then in French service, the prototype Caudron R.4 had, when it first appeared in June 1915, quite a 'solid' and modern appearance for its time. The prefix letter indicated that it had been designed by René Caudron of Caudron Frères, and it was intended for use as a 3-seat bomber. The R.4, although based on Gaston Caudron's G.VI, was virtually a new design, having a single, covered fuselage, single tail assembly and two 130 h.p. Renault engines mounted midway between the 3-bay wings. The undercarriage consisted of a twin-wheel unit beneath each lower wing, in line with the engine, and a fifth wheel under the front of the fuselage to prevent the aircraft from nosing over on landing. The pilot occupied the middle one of the three cockpits, with gunners in each of the front and rear positions equipped with one or two Lewis machine-guns on ring mountings. The R.4 had been designed to carry up to 100 kg. (220 lb.) of bombs, but when fully loaded it was considerably underpowered and its performance was too poor for successful operation. However, in an R.4A.3 form, as a 3-seat reconnaissance aeroplane, it rendered extremely useful service to the Aviation Militaire as a photographic reconnaissance aircraft from spring 1916 until April 1917. It then began to be replaced by the Letord Type 1, another twin-engined biplane broadly resembling the R.4 in general layout, but with a somewhat better performance.

To replace the R.4, Caudron evolved the R.11, which first appeared in March 1917. This was a smaller and lighter machine with shorter-span, 2-bay wings, enlarged fin and rudder and more powerful engines. At first, 200 h.p. Hispano-Suiza 8 Bda engines were installed, but the higher-rated 215 h.p. Hispano was substituted as soon as supplies became available. Some aircraft were fitted with 235 h.p. Hispano-Suiza 8 Beb engines, not necessarily to their advantage. The Caudron R.11 was built originally as a reconnaissance aircraft, but also served in the Bn. 3 category (Bombardement de nuit, 3-seat), in which capacity it could carry a 120 kg. (265 lb.) load. Night-bombing R.11s entered service early in spring 1918, but although their performance was markedly superior to that of the R.4s, the basic design was now nearly three years old and the R.11's effective bomb load was modest by 1918 standards. The R.11 really found its métier in July 1918 when, classified as Cau.11A.3, it was assigned to escort the Breguet 14 bomber squadrons. It may have been at this stage that a fifth gun was added to the defensive armament. Twin Lewis guns were mounted in each of the front and rear cockpits of the R.11, and the fifth gun was installed below the front gunner's position and fired by him downward and to the rear to protect the aircraft from attacks from below. Eight escadrilles of the Aviation Militaire were equipped with Cau.11A.3s, and for the remaining four months or so of World War 1 these 'flying gunboats' accompanied attacks by all French bombing squadrons against enemy targets. The R.F.C. and United States Air Service each evaluated two examples of the R.11. Total production of the R.11 was approximately five hundred.

A variant which is often confused

with the R.4 and R.11 is the Caudron Cau.23Bn.2, an enlarged, 4-bay, 2-seat night bomber which appeared in 1918. A contemporary of the Breguet 16 and Farman F.50, it was powered by two 250 h.p. Salmson (Canton-Unné) 9Z engines and had a much more angular fuselage with a blunter nose. No reliable evidence has been found that this aircraft went into series production before the Armistice.

53 A.E.G. G types

The series of twin-engined G types produced by A.E.G. in 1915–18 differed from most other German Grossflugzeuge in having a tractor, rather than a pusher, engine arrangement. The first in the series appeared early in 1915, before the introduction of the Grossflugzeug category, and was given the Kampfflugzeug (combat aeroplane) designation K.I. The K.I, later redesignated G.I, was a 3-seater powered by two 100 h.p. Mercedes D.I engines; comparatively few were built. In July 1915 the G.II appeared, a slightly bigger machine with 150 h.p. Benz Bz.IIIs, two or three defensive machine-guns and a 200 kg. (441 lb.) bomb load. It, too, was built in comparatively limited numbers, some G.IIs having two small auxiliary rudders. Both the G.I and G.II were flown by Schlachtstaffeln (Battle Flights) as well as by regular bombing formations. In the early summer of 1916 the G.III, which had first appeared at the end of the previous year, went into service. This had a much increased wing span, balanced and overhung control surfaces and two 220 h.p. geared and handed Mercedes D.IV engines. The G.III was armed with two defensive machine-guns and could carry a 300 kg. (661 lb.) bomb load. Again, only small numbers were built, twenty G.IIIs being in service in October 1916; they served in Macedonia as well as on the Western Front.

The most widely built G type was the G.IV, which entered service late in 1916. This had a basically similar airframe to the G.III, but utilised the more reliable direct-drive Mercedes D.IVa. A crew of three or four men was carried, and the bomb load was about 350 kg. (772 lb.); a Parabellum gun was installed in each of the front and rear cockpits. Lacking both the range and the lifting power of the Friedrichshafen and Gotha G types, the A.E.Gs. were flown mainly as day and night tactical bombers over comparatively short ranges up to about 700 km. (435 miles). With extra fuel tankage in place of a bomb load, they were also employed on long-range reconnaissance and photographic missions. The A.E.G. G.IV remained in fairly widespread use until the Armistice, appearing on the Western Front, in Salonika, Italy, Romania and Macedonia. Experimental variants included the G.IVb, with a 3-bay extended-span wing cellule, and the G.IVk, with a biplane tail unit, armoured engine nacelles and nose section mounting a 20 mm. Becker cannon.

Final production version was the G.V, which first appeared in May 1918. It retained the same power-

plant as the G.IV, but had a much enlarged wing span of 27·24 m. (89 ft. 4½ in.), a 600 kg. (1,323 lb.) bomb load and a maximum endurance of 6 hours. The G.Vs were built too late to see any combat service, but a number were employed post-war with Deutsche Luft-Reederei as 6-passenger transports in 1919. Most of them went into commercial service with the minimum of conversion, but a few machines were converted to have passenger cabins. Total wartime production of the G series reached five hundred and forty-two machines; by far the greater proportion of these, perhaps as many as four hundred, were G.IVs, of which fifty were still in service in August 1918.

54 Handley Page O/100 and O/400

In December 1914 the Air Department of the Admiralty confirmed in writing its requirement for a 'bloody paralyser of an aeroplane' for the bombing of Germany. It was to be a 2-seat aircraft, with a speed not less than 75 m.p.h. (120·7 km/hr.) and capable of carrying a minimum load of six 112 lb. bombs. By March 1915 forty such aircraft had been ordered, and the first machine (1455) was flown for the first time on 18 December 1915. It had been intended to install 120 h.p. Beardmore engines in the first Handley Page O/100, but the prototype was fitted with two 250 h.p. Rolls-Royce Eagle IIs, and these engines powered forty of the forty-six O/100s subsequently built by Handley Page. The other six were built with 320 h.p. Sunbeam Cossacks. The O/100 prototype had an enclosed crew cabin, and the engine nacelles and front part of the fuselage were encased in 1,200 lb. (544 kg.) of armour plating; but these features were omitted from production aircraft. To enable them to be housed in standard British field hangars, the wings of the Handley Page bombers were designed to fold back along the sides of the fuselage. The O/100 exceeded its specification by being able to carry sixteen 112 lb. or eight 250 lb. bombs internally. It accommodated a 4-man crew, with positions for single or twin Lewis machine-guns in nose and dorsal locations and a fifth Lewis firing downward and to the rear through a trap in the floor. The O/100 went into service with No. 3 Wing R.N.A.S. on the Western Front in November 1916. It subsequently equipped Nos. 14 and 16 Naval Squadrons, and some O/100s were still in service when the war ended. For the first few months of their employment in France they were used for daylight sea patrols off the Flanders coast, but from March/April 1917 they began to concentrate on the night bombing of major German installations, such as U-boat bases, railway stations and industrial centres. Two O/100s were used in Palestine by the forces under General Allenby and T. E. Lawrence in their campaigns against the Turks; another O/100, based at Mudros in the Aegean, took part in bombing raids on Constantinople and against the German battle

cruiser *Goeben*. This machine was at one time flown by Flt. Lt. J. W. Alcock, later the pilot of the 1919 trans-Atlantic Vimy.

The O/100 was followed into service by the much more numerous O/400, whose prototype (3138) was a converted O/100 airframe. The basic difference between the two bombers was that the fuel tanks were transferred from the engine nacelles to the fuselage, thus giving the O/400 much shorter nacelles. Successively higher-powered Eagle IV, VII or VIII engines were installed in most O/400s, though some aircraft were fitted with the 260 h.p. Fiat A-12bis or the 275 h.p. Sunbeam Maori. One machine was flown with two tandem pairs of 200 h.p. Hispano-Suiza engines to evaluate the engine layout proposed for the later V/1500. Nearly eight hundred O/400s were ordered during the war period, of which about five hundred and fifty were built in the United Kingdom. In addition, one hundred and seven O/400s were assembled from components built in the United States by the Standard Aircraft Corporation and powered with 350 h.p. Liberty 12Ns. A further eight Standard-built O/400s were completed for the U.S. Army after the war, but the rest of the one thousand five hundred ordered were then cancelled. In April 1917, more or less concurrently with the transfer of the O/100 to night operations, the O/400 became operational as a day bomber in France, itself transferring to night bombing from the following October. Handley Page O/400s served with No. 58 Squadron R.A.F., Nos. 97 and 115 Squadrons of the Independent Force and Nos. 207, 214, 215 and 216 Naval Squadrons. Two hundred and fifty-eight O/400s were on R.A.F. charge on 31 October 1918. One aircraft operated with No. 67 Squadron (No. 1 Squadron, Australian Flying Corps) in Palestine. During the last two months or so of the war the loads carried by O/400s included the 1,650 lb. bomb. In spring 1918 two aircraft were crudely converted into 12-passenger transports for the purpose of flying ferry pilots back from France to England.

