The "Bristol" Connection

Rolls-Royce

BAE SYSTEMS

ROYAL AIR FORCE HISTORICAL SOCIETY

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ABBREVIATIONS

AAP	Aircraft Acceptance Park
A&AEE	Aircraft and Armament Experimental Establishment
AONS	Air Observers Navigation School
ASR	Air-Sea Rescue
AST	Air Staff Target
ATC	Air Training Corps
BAWA	The British Aerospace Welfare Association
CANS	Civil Air Navigation School
CB	'Seabees' - US Navy Construction Battalions
CCF	Combined Cadet Force
CFI	Chief Flying Instructor
CFS	Central Flying School
C/TOL	Conventional Take Off and Landing
DTI	Department of Trade and Industry
EFA	Experimental Fighter Aircraft (aka Typhoon)
EFTS	Elementary Flying Training School
ERFTS	Elementary and Reserve Flying Training School
Gmbh	*Gesellschaft mit beschränkter Haftung* (ie 'Co Ltd')
Hp	High pressure
IRBM	Intermediate Range Ballistic Missile
ITP	*Industria de Turbo Propulsores*
LG	Landing Ground
MoD(PE)	Ministry of Defence (Procurement Executive)
MTU	*Motoren- und Turbinen-Union GmbH*
OCU	Operational Conversion Unit
OTU	Operational Training Unit
RAE	Royal Aircraft Establishment
RAeC	Royal Aero Club
RAeS	Royal Aeronautical Society
RAFO	Reserve of Air Force Officers
RLG	Relief Landing Ground
RBS	Royal Bank of Scotland
RFS	Reserve Flying School
STOVL	Short Take Off and Landing
TTTE	Tri-National Tornado Training Establishment
UAS	University Air Squadron

THE Bristol CONNECTION

BAWA, FILTON, 21 OCTOBER 2010

WELCOME ADDRESS BY THE SOCIETY'S CHAIRMAN

Air Vice-Marshal Nigel Baldwin

Good morning ladies and gentlemen. It is a pleasure to see so many members of the Society here but others too who have been attracted by the subject. If you, our visitors, like what you see, I do hope you will be tempted to join the Society – not least so that you will then receive a 'hard back'copy of the journal which we will produce recording the essence of the day. Not for the first time at a seminar spent here at the BAWA, we have been given some financial help to mount the day by BAE Systems and by Rolls Royce. That help means that we will be able to cope with the extra expense of producing the journal in hardback. We are most grateful to the two companies for their support.

This is the fourth time in our 24-year history as a Society that we have been welcomed here at the BAWA. We are, of course, extremely grateful to Jim Bishop, the Chairman, and his colleagues for allowing us to use their facilities. It is a splendid place that you can be very proud of and we are delighted to take advantage not least so that members who live a long way from our usual venue, the RAF Museum at Hendon, have a chance to attend one of our meetings.

Our Chairman today, Air Chief Marshal Sir Peter Squire, joined the Royal Air Force as a Cranwell flight cadet in 1963. His operational flying included tours on the Hunter, Harrier and Tornado. He commanded No 1 Sqn's Harriers during the Falklands War in 1982, (where he was awarded the Distinguished Flying Cross), the Tri-National Tornado Training Establishment at RAF Cottesmore, Nos 38 and 1 Groups, and was then Air Officer Commanding in Chief of Strike Command. With much experience in the Ministry Defence too, he was appointed Chief of the Air Staff in April 2000 and retired at the end of July 2003. He is now the Chairman of Trustees of The Imperial War Museum and was Vice-Chairman of the Commonwealth War Graves Commission from 2005 to 2008.

Having spent, like me, much of his flying career being kept airborne by Bristol and Rolls Royce engines, he is well placed to keep us on track today.

Sir Peter – you have control

A couple of war-winning classics – Bristol fashion.
The Bristol Fighter of WW I and the Beaufighter of WW II.

OPENING REMARKS BY SEMINAR CHAIRMAN

Air Chief Marshal Sir Peter Squire GCB DFC AFC DSc FRAes

Good Morning everyone, and may I add my own words of welcome to those of the Society's Chairman. It is a great pleasure to have been invited to chair this seminar, entitled 'The Bristol Connection'. As we all know, this year marks the centenary of the creation of the British and Colonial Aircraft Company, founded here at Filton on 19 February 1910 by Sir George White, the owner of the Bristol Tramways. At Larkhill on 21 September that year Captain Bertram Dickson flew his Bristol Boxkite to recce Army manoeuvres on the plain and report their dispositions. That was the first recorded use in Great Britain of a powered aircraft to conduct military operations.

By 1913 the company employed some 400 staff. They operated a number of flying schools and trained half of the nation's aviators and we shall hear more of that later. Suffice to say, acquiring an aviator's certificate in those days cost £75. In 1920 the links to Bristol city were formalised by renaming the firm the Bristol Aeroplane Company and by 1938 Filton was the world's largest aerospace manufacturing facility. It is now the only site with an unbroken history of more than 100 years of development and production. That said, there have been many structural changes along the way. In 1956 the company split into Bristol Aircraft and Bristol Aero Engines but with the subsequent merging of the aircraft companies it became part of the British Aircraft Corporation, while the engines side merged with Armstrong Siddeley to form Bristol Siddeley which was, in turn, purchased by Rolls-Royce in 1966.

Today we shall hear many famous names, from both stables – Bulldog, Blenheim, Beaufighter, Brabazon, Britannia and Belvedere, to mention just a few, and on the engine side – Jupiter, Mercury, Hercules, Centaurus, Orpheus, Olympus and Pegasus. I finish with Pegasus because, although today is Trafalgar Day, 21 October also marks the fiftieth anniversary of the first hover flight by the P.1127. So the Pegasus has now been a Bristol project for fifty years and, in that connection, it was a great sadness to learn of Gordon Lewis' death earlier this month. Gordon was the brains behind the Pegasus. He should have been here today and I am sure that he would have been as

disappointed as any of us at the news that the Harrier is to be withdrawn from service in the near future. He was a quiet, unassuming man but with a great sense of humour as I learned to my benefit when he took me on a trip to the United States in 1983 to talk about the effectiveness of the Harrier/Pegasus combination in the South Atlantic in 1982. His contribution had been enormous because, apart from the Pegasus, he had been responsible for the development of the Olympus, the RB199 for the Tornado and the early development of the EJ200 for Typhoon. He was made a CBE on retirement in 1986 and, very rightly, recognised by the Rolls-Royce Heritage Trust with their Life Time Achievement Award and I am sure that you would wish to join me in saluting an outstanding aero engineer. (*Spontaneous applause*)

We have a very busy programme today so I do urge everyone to keep to time and resist the temptation to go off piste and ad lib. So without more ado, I will introduce our first speaker.

On 19 October, just two days before the RAFHS held its seminar, the Government revealed the outcome of its Strategic Defence and Security Review. It included the imminent withdrawal from service of the Harrier and with it the brilliant Pegausus engine, one of Bristol's most innovative products. (Staff Sgt Aaron Allmon)

THE BEGINNING – THE WHITE FAMILY

Sir George White

Sir George White is an historian, writer, museum consultant and horologist. Keeper of the Museum of the Worshipful Company of Clockmakers since 1988, and a Fellow of the Society of Antiquaries, he has published on many aspects of horology and, of more significance to this seminar, his Tramlines to the Stars *(Redcliffe Press, Bristol, 1995), is a brief biography of his great grandfather, Sir George White (1854-1916), stockbroker, entrepreneur, tramway pioneer and founder of the Bristol Aeroplane Company.*

When I was invited to contribute a short piece entitled 'The Beginning – the White Family' to your Society's seminar, I was both honoured and perplexed. Honoured, to be invited to speak at such an august meeting, but perplexed because I was invited to speak on a subject which to me, makes little sense.

The Bristol Aeroplane Company (and its predecessor, the British and Colonial Aeroplane Company) was founded by Sir George White 1st Baronet, Bristolian, 'self-made' entrepreneur, philanthropist and visionary. While his contribution to the aircraft industry and to the formation of an aerial fighting force in this country was of outstanding importance, he died only eight years after he had first taken up the subject and six years after his pioneering company had been established. His son however, Sir Stanley White, served as managing director from 1911 until 1952 and Deputy Chairman from 1952 until his death at the age of 82 in 1964. Thus he oversaw the development of Bristol aircraft from the Boxkite to the supersonic Type 188 and provided aeroplanes for the Royal Flying Corps and the Royal Air Force from the Bristol Scout, through the Bulldog, the Blenheim and the Beaufighter, to the Britannia.

Sir Stanley was a modest man, who, through a twist of fate, never inherited his father's controlling interest in the Company. Nevertheless it was he who guided it through the depression which followed the First World War. It was he who took the major risk that was the acquisition of the Cosmos Engineering Company. It was he

Left, Sir George White, 1st Bt – founder of the British and Colonial Aeroplane Company and Chairman 1910-1916. Right, Sir Stanley White 2nd Bt – Managing Director 1911-1952 and Deputy Chairman 1952-1964.

who had the near impossible task of providing both financial backing and restraint to the irrepressible Roy Fedden. It was he who, for all but nine years of the Company's existence, quietly provided the opportunity for all the other great engineers and designers that the company employed, to exercise their genius.

His son, my father (another Sir George White), who had been responsible for the wartime production of Blenheim and Beaufighter airframes at Filton and later the establishment of Bristol Cars, was still joint Managing Director when his grandfather's company was finally forced, by the government, into mergers and into history. The idea therefore that the White family are linked only to the first years of the Bristol Aeroplane Company and that thereafter the company became a faceless industrial conglomerate is wrong. It is a myth (commonly repeated) which almost certainly began the day that the first Sir George quite deliberately chose to name his aeroplanes in honour of his native city and not in honour of himself.

That said, I have no doubt that the purpose of inviting me to speak today was to set the scene for the talks that follow and so we must return to Bristol in 1854, where the first Sir George White was born.

George White's father was a painter and decorator, his mother was a lady's maid. He was briefly educated at St Michael's Boys School, leaving at fourteen to work as an office boy at a firm of Bristol commercial solicitors. There he was put in charge of the Bristol Law Library. Instead of simply dusting the books, he read and understood them and at the almost unbelievable age of sixteen, was promoted to run the bankruptcy side of the practice.

At eighteen, he was instructed to put together a consortium of Bristol businessmen to take over Bristol Council's failed attempt to establish a horse tramway in the city. This he did with such success that he was soon appointed Company Secretary, not only of Bristol Tramways, but of Bath and Gloucester Tramways also. Refusing his articles, he set himself up in Bristol as a stockbroker and public accountant. He specialised in transport shares and with the financial support of William Butler (a protégé of Isambard Kingdom Brunel), who chaired both Bristol Tramways and a Bristol bank, he began to acquire controlling interests in failing tramway and railway companies. Taking over their management, he turned them to profit, gradually building for himself a nationwide tramway empire. This, at one time or another, extended to Bristol, Dublin, York, Stockton, Middlesbrough, Reading and London.

George White had an extraordinary ability to select the best in new technology and to apply it before his rivals did. With his lifelong friend James Clifton Robinson as engineer, he opened Britain's first conventional electric tramways, in Bristol in 1898 and London in 1901, both to great acclaim. He pioneered the use of motor buses in Bristol's streets in 1904 and later motor taxis, which he imported from France, through his agent in Paris, Emile Stern. In 1908 he built his own 'Motor Constructional Works' at Filton.

By nature George White was a 'workaholic'. He was also an inveterate smoker of cigars. In 1901, when he was forty-seven, the combined effects began to show. In the midst of intense negotiations over the rights to build London's underground system, he collapsed. Being long before the days of heart-bypass, his doctors could advise nothing but rest. So it was that he and his wife began to take lengthy

The security of the British and Colonial Aeroplane Company was underpinned by Sir George White's successful business empire based on tramways. This picture shows the inauguration of his London tramway in 1901.

holidays in France, where they were able to mix business with pleasure.