The Handley Page O/400 remained in R.A.F. service until 1920, eight of them being allocated to No. 1 (Communications) Wing as V.I.P. transports, carrying officials to and from the Paris Peace Conference between January and September 1919. Four O/400s were converted and operated by Handley Page Transport Ltd. in 1919–20 for route-proving on overseas air routes later flown by Imperial Airways. The O/400 was further developed into the O/700 transport, ten or a dozen of which were supplied to China late in 1919 and two or three more to South Africa. The O/700 was further developed into the O/10 and O/11 transports, eight and five of which were built respectively.

55 **Handley Page V/1500**

The V/1500 was too late for the war and too large for the peace, but it has several claims to a place in aviation history. It was the first British four-engined bomber to go into production, was also the largest British aircraft produced during 1914–19 and was Britain's first truly strategic bomber. It was built to an Air Ministry requirement for an aeroplane with a 600 mile (966 km.) combat radius, and thus capable of bombing Berlin from bases in East Anglia. Design was begun in October 1917, and the first prototype flew in May 1918. This was powered by two tandem pairs of 375 h.p. Rolls-Royce Eagle VIII engines, and had no front gun position. In mid-1918, after the crash of the first prototype, a second machine was completed in which a front gunner's cockpit was provided; each pair of engines was enclosed in a single nacelle, and other aerodynamic improvements were made. Production V/1500s differed from this machine in having uncowled motors, modified radiators and an enlarged tail unit. As in the O/400, single or twin Lewis gun positions were provided in the nose and dorsal positions, and a fifth gun fired downward and rearward through the fuselage floor. A sixth Lewis gun was installed on a ring mounting in the extreme tail – the first time such a feature had been incorporated in the design of a British aeroplane. The V/1500 had provision to carry up to thirty 250 lb. bombs or two of the large 3,300 lb. weapons; a load of about 1,000 lb. (454 kg.) would have been carried on flights to Berlin. In the event, however, the V/1500 was not to make such a flight. Although orders had been placed for two hundred and fifty-five V/1500s before the war ended, only three of these had been delivered (to No. 166 Squadron on 8 November 1918). They were bombed-up and standing by for two days before the signing of the Armistice rendered their mission unnecessary. After the end of the war several contracts were cancelled and only about three dozen V/1500s were built: Handley Page built at least twenty-two, Beardmore at least seven and Harland & Wolff probably completed four others. Most of these aircraft were powered by Eagle VIIIs, but the final Handley Page machine had 450 h.p. Napier Lions, with which it flew on 3 September 1919, and at least one of the Beardmore V/1500s had 500 h.p. Galloway Atlantics.

In December 1918/January 1919 a V/1500 named H.M.A. (His Majesty's Airliner) *Old Carthusian* made the first flight from England to India (Martlesham to Karachi). This aircraft was later used to help expedite a peace settlement in north-western India by bombing Kabul in May 1919 – the only time a V/1500 ever dropped bombs in anger. Another machine (F7140) was shipped to Newfoundland in 1919, where it was assembled in readiness for an attempted non-stop Atlantic crossing. The attempt was delayed because of overheating troubles with the engines, and by the time these had been dealt with the crossing had been accomplished by the Vimy flown by Alcock and Brown; F7140 abandoned its attempt and instead carried out a demonstration tour of the United States and Canada. The V/1500 was

too large, too complex and too costly to become a successful commercial aeroplane, and none came on to the British civil register. One was, however, used briefly by Handley Page Transport Ltd. in 1919 on a London–Brussels service. This may have been the same aircraft that carried 40 passengers over London at 6,500 ft. (1,981 m.) in 1919.

56 **Vickers Vimy**

A contemporary of the Handley Page V/1500, the Vimy was designed as a twin-engined bomber with range enough to attack Berlin from bases on the Western Front. It was designed by R. K. Pierson as the F.B.27, and three prototypes were ordered in August 1917. The first of these (B9952), powered by 200 h.p. Hispano-Suiza engines, was flown on 30 November 1917; it was later re-engined with 260 h.p. Salmson radials. Changes introduced on the second machine, which was completed in April 1918, included 260 h.p. Maori engines and a third machine-gun, to defend the aircraft below and to the rear. The third aircraft, which appeared a few weeks later, had an airframe more representative of the ultimate production Vimy and was powered by 300 h.p. Fiat A-12bis engines. This prototype was unfortunately destroyed in September 1918, but in the following month a fourth prototype (F9561) appeared, with 360 h.p. Eagle VIII engines and enlarged rudders.

An initial one hundred and fifty Vimys were ordered from Vickers in March 1918, contracts with other manufacturers following until, by the Armistice, more than a thousand were on order. These were to have had a wide variety of alternative engines, but in the event the great majority of those built were Eagle-powered and most of the remainder had Fiats. One hundred and forty-three Vimys were completed by Vickers, twenty-five by Westland, at least sixteen by the Royal Aircraft Establishment and at least forty by Morgan & Co.; contracts with other manufacturers were cancelled towards the end of the war. On 31 October 1918 only three Vimys were on R.A.F. charge, and only one of these was stationed with the Independent Force in France; the war ended before this Vimy was used operationally.

Main squadron deliveries of the Vimy commenced in July 1919, and they served with nine R.A.F. flights or squadrons at home and overseas, and with several training units in Britain and Egypt. They began to be withdrawn from bomber squadrons in 1924, but many continued in use for training (including parachute training) until the 1930s. About eighty aircraft in this category were re-engined with uncowled Bristol Jupiter or Armstrong Siddeley Jaguar radial engines during the last few years of their service. Standard armament of the production Vimy consisted of four 0·303 in. Lewis machine-guns, but the rear upper gun was usually omitted from peacetime aircraft. Maximum internal and external bomb load for the Fiat-powered

Vimy was 4,408 lb. (2,000 kg.), and for the Eagle-powered model 4,804 lb. (2,179 kg.). The Eagle-Vimy is generally referred to as the Mk.IV, although confusion exists over the correct nomenclature for Vimy variants both during and after the war; the Fiat-Vimy is variously described as the Mk.II or Mk.III.

Two notable distance flights were made by specially modified Vimys in 1919. In June the first non-stop trans-Atlantic crossing by Capt. John Alcock and Lt. Arthur Whitten-Brown was made over the 1,890 miles (3,032 km.) between St. Johns, Newfoundland, and Clifden, in the Irish Republic. In November/December Vimy G-EAOU, piloted by Capt. Ross Smith and his brother Lt. Keith Smith, made the first flight from Britain to Australia by Australians in a British aircraft; the distance of 11,130 miles (17,912 km.) was covered in just under 136 flying hours.

57 **Blackburn Kangaroo**

One of the lesser-known aircraft of World War 1, the Kangaroo had its origins in the Blackburn Type G.P., a twin-engined, twin-float seaplane whose prototype (1415) first appeared in July 1916. This machine carried a crew of three, was powered by 150 h.p. Sunbeam Nubian engines and had fold-back wings. It was followed by a second machine (1416), sometimes known as the S.P., which first appeared with 190 h.p. Rolls-Royce engines and introduced a number of modifications including a greater use of metal in its construction.

The twenty Kangaroos originally ordered were apparently also intended as seaplanes for the R.N.A.S. as maritime patrol bombers. However, it was evidently decided that a landplane version would have more flexibility of operation, and the aircraft were accordingly renumbered and built with wheeled undercarriages for the R.F.C. The War Office also placed a separate order for four Kangaroos. Production Kangaroos still retained the facility to fold their wings, but introduced several minor airframe modifications and were powered by 250 h.p. Rolls-Royce Falcons (which may have been tested in one of the prototypes). The first Kangaroo underwent official acceptance trials in January 1918, and deliveries began to No. 246 Squadron R.A.F., based at Seaton Carew, Co. Durham, in April. The Kangaroo carried a 4-man crew; front and rear Scarff rings each mounted a single Lewis machine-gun, and four 230 lb. bombs or an equivalent weight of smaller bombs could be carried internally. Racks could be fitted under the centre of the fuselage for additional bombs. The Kangaroo's long, slender fuselage was liable to twist under stress, but for an aircraft of its size it was light on the controls, and all crew members enjoyed an excellent view from their respective cockpits. Completion of all twenty-four aircraft has not been verified, but the four ordered by the R.F.C. and at least twelve of the larger batch are known to have been delivered. About ten Kangaroos served with No. 246

Squadron during the final six months of the war, when they sank one U-boat (in August 1918) and damaged four other 'probables'. At least fourteen Kangaroos were in existence at the Armistice.

After the war the R.A.F. Kangaroos were repurchased by Blackburn (except for three sold to Grahame-White in May 1919 for joy-riding activities); these were variously modified. Some were operated by Blackburn on behalf of the R.A.F. for training purposes until 1929; others served as passenger or freight carriers, others with the North Sea Aerial Navigation Co. (a Blackburn subsidiary); one Kangaroo was used in an attempt (unfortunately unsuccessful) to fly from England to Australia in November 1919; and one or two others took part in various racing events during the 1920s. The origin of the name Kangaroo is obscure: although generally adopted, it had no official standing and no apparent visual justification. There may have been a connection with the 'kangaroo bicycle', an early form of hobby-horse with a sloping spine, but this is purely conjecture.

58 & 59 **Caproni Ca 1 to Ca 5**

The belief still persists in many quarters that Britain and Germany, with their Handley Pages and Gothas, were the first to make widespread use of the aeroplane for heavy bombing. In fact, both Italy and Russia had evolved aircraft suitable for this type of operation well before the outbreak of World War 1, and Italian Ca 2s had made several long-range bombing raids on Austro-Hungarian targets well before the Handley Page O/100 had even flown.