Tradition tells us that George White took up aviation in late 1909, when, while holidaying in the South of France, he saw some Frenchmen flying. It was a blinding revelation, it is said, and he returned to England determined to build aircraft. Recent research however suggests that this was not the case.

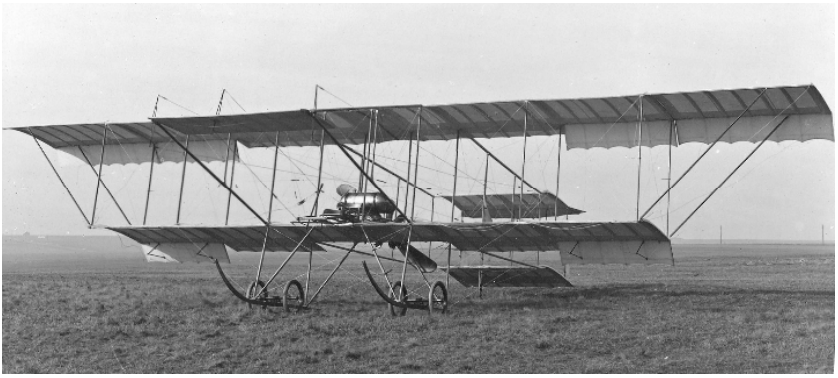
In early 1908, George White had ordered a series of French motor chassis from Emile Stern, due for delivery in August. To assist Stern, he had dispatched George Challenger, son of his General Traffic Manager at Bristol (and later designer of the Bristol Boxkite) to Paris. The order was badly delayed. By mid-October Stern reported only one chassis ready for dispatch. Thus Challenger found himself marooned in France and there his latent interest in aeronautics was set ablaze by what he saw.

'In Paris,' he wrote 'one feels the beating pulse of a new era. It

The inspiration for the establishment of an aviation industry based on Bristol lay in the demonstration flights made in France, as here, by Wilbur Wright in 1908-09.

causes no surprise if, on looking up, one sees a "dirigible" performing graceful evolutions; picture postcards of all the aeroplanes command a ready sale; aeroplanes in flight form one of the chief advertisements for many of the cinematograph entertainments; and on the evening following Wilbur Wright's sensational high flying in connection with the "Height Prize", I saw it reproduced on the cinematograph… The humble enthusiast,' he said, 'is not regarded as an "amiable lunatic" in France'. Clearly his excitement permeated Bristol, for evidence exists to show that on 28 October, a delegation consisting of Challenger, Stern and one of George White's nephews drove down from Paris to Le Mans (Camp d'Auvours), to watch the Wright Flyer in action. There they met Wilbur Wright and his European agent, Hart O Berg.

Within a fortnight George White himself was in Paris and in February the following year he and his wife travelled down to Pau on the Spanish border, to watch the Wrights flying. Later that year they attended the Rheims Air Meet. Planning continued in private until finally, on 19 February 1910, George White publicly announced his intention not only to build aircraft, but to found an aeronautical



In 1910, after failing to persuade a French-built Zodiac, designed by Gabriel Voisin, to fly, plans to produce them under licence were abandoned so the first successful 'Bristol' aeroplane became its successor, a very close approximation of an Henri Farman – the Boxkite, of which more than seventy would eventually be built..

industry in Britain. This was no chance event, nor was any decision taken on impulse. The project had taken fifteen months to evolve.

As for motivation, it is important to understand that George White was both a visionary who could see the future for great passenger-carrying aircraft and a born philanthropist. From the turn of the century he had turned to philanthropy on an almost industrial scale, saving no less than two hospitals from bankruptcy and providing them both with state of the art new premises. By 1908 George White was as aware as anybody that the main preoccupation of the British people, stirred up by the press, was the increase of German military might. Two matters concerned them in particular. One was the threat of German Zeppelins, the other was the threat of German submarines. It was characteristic of him in the last years of his life, when he had made his fortune, that he took it upon himself to counter both these threats. Against the one he financed aeroplanes; he founded flying schools and he campaigned vigorously in Britain and the Empire to persuade the military to take aeronautics seriously. Against the other and against tethered mines, he financed what was effectively an underwater aeroplane, the paravane.

BEFORE AND DURING THE FIRST WORLD WAR.

Prof Duncan Greenman

Duncan Greenman joined BAC at Filton as an undergraduate apprentice in 1968. Having gained his BSc in Mechanical Engineering from Bath University, he worked on the Concorde (including as a Flight Test Engineer), Typhoon and Airbus A320 and A321 before switching to personnel management, culminating in his appointment as Head of People Development for Airbus UK Engineering in 2005. He retired in 2008 and now works with the Universities of Bristol and West of England and is a Director/Trustee of the Bristol Aero Collection.

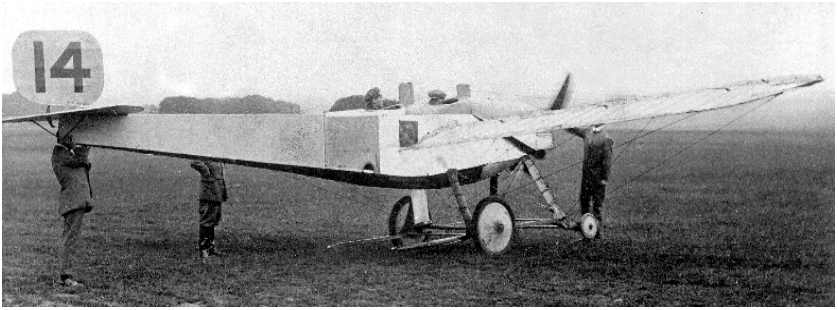
In the Beginning

Sir George White declared his interest in aviation on 19 February 1910 and very quickly established both a manufacturing plant at Filton and a Flying School at Larkhill on Salisbury Plain. Both sites were leased, not purchased – the sheds at Filton from Sir George's Bristol Tramways Company, the Larkhill site from the War Office. The Larkhill agreement also included flying rights over almost 2,500 acres of Salisbury Plain, very close to existing military installations and activities.