The first Caproni giant was designed in 1913, setting the pattern for future developments. It had a central nacelle and two slender fuselage booms supporting the tail unit: the crew and all three of the engines were located within the nacelle. An 80 h.p. Gnome rotary engine drove a pusher propeller at the rear of the nacelle while two other 80 h.p. Gnomes drove tractor propellers at the front of the booms by means of a transmission gear. This arrangement proved rather clumsy in operation, and the prototype, which first flew in October 1914, had the two tractor engines installed with direct drive. The first production version was powered by three 100 h.p. Fiat A-10 in-line engines, all driving tractor propellers, and was designated Ca 1. One hundred and sixty-two Ca 1s were built in 1914–16, and aircraft of this type made the first Italian bombing raid of the war against Austro-Hungary on 20 August 1915. Nine other aircraft, designated Ca 2, had the central engine replaced by a 150 h.p. Isotta-Fraschini V-4B in-line engine. The Ca 1 and 2 continued to serve, latterly on night operations, until the appearance of the Ca 3 in 1917. The Ca 3 was generally similar to the Ca 1, having 3-bay, equal-span wings, a box-like nacelle and three polygonal rudders atop the tailplane. Much attention was paid to making the Capronis safe for taking

off or landing on rough terrain, skids being fitted beneath the lower wingtips and tail and auxiliary wheels under the front of the nacelle to prevent a nose-over. The two pilots sat side by side in the nacelle, with a gunner/observer in the front cockpit armed with a Revelli machine-gun or a cannon; the unfortunate rear gunner occupied a cage-like open position behind the trailing edge of the top wing and directly above the pusher propeller. Powerplant of the Ca 3 comprised three 150 h.p. Isotta-Fraschini V-4B in-lines. Two hundred and seventy of these aircraft were built in Italy in 1916–18; they equipped well over a dozen squadriglie of the Corpo Aeronautica Militare, and one Italian Naval squadron in Albania. Eighty-six others, built under licence in France, served with two escadrilles of the French Aviation Militaire. Several Ca 3s were still in service at the Armistice. Variants of the basic Ca 3 included the Ca 3 Mod., with detachable outer-wing sections; one hundred and fifty-three examples were built during and after the war, some of them adapted to serve in an ambulance role.

The military designation Ca 4 was applied to a series of much larger triplanes, the first of which appeared in late 1917. Side-by-side seating for the two pilots was installed, and the front gunner's cockpit was retained; but in place of the rear gunner's cage separate positions were installed in each of the fuselage booms. The Ca 4 was powered initially by three 200 h.p. Isotta-Fraschinis, but their combined output was insufficient for an aeroplane of this size. Because of this and other shortcomings only three were built with this powerplant. They were followed in 1918 by twelve examples with 270 h.p. Isotta-Fraschinis and an oval-section nacelle with tandem pilot seating. These aircraft served with Italian Army and Navy Squadrons. The final production triplane variants were powered by Fiat, Isotta-Fraschini or Liberty engines of greater power, and the pilots' seats were situated side by side. A coffin-shaped container was suspended between the main undercarriage wheels that could hold 1,450 kg. (3,197 lb.) of bombs. Twenty-three were completed, six of them being supplied to the R.N.A.S. in 1918. The Ca 4 proved to be too slow for daylight bombing and was employed principally on night operations. The R.N.A.S. Ca 4s apparently were not used for combat purposes and were returned to Italy after the war. Variants included two which had a biplane tail unit incorporating a rearward-firing machine-gun position. One of these versions was intended for the R.N.A.S., but the aircraft were never delivered. One twin-engined variant, of which at least the prototype was completed, was a seaplane with twin sprung floats and intended to carry two torpedoes; it was powered by two 400 h.p. Liberty engines. It is thought that series production was planned, but few, if any, were completed.

The Ca 5 series marked a return to a biplane configuration, and were

slightly bigger than the Ca 3s. First model in the series had three Fiat engines of 200 h.p. The wing-mounted pair were given frontal radiators, while the radiator for the middle engine was incorporated in the nose of the nacelle. War load was 540 kg. (1,190 lb.), and only two defensive machine-guns were carried. The initial version went into service early in 1918. Improved versions followed it, with three 200 h.p. Isotta-Fraschini, Fiat or Liberty engines. The Ca 5 operated mostly with Italian night-bomber squadrons in France during the last nine months of World War 1, although some were still flying on the Italian Front when the war ended. Total Italian production of Ca 5 variants reached two hundred and fifty-five, and a small batch were built by Esnault-Pelterie in France. Following the delivery of two Ca 5s to the United States, a further three of these aircraft were built in America before the war ended. Another type intended for production was a torpedo or bombing seaplane on twin Zari floats, powered by three Liberty engines. Licence production of the Ca 5 was started by Piaggio, but only ten were completed, and these were not delivered until after the Armistice.

Caproni bombers of one type or another were thus in constant service throughout the Italian participation in World War 1. Their load-carrying capabilities may not seem exceptional in relation to their size, but it must be remembered that the majority of their targets were at a great distance from their home bases, involving long flights over hazardous mountain country. Because of their size they needed strong piloting, but their excellent flying qualities and powers of endurance were well suited to the conditions in which they were required to operate. Several civil cabin conversions were planned, some carrying up to 30 passengers, but none of them appears to have seen any commercial service. However, under the designation B.1, Breda built an 8-passenger version, and one of these aircraft made the inaugural scheduled flight between Milan and Rome on 29 January 1919.

60 **Siemens-Schuckert R types**

Marking the opposite extreme in size to its neat little D type fighters (see the *Fighters 1914–1919* volume), the Siemens-Schuckert Werke G.m.b.H. of Berlin and Nuremberg was also involved in manufacturing some of the largest German aircraft of World War 1. The company, originally noted for airship construction, had closed down its aircraft department in 1911, but reopened it in 1914, at first building small monoplanes. Its first large aeroplane, designed by Forssman, was apparently based upon earlier Sikorsky four-engined biplanes, and was begun in October 1914. Powered by four 110 h.p. Mercedes engines mounted singly on the lower mainplanes, and having a wing span of 78 ft. 9 in. (24·00 m.), it was completed and flown in the spring of 1915. It was, however, considerably underpowered, and the two inner engines were replaced

by 220 h.p. Mercedes D.IVs, the outer pair of 110 h.p. engines at the same time being remounted at mid-gap. Thus modified, it resumed trials in September 1915, and in April 1916 was eventually accepted for service use as a training aircraft. Meanwhile, in late 1914 the Idflieg had authorised the development of a new, 3-engined large biplane bomber designed by the brothers Bruno and Franz Steffen.

Construction of this aircraft, designated G.I.32/15, began in December 1914, and it made its first flight, from the Steffen works at Neumünster, in the following May. Its configuration was, to say the least, unusual. The unequal-span wings carried ailerons on the upper mainplanes only, but secondary ailerons were mounted between the upper and lower wings. The fuselage comprised a nose/cabin structure having polyhedral rear faces, mated to two triangular-section tapering booms (an upper and a lower) the purpose of which was to allow a wide field of fire to the rear. The lower boom incorporated the customary ventral tunnel, also for a rearward-firing gun. The tail assembly, supported primarily by the inverted-triangular upper boom, consisted of a triangular tailplane and rectangular elevator, beneath which were a central fin, two small outlying rudders, and two auxiliary elevators.

All three Benz engines were mounted within the forward fuselage, where minor in-flight repairs or adjustments could be made, and their radiators occupied the entire frontal area of the nose. Power was transmitted via a clutch and gear system to a tractor propeller mounted on each of the inboard bays of interplane struts. Idflieg acceptance of the G.I.32/15, in July 1915, was accompanied by an order for six similar aircraft, to be designated G.33/15 to G.38/15. With the introduction of the Riesenflugzeug (giant aeroplane) category in November 1915 the designations were changed to R.I to R.VII; and again in March 1917 to R.1/15 to R.7/15 respectively.

The six new aircraft were intended originally to be powered by a trio of Maybach engines, but development problems with these units led instead to the use of 260 h.p. Mercedes D.IVas in R.II and R.VII, and 220 h.p. Benz Bz.IVs in R.III, IV, V and VI. These being of lower power than the intended installation, wing spans were correspondingly increased, compared with R.I, to 124 ft. 8 in. (38·00 m.) in R.II; 112 ft. 7½ in. (34·33 m.) in R.III and R.V; 123 ft. 4½ in. (37·60 m.) in R.IV; 109 ft. 5½ in. (33·36 m.) in R.VI; and 126 ft. 1½ in. (38·44 m.) in R.VII. Fuselage design and length also varied to some degree between the six. The R.II, the heaviest of the six at 18,651 lb. (8,460 kg.), was also the slowest, with a maximum speed of 68·4 m.p.h. (110 km./hr.); the other five could all manage top speeds of 81–82 m.p.h. (130–132 km./hr.).

In the event, only four of the SSW R types (R.IV to R.VII) were employed on operational duties,

these serving in 1916–17 with Riesenflugzeugabteilung (Rfa) 501, based at Vilna, on the Eastern Front in Russia; R.II and R.III, like R.I, remained in Germany and were employed only for training, a function to which R.IV and R.VII also were later transferred. In February 1918 construction of two even larger R types was started by SSW, but of these only R.23/16 (R.VIII) was completed. Spanning 157 ft. 5¾ in. (48·00 m.) and powered by six 300 h.p. Basse und Selve BuS.IV engines, it had a gross weight of 35,053 lb. (15,900 kg.) and an estimated top speed of 77·7 m.p.h. (125 km./hr.); but, while undergoing ground testing in 1919, it was severely damaged by its propellers following a transmission failure, and never flew.