It is part of the Bristol legend that Sir George bought six French Voisin-type Zodiac aircraft to be assembled at Filton, but the first aircraft performed so poorly that all six were scrapped in mid-June 1910. Within a few weeks, the newly appointed Engineer and Works Manager, George Challenger, had produced drawings for a Farman-type aircraft with some Zodiac attributes – this was the aircraft that later became known as the Boxkite.

After only six weeks, the first Boxkite – Bristol Constructors Number (C/n) 7 – was taken from Filton to Larkhill on 29 July 1910. Assembled and prepared overnight, it made its first flight the following day, achieving 150 feet at its first attempt, to the great astonishment of the pilot, Maurice Edmond, and the onlookers.

The Flying School prospered and on 1 April 1911 No 2 (Aeroplane) Company, Royal Engineers was formed alongside it at



A Bristol-Coandă Monoplane wearing its competition number for the 1912 Military Aeroplane Trials. Flown by Harry Busteed it came third (from a field of thirty-two) winning a prize of £500. It subsequently flew with No 3 Sqn but crashed on 10 September 1912, killing its two occupants – one of the accidents which contributed to the Military Wing's short-lived, but notorious, ban on the flying of monoplanes.

Larkhill. It was re-designated to become No 3 Squadron, RFC on 13 May 1912 and among the early types that it flew before moving to Netheravon in June 1913 were examples of the Boxkite and the Bristol Prier and Coandă Monoplanes.[1]

Thus began the close relationship between the Bristol company and the British armed services which has lasted until today. The Larkhill Flying School was closed on the 2 June 1914 but, by then, almost 50% of all the pilots available for war service had been trained at Bristol Flying Schools and many more on Bristol-built machines.

Back at Filton, two distinct activities linked the Bristol company with the RFC. The first was through the Bristol products used by the RFC and RAF, whilst the second was the RFC/RAF presence on the Filton airfield, which the company and the military shared between 1915 and 1919.

From the military point of view, the airfield had two functions:

- to act as a *de facto* 'advanced' training school, by hosting newly formed squadrons flying a variety of aircraft before they were mobilised, and
- from March 1917, to receive new aircraft from designated manufacturers, check them and store them pending issue to a unit.

Frank Barnwell joined the company in 1911, but had been hidden away in a secret design department, which gave him very little contact with the general design activities then being undertaken. His work was dedicated to the Bristol-Burney hydrofoil seaplanes, but he was released in July 1914 when Sir George White cancelled these less-than-successful projects.

When Henri Coandă, who had been, in effect, Chief Designer since 1912, returned to Romania in October 1914, Barnwell formally took over this position. His genius was revealed when, early in 1914 working with the New Zealander pilot Harry Busteed, he sketched out the brilliant 'Baby Biplane', the first of a series of Bristol Scouts.

Having been building BE2s against government contracts since early 1913, the company received further large orders for BE2cs following the declaration of war in August 1914. The downside to this commercial success was that the company was directed to build nothing else, but the 'Baby' refused to go away. A few Service pilots had been able to fly it and, such was their enthusiasm, that the War Office placed an order for twelve in November 1914, followed by the Admiralty ordering twenty-four in December. As a result, the Scout, as it was known, became the main aircraft product of the Brislington factory of the Bristol Tramways Company in south-east Bristol.

However, all was not running smoothly with the licence production of the BE2s, due to increasing and recurrent errors in the official drawings. Nevertheless, the number of these aircraft demanded by the military increased rapidly and this effectively stifled innovation, because the War Office flatly refused to consider any other design.

At Filton, the outcome was that skilled staff started to leave to join other companies or military contractors while others joined the Army or Navy. Barnwell took a commission in the Royal Flying Corps as a 2nd lieutenant, resulting in the industry being deprived of one of its most talented designers, at the very time he was needed most.

Despite the inadequacies of the BE2, large scale production continued at Filton. Much has been written on this topic but Oliver Stewart put it as succinctly as anyone in 1936 when he wrote:

> 'Most urgently and most frequently reviled of all war-time aeroplanes, the BE2c was an example of State manufacture

An RNAS Bristol Scout C at Redcar. (J M Bruce/G S Leslie)

which will always be quoted whenever the perennial problem of how far the State may be allowed to take over the production of armaments without impairing the efficiency of the fighting forces comes up for discussion.

There can be no question that several ingenious and highly skilled men worked on the design of the BE2c, nor that it incorporated a large number of theoretically desirable features. On the other hand, there can be no question that it was responsible for extremely heavy casualties in the Royal Flying Corps. For in combat, it was utterly incapable – the most defenceless thing in the sky.'[2]

By mid-1915, the combination of Zeppelin attacks on British towns and the 'Fokker scourge' on the Western Front, forced the War Office to seek aircraft with a much higher combat capability. Thankfully, the now Captain, Barnwell was released to return to Filton, generously on indefinite leave but without pay, to resume the Chief Designer's mantle.

He made improvements to the Scout which, although widely used, never equipped an entire squadron. One Scout D (3028) was experimentally mounted on a Porte Baby flying boat, the idea being that the Scout should be air-launched and then dispose of the threatening enemy bombers. The Scout was successfully launched at 1,000 feet, piloted by Flt Lt M J Day of HMS *Vindex*, but the idea was not developed further.

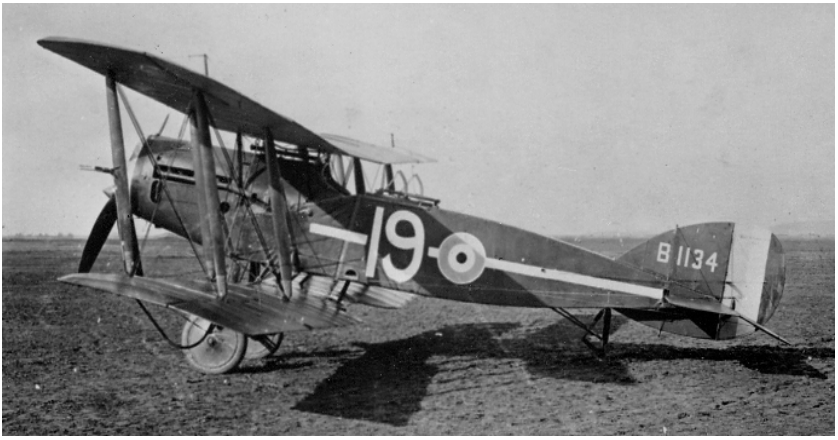
C4910, the tenth production M.1C at Filton.