61 **Zeppelin (Staaken) R types**
Several German manufacturers produced Riesenflugzeug (giant aeroplane) designs during World War 1, and the most successful of these, though by no means the largest, were those produced by the Zeppelin Werke Staaken. Prior to its move to Staaken in mid-1916 the team responsible for these aircraft was based at the Versuchsbau Gotha-Ost (East Gotha Experimental Works), the first such design being started in November 1914. This was the V.G.O.I, which flew for the first time on 11 April 1915, powered by three 240 h.p. Maybach Mb.IV engines. One of these, mounted in the nose, drove a tractor propeller, while the other two, mounted midway between the wings, drove pusher propellers. In the front of each of the wing nacelles was a small cockpit mounting twin machine-guns. Redesignated R.M.L.1, this machine was later employed on operations by the German Navy on the Eastern Front, where it was later joined by the V.G.O.II, a second machine of similar type. Both aircraft served with Rfa 500 (Riesenflugzeugabteilung) late in 1916, but they were seriously underpowered, and the V.G.O.I later returned to Staaken where it was refitted with five 245 h.p. Maybachs, two in each nacelle; it was later destroyed in a crash. An alternative attempt to provide sufficient power resulted in the V.G.O.III (later R.III after the introduction of the R category), in which six 160 h.p. Mercedes D.IIIs were installed. Two of these engines were paired in each nacelle to drive single pusher propellers, while the third pair were installed side by side in the nose to drive a tractor propeller. Armament was increased to five machine-guns.

The first aircraft in the series to have an R designation from the outset was the R.IV, which was basically a V.G.O.III airframe, but with the nacelle engines exchanged for four 220 h.p. Benz Bz.IVs. Up to seven machine-guns were carried by the R.IV, which entered service in July 1917 on the Eastern Front and was later transferred to the Western Front and used in raids on the United Kingdom. Work was also begun in 1916 on single examples of the R.V and R.VII, each powered by five 240 h.p.

Mb.IVs – a single one in the nose and a tandem-mounted tractor pair in each outer nacelle, the gun positions of which were relocated at the rear. A fifth machine-gun was carried in a Schwalbenest (swallow's nest) position above the top centre-section. The R.V and R.VII differed chiefly in their tailplane bracing; the former was accepted for service in September 1917 and used against London in 1918, while the latter was lost in a crash in August 1917 during delivery to its unit.

The only Zeppelin R type to go into series production was the R.VI, eighteen of which were completed, one by Zeppelin (Staaken), six by Aviatik, four by O.A.W. and seven by Schütte-Lanz. Fifteen of them were powered by four 260 h.p. Mercedes D.IVa engines, in tandem pairs each driving one tractor and one pusher propeller. With the elimination of the nose engine it was possible to install a front gun position with a ring mounting for two Parabellum weapons, and single dorsal and ventral guns were separately manned to the rear of the wings. Between these the two pilots sat side by side in an enclosed cabin. Three of the Aviatik machines, completed in 1918, had four 245 h.p. Maybachs, the cabin extended to the extreme nose and a large central vertical tail fin. The Staaken R.VI could carry internally up to eighteen 100 kg. P.u.W. bombs within the centre of the fuselage. Its maximum load was 2,000 kg. (4,409 lb.), though about half of this total was the usual average. Individual bombs of up to 1,000 kg. (2,205 lb.) could be carried semi-recessed under the aircraft's belly. Deliveries of R.VIs began in June 1917, and from September they were actively engaged in bombing raids against targets in France and England, operating with Rfa 500 and 501. During their combat career only two R.VIs were shot down by the Allies, but another eight were written off in crashes. Two R.VIs were fitted experimentally with an additional engine, a 120 h.p. Mercedes D.II, driving a compressor to supercharge the main power plant and enable the bomber to sustain its performance at greater heights.

Subsequent Zeppelin R types were built in small numbers only. They included three R.XIVs, one R.XIVa and three R.XVs all powered by five 245 h.p. Mb.IVs and armed with five machine-guns. These had three tractor and two pusher propellers and, therefore, no nacelle gun positions. The R.XVs were probably too late for operational service. Aviatik completed one example (of three ordered) of the R.XVI in October 1918, this having one 220 h.p. and one 550 h.p. Benz in each nacelle. Variants of the R.VI included the Type 8301 seaplane, three or four of which were built using R.VI wings and engine installations with an entirely new fuselage suspended mid-way between the wings and a tail assembly incorporating the large central fin of the final R.VIs. One of these machines was later fitted with a land undercarriage. The Type L seaplane, which was destroyed

during trials, was essentially a standard D.IVa-powered R.VI mounted on twin floats some 13 m. (42 ft. 7⅞ in.) long.

62 **Sikorsky Ilya Mouromets**

The world's first four-engined aeroplane, the *Le Grand*, was designed by I. I. Sikorsky and G. I. Lavrov in 1913 and flew for the first time on 13 May that year. From it was developed an even larger aeroplane, the Ilya Mouromets, which was flown early in 1914 and powered by four 100 h.p. Argus engines. Fitted with a ski undercarriage, it carried a crew of five and had compartments in the rear fuselage for sleeping and eating. In February 1914 this aeroplane lifted 16 human passengers and a dog to an altitude of 2,000 m. (6,562 ft.) and remained in the air for 5 hours. In spring 1914 ten examples of a military version were ordered for the Imperial Russian Air Service; after the outbreak of war in August this order was increased substantially by the Central Military Technical Board, and eventually nearly eighty Ilya Mouromets bombers were built.

Production aircraft were built by the Russo-Baltic Waggon Factory (R.B.V.Z.) and appeared in five basic forms, all differing in dimensions, weights and powerplant. Inadequate supplies of aircraft engines posed a constant problem for the Russian aircraft industry, and several of the Sikorsky bombers were completed with inner engines of one rating and outer ones of another. About four Ilya Mouromets Type B were completed (two 135 h.p. and two 200 h.p. Salmson/Canton-Unné). They were followed by thirty-three Type V. All but three of these machines had four 150 h.p. Sunbeam engines (a highly unsatisfactory unit); the others had two 125 h.p. and two 140 h.p. Argus engines. The twenty or so G-2s had four 150 h.p. RBVZ-6s; fifteen G-3s had a pair of these engines together with two 220 h.p. Renaults. The largest Mouromets, the E-1, was powered by four 220 h.p. Renaults. At an all-up weight of 7,000 kg. (15,432 lb.) the E-1 was also the fastest variant, with a maximum speed of 136·7 km./hr. (85 m.p.h.). Operational performance of the first pair of Mouromets bombers was so disappointing that the R.B.V.Z. was asked to suspend production. Fortunately, however, the type was reprieved, and under the command of Major-General M.V. Shidlovski (former chairman of the R.B.V.Z.) the Eskadra Vozdushnykh Korablei, or Squadron of Flying Ships, was formed specially to exploit and operate the subsequent aircraft. This was more than an ordinary bomber squadron: it was a completely self-contained unit which carried out its own test flying, training, overhaul and other activities as well.

From its base at Jablonna in Poland the E.V.K. made its first raid on 15 February 1915 over East Prussia, and from then until the Revolution in November 1917 this unit was responsible for some four hundred bombing raids over German and Lithuanian territory. During that time only one Ilya

Mouromets was lost to enemy air attack; this occurred on 12 September 1916, but not before the Mouromets's gunners had accounted for three of the enemy fighters. Two other machines were lost in crashes, and in February 1918 thirty were destroyed on their airfield at Vinnitza to prevent capture by the Germans.

Because of its size, the Ilya Mouromets needed plenty of attention on the ground and strong handling in the air; but it was a well-built aeroplane, capable of absorbing plenty of battle damage. It carried highly efficient bomb-sights of Russian design and manufacture which enabled it to score direct hits on well over 60 per cent of its targets. A typical bomb load was that carried by the G-2 and G-3, which ranged from 450–700 kg. (992–1,543 lb.). Normal defensive armament was three or four machine-guns, but up to seven could be fitted, including a turret in the tail. Basic crew, as in the Type B, was four men, but could be increased in proportion to the number of guns installed. The Ilya Mouromets also undertook long-range reconnaissance missions, for which it was ideally suited in the areas in which it operated. In December 1916 Tsar Nicholas II approved British and French requests to build the Ilya Mouromets under licence, but these options were not taken up.

63 **Caudron G.III, G.IV and G.VI**

Most nacelle-and-tailboom aeroplanes of 1914–19 were pusher biplanes; the Caudron G.III differed in having its engine at the front. It was developed from, and was similar to, the single-seat G.II which in 1913–14 was a familiar sight at many European air meetings. In its initial military form the G.IIIA.2 was a 2-seat corps reconnaissance and artillery observation aircraft used widely throughout the first half of World War 1 by the French, British, Belgian, Russian and Italian air forces. Most of the many hundreds of G.IIIs built were manufactured in France, but small quantities were built in the United Kingdom by the British Caudron Co. and in Italy A.E.R. built one hundred and seventy G.IIIs in 1915–16. The G.III was originally powered by an 80 h.p. engine, of Gnome, Le Rhône or Clerget manufacture, but a common installation in later machines was the 100 h.p. Anzani 10 C radial. The G.III had a useful endurance (4 hours), but was generally too slow and too vulnerable to be retained for long on observation duties. The French machines were withdrawn from the Front in mid-1916, but Italian G.IIIs continued to serve until March 1917 and the British models were not withdrawn from operational units until August 1917. As late as 1 January 1917 the R.F.C. was using Caudron G.IIIs, armed with small bombs and carrying a machine-gun in the front cockpit, for ground-strafing missions. The R.N.A.S. used a few of its G.IIIs for coastal patrol. One hundred and twenty-four G.IIIs were supplied to the R.N.A.S., and one hundred and

nine to the R.F.C., and they served on every major front. Their withdrawal from front-line duty did not, however, mark the end of their career, for they became one of the most popular and familiar types of training aircraft to be used in the Allied air forces. In this role the aircraft was designated G.IIIE.2; one hundred and ninety-two E.2s were purchased by the A.E.F. in 1918. Most Caudron G.IIIs had warp-controlled wings, but ailerons were fitted to the top wings of some later aircraft.