During the first part of 1916, Barnwell schemed a fast, single-seat monoplane scout as a direct challenge to the German 'Eindeckers', which were slowly obliterating the RFC over the Western Front. Even in its later forms, the Fokker was slow, with a top speed of less than 90 mph. However, it was not its speed that was important. It was equipped with a synchronising mechanism which allowed the gun to fire through the disc swept by the propeller.

The gun was mounted on top of the fuselage just in front of the cockpit, permitting the pilot to aim his aircraft at his target, which was much easier than the gunner in a two-seater trying to engage, with a hand-held gun, a fighter approaching from behind – especially if, as in the case of the BE2, the gunner was in the *front* cockpit! Unfortunately, since 1912, some influential military and political figures in the UK had believed that monoplanes were inherently unsafe, so the Bristol machine was not immediately adopted.

Eventually, and apparently reluctantly, an order for 125 M.1C monoplanes, equipped with synchronising gear, was placed on 3 August 1917, but only four squadrons were issued with these 130 mph. machines. It was said that higher authority considered the landing speed of 49 mph to be too high for small field operations in France. As a result, the handful of M.1s that did become operational were sent to the Middle East.

It is worthy of note that several M.1s were successfully used as racing machines after the war and one of the six aircraft sent to Chile in 1917 famously became the first aircraft to cross the Andes when Lt Godoy flew from Santiago in Chile to Mendoza in Argentina on



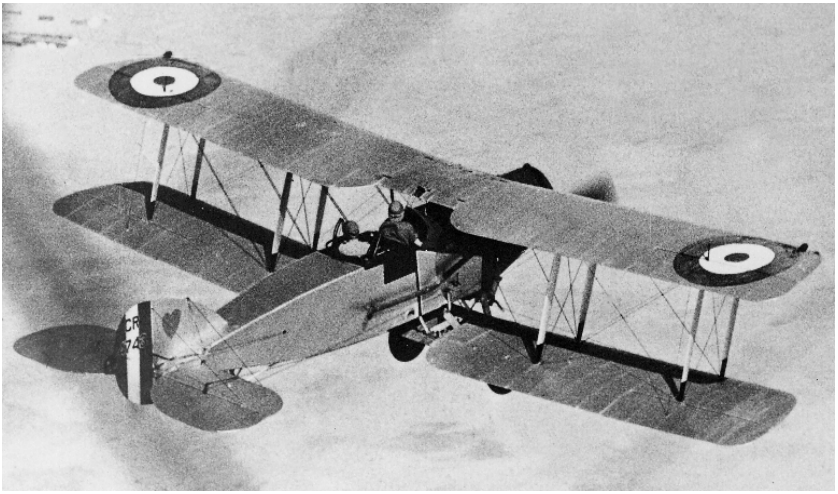
Apart from its service in the fighter reconnaissance role, a few Bristol Fighters began to find their way piecemeal to the RE8- and FK 8-equipped corps reconnaissance squadrons during 1918. This example was one of a handful that was acquired by No 35 Sqn. (J M Bruce/G S Leslie)

12 December 1918. This feat was repeated, in both directions, by Lt Cortinez on 4 April 1919 – he had not obtained official sanction, so he was sent back!

In 1916, Barnwell created one of his greatest designs – the Bristol Fighter. Powerful, robust and armed with both forward and rear-facing machine guns, it became one of the great aircraft of WW I and contributed significantly to British air superiority over the Western Front.

The original F2A had an inauspicious start because its crews flew it as a conventional two-seater when it was first committed to action with No 48 Sqn in mid-April 1917, resulting in a high loss rate. Once its pilots realised they should fly it as they would a single-seater, using the forward firing gun as the primary armament with the rear gunner providing tail cover, Barnwell's design philosophy was vindicated and the Fighter's success became immediate and emphatic.

Only a few weeks after the rather calamitous service debut of the F2A, Major Vere Bettington, OC 48 Sqn, wrote these words, extracted from a letter from France on 13 May 1917.[3]



A post-war Bristol Fighter of No 208 Sqn flying over Egypt in 1925.
(J M Bruce/G S Leslie)

> 'Regarding the Bristol, she is a topping fighting two-seater, the best here; not excepting the DH as she is much handier than that and the communication between pilot and passenger in the Bristol is splendid whereas the D.H.4 is not . . . She is faster than the Hun two-seater . . . Where she does score tremendously is in her power to dive, in this she is alone amongst English or Allied machines. [*The Bristol can be*] dived plumb vertically for thousands of feet . . . probably the speed is over 230 mph . . . She loops well. . . She stands an enormous amount of punishment in the way of being shot about and several have been very hard hit and come home, to be written off charge as beyond repair . . .'

Much more could be written about the exploits of the Bristol Fighter, but these few words from a service pilot and Squadron Commander are an eloquent testament and suffice to certify the Fighter as one of the truly great aircraft of 1917 and 1918.

It seems fitting that the very first mission flown by the new RAF on 1 April 1918 was by a Bristol Fighter. The 'Brisfit' might well be considered the first multi-role combat aircraft, such was its

Type	Squadrons that were fully or partially equipped
Bristol Boxkite	1, 2, 3
Bristol Coandă Monoplane	3
Bristol Prier Monoplane	3
Bristol Scout	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19, 21, 22, 24, 28, 30, 33, 36, 39, 43, 45, 47, 54, 59, 63, 67, 111
Bristol M1B	50, 111
Bristol M1C	47, 63, 72, 150
Bristol F2A Fighter	48
Bristol F2B Fighter (1917-19)	5, 6, 8, 9, 10, 11, 12, 20, 22, 33, 34, 35, 36, 39, 48, 59, 62, 67, 76, 82, 88, 105, 106, 111, 114, 138, 139, 141, 208 plus L, M, N, O & P Long-Range Artillery Flights
Bristol F2B Fighter (post-war)	2, 4, 5, 6, 8, 13, 14, 16, 20, 24, 28, 31, 100, 208

Fig 1. RFC/RAF squadrons which were either partially or fully equipped with WW I-era Bristol-designed aeroplanes.

ruggedness, versatility and popularity.

When production ended in September 1919, 2,081 Fighters had been completed at Filton, 1,045 at Brislington, plus another 1,621 by other contractors. Remarkably, the Bristol Fighter served the RAF at home and abroad until 1932, even with the Oxford and Cambridge University Air Squadrons.

The importance of the relationship between Filton and the RFC/RAF is illustrated by Figure 1 which lists the operational units which flew Bristols of one kind or another both during and after the war.[4]

BE Production at Filton

As has already been noted, the War Office had initially prohibited the British and Colonial Aeroplane Company from making anything other than BEs. Based on surviving company records, the aircraft that it was contracted to build are listed at Figure 2 by their Constructors

Model	Constructors Number (C/n)	Remarks, including serial numbers
BE2a	114-117, 140-141, 168-174, 190-195	(19 aircraft) included 222, 225-242
BE2b	212-217	(6 aircraft) included 396, 397 and 487
BE2c	348-393, 400-419, 621-770	(246 aircraft) 1652-1697; 1698-1747, 4070-4219
BE2c	561-570	(10 aircraft – ordered as single-seaters but delivered as standard two-seaters) 4700-4709
BE2d/e	894-1043, 1174-1373	(350 aircraft) 5730-5879; 7058-7257
BE2e	1487-1836, 2519-2718	(550 aircraft) A2733-A2982; A8626-A8725; B4401-B4600
BE8	201-202, 208-211	(4 aircraft) included 636, 656
BE10	343-346	(4 aircraft ordered, but not built) 1648-1651 allocated

Fig 2. Production of BEs by British and Colonial.

Numbers, linked, where known, with their corresponding military serial numbers.

This adds up to 1,185 aircraft built, plus four BE10s allocated sequence numbers but not completed.[5] Total BE2 production ran to more than 3,500 machines by twenty different contractors. Output on that scale was a truly remarkable achievement, especially when it is remembered that aircraft production at Bristol, and indeed everywhere else, had begun less than five years before war was declared.

Aircrew Training at Filton

In 1915-17, it was a common practice for newly formed Service Squadrons to spend the first few months of their existence as training units They took pupils who had completed their basic training at a

This BE2c, 5434, was one of several that crashed at Filton, but no other details are known.

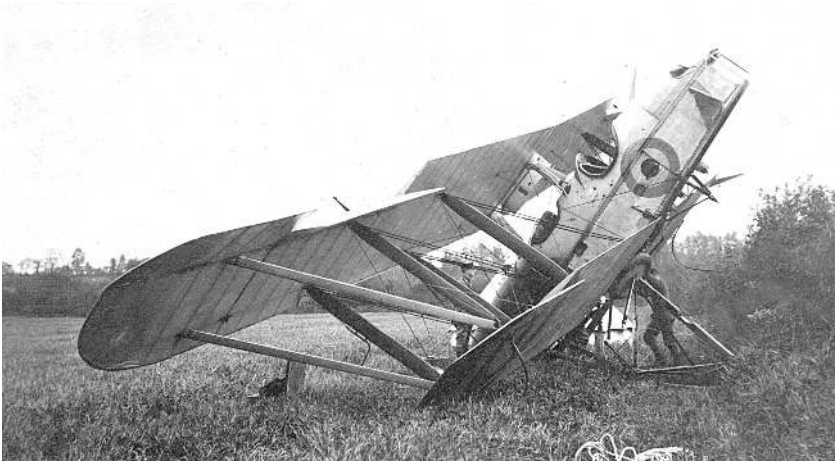
Reserve (later Training) Squadron and brought them up to, what passed at the time for, 'wings' standard. They were then posted, either to a squadron that was mobilising for deployment, or directly overseas to replace casualties in units that were already operational. Until they themselves were mobilised, these units were provided with a motley collection of aeroplanes on which to carry out their training tasks, often those handed down by a squadron that had recently been re-equipped with an operational type prior to going into action.

A number of squadrons spent some time at Filton during WW I, some having been formed there, while others were merely passing through – see Figure 3. Of these, the only relatively long-term residents were Nos 19, 42, 66 and 62 Sqns which served as training units during 1916-17 before being re-equipped with, respectively, the BE12s, BE2es, Pups and Bristol Fighters which they took to France.

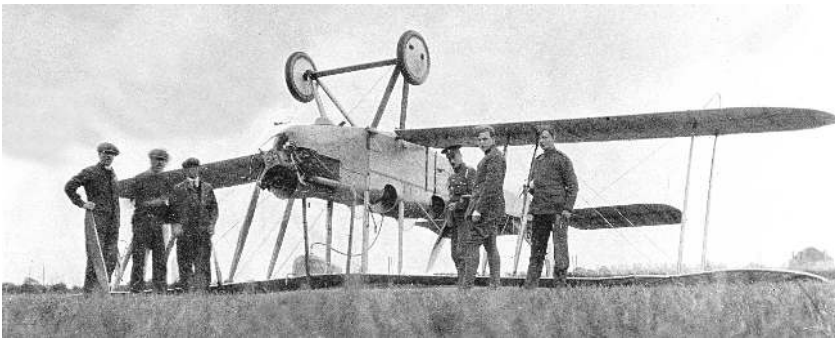
There was one other unit at Filton which should be mentioned. Formed as the Bristol Aircraft Acceptance Park (AAP) on 22 March 1917, it was redesignated to become No 5 AAP on 10 December 1917 and moved to Eastleigh on 27 October 1919 before closing down early in 1920. Its function was to receive aircraft from specific manufacturers and store them prior to issue to user units. The AAP at Filton handled Bristol Fighters produced both locally and by the Gloucestershire Aircraft Company, and Whitehead-built DH 9s and DH9As.