The Caudron G.IV, which appeared in March 1915, was in essence a scaled-up version of the G.III, powered by two engines. Originally these were 80 h.p. Le Rhônes, with the 100 h.p. Anzani being introduced for later production aircraft; the vertical tail surfaces were increased to four. A free-firing Vickers or Lewis machine-gun was mounted in the front cockpit, and in its G.IVB.2 day bomber form the aircraft could carry a 100 kg. (220 lb.) bomb load. Some G.IVs were fitted with a second machine-gun, mounted over the top wing to fire to the rear. Although its bomb load was modest, the G.IV had a useful performance and a particularly good rate of climb; in service it proved to be a thoroughly reliable aircraft, as is shown by its adoption by the Italian Air Force for long-range flights across the Alps. It entered service with the French Aviation Militaire in November 1915, serving until the following autumn. In Italy A.E.R. built fifty-one G.IVs in 1916–17. The R.N.A.S. received forty-three French-built G.IVs and twelve completed by the British Caudron Co. These were used in 1916 and early 1917 for day and night attacks on enemy seaplane and Zeppelin bases in Belgium by Nos. 4 and 5 Wings. Aircraft in French service included both B.2 and A.2 versions of the G.IV. In 1918 the A.E.F. purchased ten G.IVA.2s for use as trainers.

In summer 1916 a link between the G.IV and the later R-prefix bombers designed by René Caudron appeared in the form of the G.VI. This was a development of the G.IV, but incorporated many features, including the distinctive 'keeled' and covered fuselage, and single fin and rudder, of the Caudron R.4 and R.11. Powerplant for the G.VI was two Le Rhône rotary engines of 80, 110 or 120 h.p. The observer sat in the rear cockpit, in which was a ring mounting for one or two defensive Lewis guns. The G.VI was apparently built only in an A.2 form, and in view of the imminence of the R.4 and R.11 it is probable that it was not built in substantial numbers. It has not been possible to provide a breakdown by types of French squadron allocations of Caudron G series aircraft, but in all the Aviation Militaire operated thirty-eight escadrilles equipped with these aircraft during World War 1.

64 **Lohner L**

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 h.p. Hiero engines, and in August 1914 one of these aircraft (E18) made the first World War 1 sortie by an Austrian aircraft. The later S types were unarmed training versions of the Type E. About two hundred, some of them converted Es, were in service during 1914–18; most of them had 85 h.p. Hieros, but some were fitted with 80 h.p. Oberursel rotaries.

In size and general configuration the Lohner L resembled the Type E, but was powered either by a 140 h.p. Hiero or by an Austro-Daimler of 140 or 180 h.p. A slender, elegant aeroplane with sweptback sesquiplane wings, the Lohner L seated a crew of two side by side, the observer occupying the right-hand seat and having a Schwarzlose machine-gun on a rotatable mounting. Up to 200 kg. (441 lb.) of bombs and/or depth charges could be carried. The Lohner 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 Ms 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 Ls were the most widely used flying-boats of the Austro-Hungarian Navy, 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, Lt. 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. (Five Type Rs were owned in 1923 by Alfred Comte, at which time he founded the Luftverkehr und Sportfliegerschule in Zurich.) The illustration depicts one of two Lohner Ls from the Austrian Naval base at Kumbor that attacked the French Laubeuf-class submarine *Foucault* off the coast of Cattaro on 15 September 1916.

65 **Franco-British Aviation flying-boats**

The Franco-British Aviation Co. was almost entirely French in outlook and operation: its only 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 F.B.A. Type B appeared, a development of the basic Lévêque design by Louis Schreck having an upswept rear hull with an oblong rudder and a 100 h.p. Gnome Monosoupape rotary engine driving a pusher propeller. This was built in

some numbers for the Marine Nationale and the R.N.A.S. In addition to forty-four complete Type Bs (three of which it later transferred to the R.F.C.) the R.N.A.S. had twenty more of these aircraft completed by the Norman Thompson Flight Co. from French-built hulls, and a further sixty built entirely in England by the Gosport Aviation Co. 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 Type B was followed by the Type C, generally similar except for a 130 h.p. Clerget 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 F.B.A. flying-boat, and possibly the most widely built flying-boat on either side during the war years, was the 3-seat Type H. This had a less swept-up rear hull, a high, strut-mounted tailplane and roughly 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's rotary. Powerplants were Hispano-Suizas of various ratings or 160 h.p. 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 F.B.A. that, despite the pre-eminence in Italy 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 h.p. Isotta-Fraschini V-4Bs and sported a small vertical fin. Armament consisted of a single machine-gun in the front cockpit. Four Italian-built Type Hs were presented to the R.N.A.S. 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 F.B.A. Type S, had a 200 h.p. Hispano-Suiza, and increased bomb load of two 35 kg. or 50 kg. weapons. It featured an enlarged tail assembly, including a triangular vertical fin, and carried a 2- or 3-man crew. 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 wings 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 F.B.A. types.

66 **Sopwith Baby**

One hundred and thirty-six military examples of the 1914 Sopwith Schneider floatplane were built for the R.N.A.S., which used them widely for a variety of duties during the first half of World War 1. From this basic design was developed the Baby, which differed chiefly in having a more powerful rotary engine enclosed in a 'horseshoe' cowling. Five of the first one hundred Babies built by Sopwith had the same engine (100 h.p. Gnome Monosoupape) as the Schneiders, but the remaining ninety-five aircraft were fitted with 110 h.p. Clergets. This engine also powered sixty-one Babies built by Blackburn, twenty by Fairey and thirty by Parnall; the 130 h.p. Clerget was installed in one Sopwith-built machine, one hundred and fifteen by Blackburn, thirty by Fairey and one hundred by Parnall, thus bringing total Baby production to four hundred and fifty-seven aircraft. Sopwith aircraft were armed with a single Lewis machine-gun firing forward and upward at an angle through a small cut-out in the top wing; in other Babies this was replaced by a synchronised forward-firing Lewis mounted in front of the cockpit, except for forty of the Blackburn machines. This Blackburn batch carried Ranken darts or Le Prieur rockets for anti-Zeppelin attacks instead of a gun.

The Babies built by Fairey from 1916 were known as Hamble Babies, having been considerably redesigned by Fairey to have thicker wings with full-span trailing-edge flaps on all sections, an angular fin (similar to that of the Campania) and floats of improved hydrodynamic form. Fifty-six of the Parnall Babies were completed with Sopwith-type floats and tails and Fairey-type wings, and the remaining seventy-four were built as Hamble Baby Converts with a wheel-and-skid land undercarriage.

The Sopwith Baby served widely with the R.N.A.S. for most of 1917–18, at a dozen or more bases around the British coast and aboard eleven seaplane carriers operating in the North Sea and the Mediterranean. During the first half of 1917 they flew fighter patrols from Dunkirk, while in Italy, Egypt, Palestine and the Aegean they operated mainly in a bombing role. For bombing or anti-submarine work the Baby normally carried two 65 lb. bombs under the centre of the fuselage. Withdrawal of the Baby from front-line service began some time before the Armistice: the Hamble Baby Converts and several ex-operational Babies were employed in a training capacity. On 31 October 1918 there were eighty Babies of one kind or another on charge, but these were all officially declared obsolete in November. During the war period Babies were supplied to Canada (eight), France (nine), Japan (one), the Netherlands, and the U.S. Navy (one), and a few were also supplied to the Royal Norwegian Air Force after the end of the war.

67 **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 is 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.

The FF33 went into service in spring 1915 in replacement of another Friedrichshafen design, the FF29A, the first machines being six FF33As with back-to-front seating and 100 h.p. Mercedes D.I engines. They were followed by eleven FF33Bs, six with 120 h.p. D.II engines and five with 160 h.p. D.IIIs, in which the pilot more logically occupied the front cockpit. The first major production model was the FF33E, powered by a 150 h.p. Benz Bz.III, which became the standard installation on all later FF33 variants. The FF33E was also the first model to introduce wireless equipment. One hundred and sixty-two were built, plus a further three armed with a rear-mounted Parabellum machine-gun, which were redesignated FF33Fs. In 1917 the E model was transferred to the training role, its place being taken by the modernised and more efficient FF33J, of which about a hundred were completed. Thirty modified Js were also built as FF33S trainers.

Before the FF33J, however, there had appeared a slightly smaller variant, with 2-bay wings and a ring-mounted Parabellum gun for the observer. This was the FF33H, produced as a seaplane fighter or escort to the unarmed FF33s in 1916; forty-five of these were built, L.V.G. and Sablatnig sharing with the parent company the manufacture of the E and H models. The most effective model of all was the FF33L, which was a slightly smaller development of the H with a spinnered propeller and provision for a forward-firing second gun; it was more manoeuvrable and had a better performance than its predecessors. One hundred and thirty-five FF33Ls were built.

The FF39 was an interim design, which appeared in 1917 with a strengthened and refined fuselage, 200 h.p. Benz Bz.IV engine and rear-firing Parabellum; fourteen were completed. The principal Bz.IV-powered model, however, was the FF49, of which twenty-two FF49Bs and two hundred and eighteen FF49Cs were built by Friedrichshafen, L.F.G. and Sablatnig. The Bs were unarmed, but most Cs had a rear-firing Parabellum and at least thirty of the late-production machines in 1918 had two guns fitted. Apart from the 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 greater range than its predecessors. Friedrichshafen built forty-four seaplanes after the war, in 1918–19, but it is not known what types(s) these were. The only 'in service' figures available are those for FF33 variants in May 1917: these included one hundred and twenty-one Es, twenty-five Hs, thirty Js and one hundred and fourteen Ls.

APPENDIX 1

The research into the aircraft colour schemes illustrated in this volume is the work of Ian D. Huntley, A.M.R.Ae.S., whose studies of aircraft colours and markings have been made over a period of more than twenty years. Ian Huntley was one of a small team of experts formed from members of the Royal Aeronautical Society and the Society of Licensed Aircraft Engineers in 1958 to undertake full-scale restoration work on the aircraft of the Nash Collection, which was bought by the R.Ae.S. in December 1953. With the title Historic Aircraft Maintenance Group, this body began work at Hendon, transferring its activities later to the B.E.A. Engineering Base at London (Heathrow) Airport. After 1 April 1964 the aircraft were gradually dispersed to various R.A.F. stations in the United Kingdom for continued restoration, and are now on permanent loan to the Royal Air Force Museum at Hendon for display. Effectively, this meant that the official duties of the H.A.M.G. ceased towards the end of 1965, but Ian Huntley and A. S. Hughes, the H.A.M.G.'s Chief Engineer, continue to act as civilian consultants on the subject of historic aircraft restoration.

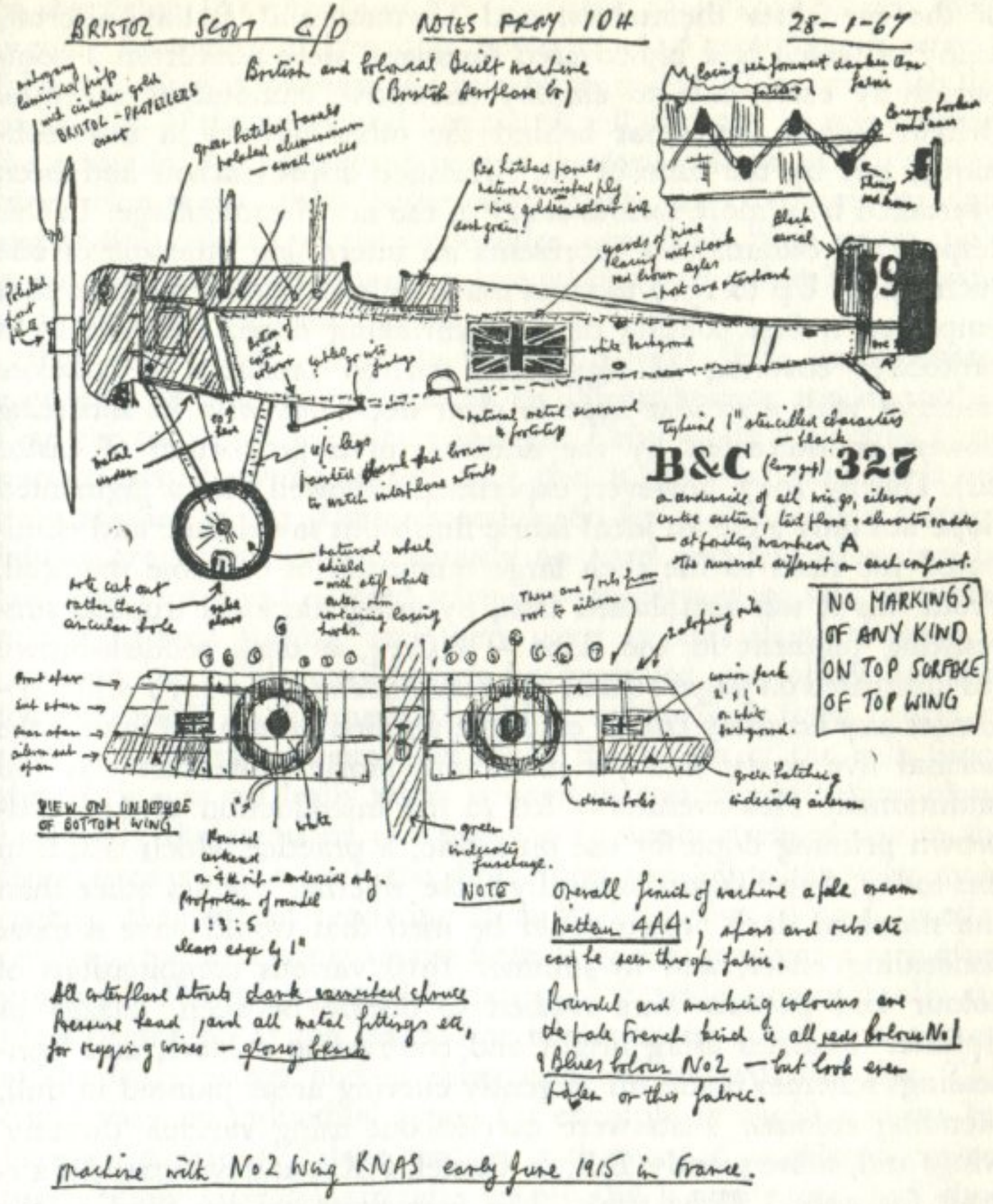
Soon after the move to Heathrow an appeal was made for information that would contribute towards restoring the various aircraft in authentic colour schemes, and a landslide of 'bits and pieces' arrived in response. In August 1961 a second similar appeal brought a second similar flood of information and material. Inevitably, much of it was too vague or contradictory, and the only satisfactory way to solve the problems and establish the true colour finishes was to trace the original paint specifications and to approach manufacturers to re-create paints and materials from them. Ian Huntley became a 'one-man Specifications Committee' charged with this task and with classifying and authenticating the material submitted. As a result he was in a unique position to advise on the completion of the colour illustrations in this volume, and the real hues of many colours can now be seen for the first time since World War 1.

Such research proves, if proof is needed, that the only really

satisfactory method of recording and relaying colour information must be based on first-hand inspection of the colours concerned, whether *in situ* on present-day aircraft or in the form of re-created samples; these must then be related to a comprehensive dictionary of colours which gives a key 'code' for individual shades of a given colour. This is the formula adopted in preparing the illustrations in this series, for which we use as our main colour dictionary *The Methuen Handbook of Colour* by A. Kornerup and J. H. Wanscher.* This handbook gives a spectrum of colour variations that are especially well related to aircraft paint finishes through the years, and when correct colour values, using this handbook to code them, are compared with most existing verbal or pictorial representations of specific aircraft types, the need for a standardised scheme of reporting and portraying colour values is self-evident; and the inadequacy of mere verbal descriptions, such as 'dark green' or 'pale blue', is also woefully apparent – there are dozens of them. The need to have a standard system is especially urgent in the case of aircraft of the 1914–18 period, where the number of people with first-hand knowledge of these aircraft is diminishing rapidly.

There is still, unfortunately, an almost unbelievable lack even of good basic general knowledge about aircraft colour finishes – something like *eighty-five per cent* of the material submitted to the H.A.M.G. was either the result of guesswork or the perpetuation of a long-standing fallacy. Much of the guesswork undoubtedly arises from the fact that most photographs taken during the war and reproduced then or since were taken on film which was not colour-sensitive and which in any case gave only a black and white result. A little orthochromatic, and even less panchromatic, film was then available which, with appropriate colour filters, could give a more accurate tonal rendering of colours within the limits of a black and white medium. Uncertainty regarding the type of film used to take a particular photograph is therefore a contributory factor: one type, for example, may make a red rudder stripe appear darker than a blue one, while another type will give the reverse effect. All too often an inaccuracy arises, probably quite innocently, from an incorrect deduction made from such evidence; and 'for want of a nail' the error gradually gathers weight as more and more followers accept it and repeat it until it attains the status of an unassailable

* First published by Politikens Forlag, Copenhagen, in 1961, and by Methuen & Co., London, in 1963 (revised 1967).



Typical sketch produced by Ian Huntley as a basic guide for artists preparing the colour plates in this series.

fact. There is not the space here to discuss individual cases at length, but one of the commonest misconceptions, which concerns the British P.C.10 khaki finish of World War 1, is dealt with in some detail in Appendix 2.

World War 1 was as much a forcing ground for the evolution of aircraft protective finishes – in all senses – as it was for the design

of the machines themselves, and German and Italian aircraft, many of which had ply-covered fuselages, were able from a comparatively early date to employ disruptive camouflage schemes. Britain lagged somewhat behind the other powers in this technique, but by the time of the Armistice improvisation had been overtaken by a more serious study of the art of camouflage. In this respect the Salamander represents an interesting outcome of one such study. Up to 1917 use was made only of doping schemes that employed a first coating of clear shrinking dope, followed by a protective covering of pigmented varnish medium (a cellulose material with a similar base to clear dope but with its shrinking powers counteracted by the addition of a proportion of castor oil). During 1917, however, experiments showed that a pigmented dope not only gave an ideal fabric finish but saved time and eliminated the need to use such large quantities of cellulose material. From this it was established that, by using the ideal tropical sun-resisting pigment in the dope – P.C.12, a dark reddish-brown (as illustrated on pages 18 and 83 of the *Fighters 1914–1919* volume) – almost any finishing colour could be applied on top, all within the normal five coats, and yet maximum fabric protection was still maintained. This eventually led to the introduction of dark red-brown priming dope for use on fabric, a practice which is still in use today. Speculation naturally arose whether colours other than the standard dark brown could be used that would have a more concealing effect, and in summer 1918 various combinations of colour and pattern were studied to decide between 'dazzle' or 'splinter' schemes using bright and contrasting colours, and 'concealing' schemes made up of gently curving areas painted in dull, blending colours. Tests were carried out using various 'dummy' wings and, subsequently, B.E.2c, Camel, F.K.3 and Salamander aircraft for actual flight trials. The four matt colours used in the Salamander scheme were advertised in later years by Cellon Ltd. as 'Salamander colours', and several contractors building British observation aircraft were asked to prepare drawings showing the aircraft in these colours.