	In		Out	
Unit	**Date**	**From**	**Date**	**To**
No 20 Sqn	15 Dec 15	Netheravon	19 Jan 16	France with FE2b
No 33 Sqn	12 Jan 16	Formed at Filton	29 Mar 16	Tadcaster for Home Defence
No 19 Sqn	29 Mar 16	Netheravon	30 Jul 16	France with BE12
No 42 Sqn	1 Apr 16	Netheravon	8 Aug 16	France with BE2e
No 66 Sqn	24 Jun 16	Formed at Filton	2 Jul 16	Netheravon
No 66 Sqn	27 Jul 16	Netheravon	3 Mar 17	France with Sopwith Pup
No 62 Sqn	8 Aug 16	Netheravon	17 Jul 17	Rendcomb with Bristol F2B
No 55 RS	15 Nov 16	Formed at Filton	22 Nov 16	Yatesbury
No 51 RS	30 Dec 16	Formed at Filton	8 Jan 17	Wye
No 35 RS	1 Feb 17	Formed at Filton	16 Feb 17	Northolt
No 121 Sqn	10 Aug 18	Narborough	17 Aug 18	Disbanded
No 101 Sqn	18 Mar 19	France as cadre	11 Oct 19	Eastleigh

Fig 3. RFC/RAF units stationed at Filton during and immediately after WW I.
(RS = Reserve Squadron)



Among the many aeroplanes that were comprehensively crashed at Filton in 1916 were this RE7 (above) and a BE2c (below).



There are few surviving records relating to daily events at Filton during the war, but several of the eighteen hangars still exist. At least two of these have preservation orders on them and one, dating from 1915, remains in a good state of repair and is still in use.

On the other hand, the Bristol Aero Collection holds a number of remarkable photographs, three of which are reproduced here, showing incidents that occurred in 1916. Some of these aeroplanes look too badly damaged to fly again and there are known to have been several fatalities.[6]

By the end of 1919, the RAF had left Filton. It would return ten years later, but that is another story.

Notes:

Unless otherwise noted, the photographs illustrating this paper are the copyright of Duncan Greenman, Bristol AiRchive.

[1] Jefford, C G; *RAF Squadrons* (Shrewsbury, 2001).

[2] Commentary by Oliver Stewart MC AFC in Bridgman, Leonard; *The Clouds Remember* (Arms & Armour, London, 1972 Edn) p19.

[3] Barnes, C H; *Bristol Aircraft since 1910* (Putnam, London, 2nd Edn, 1970) p109.

[4] Jefford, C G correspondence with the author 29 September 2010.

[5] There is a problem with very early aeroplanes in that records are incomplete and sometimes contradictory. For instance, of the aircraft listed in Figure 2 as having been built by Bristols, other reliable sources indicate that BE2a serial number 235 was actually built by the Coventry Ordnance Works, 222 and 236 by Vickers and BE2b 487 by the Royal Aircraft Factory, while 397 was an Avro 504. That said, there is a close correlation between the company-sourced information at Figure 2 and an unpublished, but extremely comprehensive database recording the known 'biographies' of every BE-series airframe, compiled over many year by Mick Davis of Cross & Cockade International, from which the following has been extracted (**Ed**):

Model	No built	Bristol-built Serials
BE2a	24	217, 218, 225-234, 237-242, 245, 248-250, 273, 449
BE2b	1	396
BE2c	246	1652-1747, 4070-4219,
BE2c	10	4700-4709 – ordered as single-seaters but delivered as standard two-seaters))
BE2d/e	350	5730-5879, 7058-7257
BE2e	550	A2733-A2982, A8626-A8725, B4401-B4600 (C1701-C1753 cancelled)
BE8	4	365, 373, 636, 656 (2181-2184 ordered but cancelled)
BE 10	0	1648-1651 (not completed)
Total	**1185**	

[6] Chris Hobson's comprehensive *Airmen Died in the Great War, 1914-1918* (Hayward, London, 1995) records the deaths in flying accidents of four personnel of No 66 Sqn and four of No 62 Sqn while they were stationed at Filton, during which time each unit also lost one air mechanic to causes other than flying.

THE BRISTOL FLYING SCHOOLS

Bill Morgan

Bill Morgan joined the Bristol Aeroplane Company as an engineering apprentice in 1952. Following National Service with the RAF he returned to the company's Product Support Department and subsequently worked on Britannias, Canberras, Lightnings, the BAC 1-11 (including managing the establishment of licence production in Romania), the abortive BAC 3-11 project, Concorde and, as Manager of Strategic Contracting, creating and running the international design and manufacturing contracts for the A320, A330 and A340 wing programmes. At various times this involved lengthy stints abroad, in Cuba and Argentina (1958-62) and the USA (1964-70 and 1989-92).

1910 to 1914

Sir George White, the founder of the British and Colonial Aeroplane Co and the Bristol Aeroplane Company[1] on 19 February 1910, was a far-sighted man in that, apart from grasping the potential of aviation as a means of transport and a further resource for the armed services, he also appreciated the immediate need to train aviators in the new science of aeronautics. Within three months of forming the company Sir George had set up an embryonic Flying School at Brooklands. In the USA the Wright brothers had been flying for more than six years before they got around to opening their first civilian flying school. This was in the spring of 1910 when they procured a field and a hangar outside Montgomery, Alabama for this purpose. This eventually became, and still is, Maxwell Air Force Base; by contrast, today's Brooklands houses a museum and a trading estate.

Going back to Sir George and 1910, his early pilots were an eclectic mix of men who certainly had an interest in aviation but more particularly in aviating, whereas Sir George's driving ambition was to create an industry by gathering together the most promising designs and the most competent individuals, some imported and some home-grown. Pilots, who had already qualified in France before coming to

A Bristol Boxkite from Larkhill over Stonehenge.