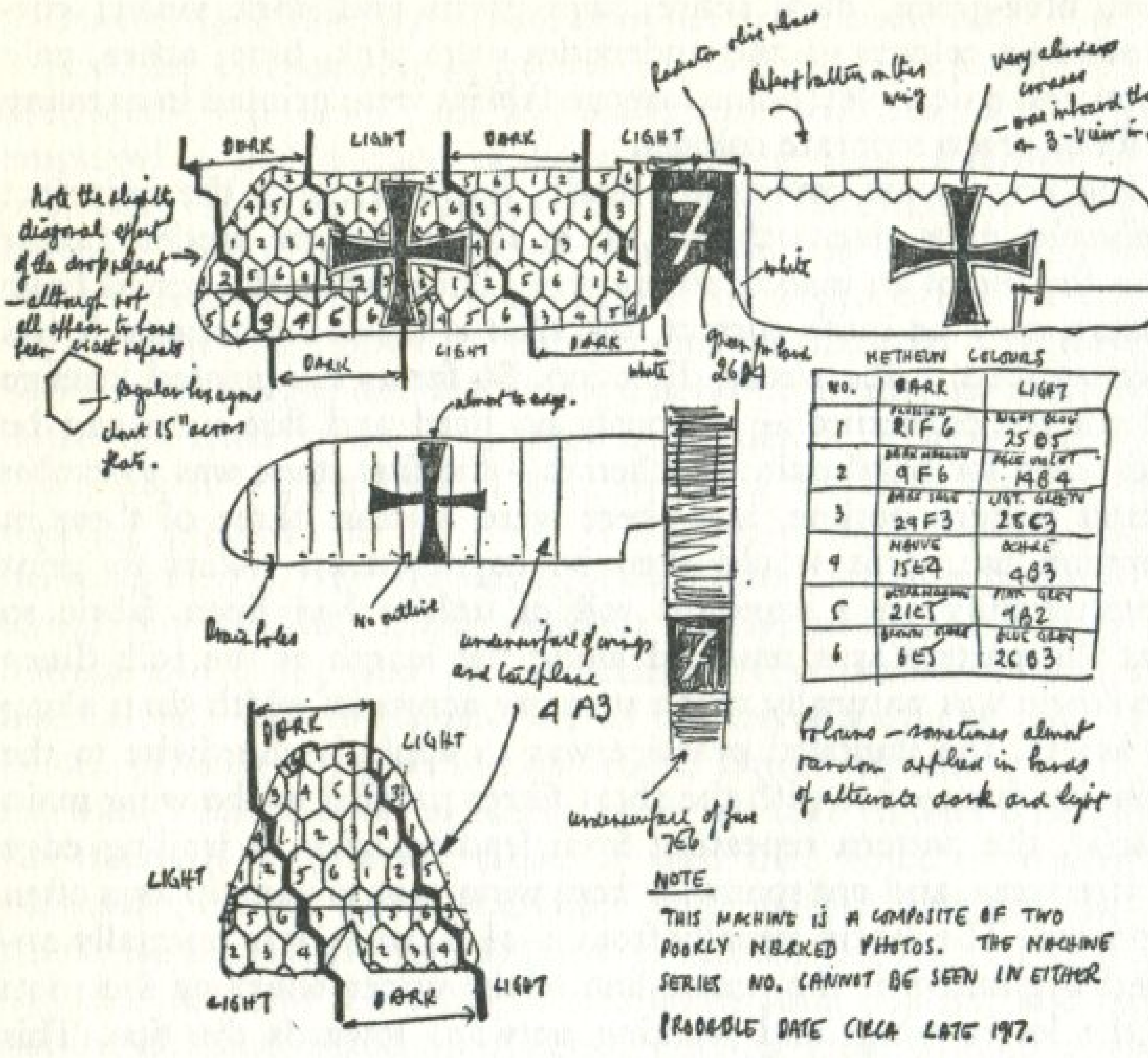
Other traps for the unwary exist when dealing with the 'lozenge' finishes adopted by the German and Austro-Hungarian air services. For one thing, there were probably more distinct patterns and colour combinations in printed schemes than is usually appreciated, quite apart from hand-painted schemes applied extempore by units

in the field. The shapes of the 'lozenges' themselves varied from regular hexagons to irregular polygons, and generally a second fabric, of similar pattern but lighter tones, would be used for the undersides of the wings and horizontal tail surfaces. In one scheme, for example, the upper-surface and fuselage colours were Prussian blue, blue-green, dark ochre, sage green and dark violet; corresponding colours on the undersides were pink, blue, ochre, pale green and pale violet. Some lozenge fabrics were printed in as many as six or seven separate colours.

The error most commonly made, however, is in the incorrect *application* of a given scheme to an illustration or model, rather than the use of an inaccurate pattern. Thus, while the actual basic pattern may be quite correct, the *effect* is incorrect because it has been applied in the wrong direction. So far as the printed lozenge fabrics are concerned – obviously no hard and fast rules can be laid down for hand-painted schemes – the first stage was to evolve a unit pattern outline, and there were at least three of these in common use. This would then be engraved on rollers to print longitudinally on a standard roll of unbleached linen fabric so that the pattern was repeated along the length of the roll. Since the fabric was naturally much stronger across its width than along its length, the standard practice was to apply it chordwise to the flying surfaces – i.e. with the short fibres parallel to the wing main spar(s), the pattern repeating from leading edge to trailing edge or vice versa, and not spanwise from wing root to wingtip as is often supposed. The fabric, usually from 4–4½ ft. wide, was normally applied beginning at the centre-line of the upper wings or the roots of the lower wings and working outward towards the tips. This could vary on individual types, for example to avoid a seam between two strips of fabric coming in the way of an aileron control wire. Many German aircraft, mostly the larger types, had their wing fabric applied at 45 degrees to the leading edge, whereas British practice was to discourage this arrangement during the war period.

The above remarks apply of course to ex-works machines; repairs in the field would often have to be made with any odd length of fabric available, which would not necessarily be applied in the correct way or even be of the correct pattern. Movable flying surfaces – ailerons, elevators and rudders – and sometimes tailplanes did not always conform to standard practice. Because

of their small areas and often irregular shapes, fabric might be applied to these components in whatever was the most convenient way, so that the pattern could run in any direction compared with that on the main airframe. Covering the fuselage was a relatively



Austro-Hungarian hand-painted hexagons.

simple matter of making an 'envelope' of two, three or more longitudinal strips of fabric, depending on the size of the aeroplane, sewn together and laced up along the centre-line underneath. Sometimes ply-covered sections of aircraft – e.g. Albatros fighter fuselages or Gotha bomber noses – would be wrapped transversely in lozenge fabric to provide a hasty camouflage effect.

An interesting variation on German fabric finishes is the 'streaky' effect produced on some aircraft *circa* 1917 and excellently illustrated in the plate depicting the Fokker Dr.I. These aircraft came at a time when Germany was making every effort to use only

cellulose for shrink-dope purposes and was evolving schemes to use dyes and other paint forms for its camouflage and markings. (The greatest shortage, incidentally, was of good red-pigmented materials, and explains why the use of red at this time was such a mark of the 'ace'. Only pilots of particular eminence could command the priority for materials in such short supply.) Over the yellowish (i.e. unbleached) linen Fokker tried applying a dark olive varnish, very sparingly, which gave a 'brushed-out' effect. This was then coated with a dark linseed-oil varnish which had the effect of transforming the dark olive to a brownish shade of green and the yellowish fabric that showed through it to a more orange shade.

These notes, brief as they are, show a few of the traps that exist for the student of aircraft colour schemes, and how easy it can be to fall into some of them. They will only be eradicated by more research, and by a wider publication of the results of that research. Many enthusiasts, in all parts of the world, are carrying out this kind of work with the same dedication and diligence that characterises Ian Huntley's efforts in this field. Sometimes the results of their labours are fortunate enough to get into print, but in all too many cases they do not. Through the medium of Blandford colour series it is hoped that the results of research of this kind can be made available economically to a wide circle of aviation enthusiasts who, for whatever reason, have a need for accurate reference on this subject. As already emphasised, verbal descriptions are especially valuable if they are based on first-hand knowledge or observation and can be related to a comprehensive colour dictionary – either the one already cited or a suitable alternative such as the U.S. Federal Standard publication F.S. 595a.

No single writer, historian or artist can hope to be a 'one-man encyclopaedia' of such a vast subject, and constructive help, be it in the form of fabric or paint samples, colour illustrations, verbal description of individual or national finishes, or any other form, will be welcomed – either by Ian Huntley, care of The Royal Aeronautical Society, 4 Hamilton Place, London W1V 0BQ, or by the author, care of the publishers.

APPENDIX 2

by Ian D. Huntley, A.M.R.Ae.S.

The basic colour in which the upper surfaces of most British aircraft on the Western Front were finished has been referred to repeatedly in the past as 'khaki green' or even 'dark green'. The latter description is inaccurate, and the former sufficiently imprecise to mislead. The actual specification differed in constituent details over the four war years, but the early form, introduced as a varnish from 1916 onward, was mixed in a ratio of approximately 17 parts yellow ochre to 1 part lamp black (carbon black), by weight of dry pigment. This was not such an unbalanced mixture as it sounds, since the yellow ochre weighed fairly heavily while the lamp black was extremely light in weight. When mixed together the only possible pigmentation result is a khaki-brown shade, as discussed in detail later. What has given rise to the 'green' part of earlier descriptions is that, for protective purposes, this dry mixture was intermixed with cellulose acetate, oil varnish, or some other glossy liquid medium, producing an optical effect known as 'green shift' which gave the finished coat a tendency to look slightly greenish under certain light conditions. (All British finishes, except some of the late-war night colours, were highly glossy in their original state.) An ex-works aircraft could therefore show a tendency towards a greenish-brown shade – though still predominantly brown – but once the material had 'weathered' after the aircraft had been in service for a while the effective colour was a positive brown. Re-created paint samples and the inspection of actual fabric samples from contemporary aircraft bear this out.

In later years, as an aid to production at a time of materials shortage, the two original pigments were mixed in their original proportions and canned under the name 'Standard Khaki'. It was added straight from the can to the most readily available base medium, and its final coloration was accordingly dictated by the medium chosen; for example, mixing with an oil varnish would

produce a greater degree of 'green shift' than mixing with cellulose acetate, and both shades could be observed on one airframe, the former finish applied to ply panels and the latter to upper-surface fabric. (An incidental point, often overlooked in describing or illustrating World War 1 colour schemes, is that often this dark finish was carried round and under the leading, and sometimes the trailing, edges of the flying surfaces for an inch or two, depending upon the size of the aeroplane, giving them an 'outlined' effect when seen from below.)

The British Khaki finishes

A protective coating or covering for the flimsy, fabric-covered flying surfaces of early aeroplanes was essential for two basic reasons: to keep the fabric stretched tautly over the main structure, and to prevent it from rotting under all conditions of use and weather. After various unsuccessful earlier experiments, an Advisory Committee for Aeronautics was set up in Britain in 1909 which, in conjunction with the Army (later Royal) Aircraft Factory, made a significant contribution towards solving this problem by evolving a series of P.C. (Protective Covering) varnishes. The Protective Covering studies were part of a series of experiments, started in early 1914, to find an ideal pigmentation that could be applied over clear-doped aeroplane fabric to shield it from the rapid rotting caused by the injurious (ultra-violet) rays of the sun. Most successful of the original P.C. series was P.C.10, then described as a dark khaki varnish, which afforded not only protection from the sun in a temperate climate but also a degree of camouflage when seen from above.

Patent rights on the P.C. series were taken out, and they became the only materials approved by the British War Office for use on the fabric of aircraft built for the Royal Flying Corps. The Admiralty's Air Department, being at that time a separate and autonomous organisation, chose not to be bound by the conditions imposed by the War Office, and freely purchased proprietary materials, including dopes and varnishes, which did not – and could not – conform to the patented P.C. series, in either constituent materials or colour, until R.F.C. and R.N.A.S. materials were standardised in 1916, following the formation of the joint-service Air Board. Before 1916, therefore, there were *two* forms of this protective

finish: P.C.10 for aircraft built for the War Office, and Proprietary Khaki for aircraft built for the Admiralty.

Because of their 'freelance' nature, the Proprietary Khakis naturally varied in both chemical composition and hue, but the re-creation of many of these was facilitated by reference to published Admiralty formulae in which actual pigment proportions were given. Hence, in recent research to re-establish the nature and coloration of P.C.10, it was possible first to reproduce and eliminate a series of varnishes which were *not* P.C.10. Having done this, it was then necessary to isolate the original P.C.10 non-shrinking cellulose top-coat varnish from other finishing materials which, although using the pigments of P.C.10, were of a different chemical composition. (It is important here to realise two things. First, that the designation P.C.10 applied to the dry pigment used to colour the protective medium, and not to the finishing medium itself: in different chemical forms it was a constituent in at least four different forms of dope or varnish, producing in each a correspondingly different colour value. Second, that different media and systems of application over the years also resulted in different colour values.) The early varnishes incorporating P.C.10 pigments were applied directly to the fabric in three or four coats, followed by two or more top coats of clear, non-shrinking varnish. At a later stage, P.C.10 was applied in varnish form as two finishing top coats over five coats of clear, shrinking dope. The final P.C.10 dopes, using darker pigments, in greater proportions and in a different medium, were applied in three or four coats directly to the fabric.

Any assessment of P.C.10 colour values must, therefore, have as its basis the nature and proportions of the pigments involved. These were specified as natural oxide of iron (yellow ochre), darkened by the addition of a little lamp black (see opening paragraph). Ochre occurs in nature in a range of colours from dull yellowish-brown to light reddish-brown, depending upon the nature of any impurities in the soil where it is found and upon the proportion of ferric oxide (Fe_2O_3) which it contains; the greater the Fe_2O_3 content, the purer it is and the nearer it lies to the reddish-brown end of its colour range. Initially, the early P.C.10 varnishes called for a minimum ochre content of 30% Fe_2O_3, the first pigmented dopes for not less than 40%, and the later dopes not less than 60%. Although less critical to the final colour, the degree of purity of the carbon black pigment was also dictated by the P.C.10 specification.

Thus the early varnishes, having a low proportion of Fe_2O_3 in the pigment and being spread thinly on the fabric, resulted in a light olive-brown hue. The later dopes, with a higher percentage of pigment (which helped to save cellulose), appeared denser, more opaque, and of a more yellowish-brown colour. The introduction of P.C.10 pigments in linseed oil and long oil (copal type) varnishes, again in different proportions and strengths, produced further variations in final hue. It is the variety of application media – oils, varnishes, cellulose – which, with their optical effect of 'green shift' on a newly-finished aircraft, gave rise in the past to the oft-repeated 'dark green' or 'khaki-green' descriptions of aircraft finished in P.C.10 shades. At last, the exposure of this fallacy is becoming more widely recognised, although regrettably it is still perpetuated by some 'authorities' on the subject.

One other factor to emerge from the wartime use of these finishes was that a cellulose medium cannot be applied over an oil-based one (although the reverse was acceptable in an emergency). This necessitated a careful system of identifying various finishes by stencilling doping code letters on the finished surfaces, and the Air Board sought to standardise a single doping scheme for the fabric of all front-line aircraft, regardless of service. In the event, however, materials shortages and distribution and other problems prevented this ideal from being reached and, indeed, the doping code system became of increasing importance as more and more alternative doping and paint schemes came into being. The three main classes of doping/finishing schemes were as follows:

Class A
Using a clear, shrinking cellulose dope with a top coat of non-shrinking pigmented cellulose varnish. Introduced in April 1916 and remained in use throughout the remainder of the war. Consisted usually of five coats of clear dope and two of pigmented varnish (e.g. P.C.10, P.C.12, NIVO or black). When used initially in a Class A scheme, P.C.10 varnish could be applied also to metal and plywood components, and ex-works schemes usually called for such an application.

Class B
Using an opaque, shrinking cellulose dope with a top coat of clear, non-shrinking cellulose varnish. Introduced gradually during the

latter part of 1917. A much-improved scheme, consisting usually of three coats of pigmented dope and two top coats of clear varnish, the latter acting as a waterproofing agent. Finish lasted longer than that of Class A and was quicker to apply, but used greater quantities of basic pigment. Introduction of Pigmented Oil Varnishes (P.O.V.) was necessary for painting metal and plywood components, saving valuable cellulose while giving an oil finish to match cellulosed fabric. Partially phased out in 1918 in favour of Class C.

Class C

Using a waterproof, opaque, shrinking cellulose dope only. Introduced from early 1918, this was a much superior scheme giving a much longer-lasting finish, often with the application of only three coats. Like Class B, it saved basic cellulose but required much more pigment, solvents and softeners.

There were, of course, variations from standard. Some engine cowlings were left unpainted; in 1917 some aircraft appeared with P.C.10 cellulose on fabric upper surfaces and P.O.V. Standard Khaki (the official name of the P.C.10 P.O.V.) on the plywood and metal surfaces. During the early part of 1918, as Class B and C finishes called for greater quantities of basic pigment materials, a shortage of P.C.10 pigments led to the use of a dark grey P.O.V., or other shades of grey, as an alternative to P.C.10; and some aircraft, by mid-1918, displayed a mixture of grey P.O.V. cowlings and plywood surfaces with Class B finish on the wings only. No one scheme completely superseded another, which was why the 'finishing marks' on the fabric were so important.

Summary

The designation P.C.10 refers to the khaki-producing *pigment chemicals* used in early experiments. The actual range of colours resulting from the use of those pigments depended upon their purity, their proportions and the base medium with which they were mixed. The original specification called for this to be a nitro-cellulose (non-shrinking) varnish, but later specifications introduced acetate/nitro-cellulose (shrinking) dopes, spirit/oil varnishes (P.O.V.) and other media incorporating P.C.10 pigments, and each medium affected slightly the resulting coloration. Gradual weathering of aircraft in service affected this further still. Despite these possible

variations, the control exercised over paint finishes from April 1916 onward kept them all within a fairly well-defined avenue of colour, and the table below shows the approximate colour 'envelope' of Methuen reference numbers within which the great majority of shades can be said to fall. This table is based upon 48 original samples of fabric, and 32 reconstructed paint samples made from original specifications. The early-war Proprietary Khakis of Admiralty-sponsored aircraft were greener by comparison, and came generally within the Methuen range 3 F 8 to 4 F 8 .

P.C.10 covering range, from light khaki varnish to brownish P.O.V.

FABRIC STATE	A	B	C	D
	Lightest	Normal	Dark	Darkest
	Greenish-ochre	Greenish-brown	Brown-green	Almost all-brown
New*	3 E/F 7	4 F 7	4 F/G 7	4/5 F 6
Moderate wear	3 E/F 5	4 E/F 5	4 F/G 5	4/5 E/F 4
Well worn	3 E/F 4	4 E/F 4	4 F/G 4	4/5 F 2
Average	3 E/F 5/6	4 E/F 5/6	4 F/G 5/6	4/5 F 4/5

* Based on Air Board colour master.
Note. E or G values lighten or darken only marginally.

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by Kenneth Munson

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