Filton included Henri Jullerot and Maurice Tétard.

Bristol established themselves at Brooklands in a leased shed where other pioneers, including A V Roe, Tommy Sopwith, Helmut Martin and George Handasyde, had found that young men of means with an interest in speed would congregate. Maurice Edmond, another retained French pilot, failed to get Filton's licence-built French Zodiac airborne, which was hardly an auspicious start. Nevertheless, Brooklands quickly became an important training establishment for the company once the Zodiac had been supplanted by the Bristol Boxkite which, in reality, was an improved Farman design with a 50hp Gnome engine. There was a bit of a problem with the Farman brothers over intellectual property but the dispute was settled amicably without resort to lawyers and without the payment of any moneys.

Meanwhile, in June 1910, the Bristol company had negotiated the lease of 2,284 acres of land with flying rights from the War Office at Larkhill, not far from Bulford and Tidworth Camps, with the intention of attracting interest from the Army. The Larkhill site had first been used as an aerodrome a year before, when Horatio Barber had built a shed there in which to keep his flying machine. He was followed by George Cockburn and Capt John Fulton of the Royal Artillery. Next to these buildings the War Office built a further shed for the Hon Charles Rolls' aeroplane on which it was intended that officers of the Air Battalion would train. Sadly, this project was prematurely curtailed on

12 July 1910 when Rolls became the first Englishman to die in an aircraft accident. By the end of that month Bristol had erected three hangars at Larkhill and on 30 July, Edmond flew a Filton-manufactured Boxkite for the first time and to a height of 150 feet.

During the Autumn Manoeuvres of 1910 on Salisbury Plain the British Army gained its first experience of employing aeroplanes in the field. There were three of them, a pair of Boxkites, loaned by the company and flown by Capt Bertram Dickson and Mr Robert Loraine, and a privately-owned Farman flown by Lt Lancelot Gibbs. On 26 September Loraine used airborne wireless for the first time in the UK. Unfortunately, it was not a 'world's first' as John McCurdy had already done this a month earlier from a Curtis Model D in the USA. Nevertheless, the point was made and the military potential of aerial reconnaissance and communication, albeit only air-to-ground using Morse, had been demonstrated, although the impact of the practical application of these innovations would not really become apparent until the Manoeuvres of 1912.

By the end of September both of the Bristol Flying Schools had enrolled their first students. The first to graduate was Bristol-born Leslie Macdonald, who qualified for his Royal Aero Club (RAeC) Certificate at Brooklands on 15 November, followed by Messrs Archibald Low and Sydney Smith on the 22nd and Capt Herbert Wood on the 29th. Before the end of 1910 two more students had gained their Certificates on Boxkites at Bristol's school on Salisbury Plain, Mr Joseph Hammond on 22 November and Lt Reginald Cammell on 31 December.

Before the end of the year, Herbert Wood had demonstrated a Boxkite at Eastchurch in the hope of starting a third Bristol School near Chatham and Sheerness to interest naval officers. This initiative was frustrated by the generosity of Francis McClean, who owned the flying field at Eastchurch, because he had already leased it to the Royal Aero Club at a peppercorn rent of £1 per annum and had loaned the Navy two of his Short biplanes on which the first four naval pilots were to be trained free of charge.

By the end of 1910 there were fifty-four (two others had died in flying accidents) certificated British pilots. Only eighteen of them had been formally trained at British schools, however, but of those, six had been trained by Bristol, which was not a bad start for a company

which had not even existed at the beginning of the year. Meanwhile additional pilots had joined the staff, including Maurice Tabuteau, Robert Grandseigne, Leon Versepuy and Douglas Gilmour.

In the autumn of 1911 the War Office introduced a scheme whereby army officers who had learned to fly at their own expense, could claim a grant of £75 on successfully gaining their RAeC Certificate, which exactly covered the cost of the course.[2] Bristol had originally charged £100 plus any costs incurred in repairing damage caused by the student. This was clearly uncompetitive, of course, and the price was quickly dropped to the standard £75 with the company bearing the cost of breakages.

Expansion of Bristol's training activities at Larkhill and the purchase by the War Office of four Boxkites in March 1911 created a need for yet more hangars. This gave rise to objections from the public, as it was considered in some quarters that the additional buildings would have adverse implications for the historic site of nearby Stonehenge. It would seem that some people in this country have had problems with aerodromes ever since the earliest days of aviation! The objections were overcome, on condition that a gap was left between the three existing sheds and the five new ones so as not to obscure the rising sun on Midsummer's Day. It is said that this space between the buildings, the 'sun gap', often proved to be invaluable to a student making a less than perfect landing! The five new 'Bristol' sheds are still there today.

Gordon England, later to become a biplane designer at Filton, gained his RAeC Certificate with Bristol at Brooklands on 25 April 1911 and transferred to Larkhill, joining instructors such as Prier, Jullerot, Hotchkiss and Bendall, while Howard Pixton moved to Brooklands where he ran the Bristol School until later that year when Collyns Pizey, a young ex-Bristol Tramways Company apprentice, took over. At this time Warren Merriam joined Bristol as an engineer at Filton and shortly thereafter learned to fly at Brooklands. Pizey was his instructor and by February 1912 Merriam had passed his test 'without damaging an aeroplane'.

Meanwhile there had been some changes in the aeroplanes being used at the schools. By July 1911 single- and two-seat Bristol monoplanes, designed at Filton by Pierre Prier for more advanced training, had joined the Boxkite fleet which continued to be used to

1911 advertisement.

Above – the five Bristol sheds at Larkhill in 1912 with, beyond them, the 'sun gap' and the three earlier sheds. The aeroplanes are, from left to right, one of the two rather unsatisfactory Gordon England-designed Bristol GE3 biplanes, a Bristol-Prier monoplane and, on the right, a Coandă two-seater; there are two more dismantled Coandăs in the open shed. Below – now Grade II Listed, the Larkhill 'Bristol' sheds in 2008. (Psychostevouk)

provide initial instruction. The Priers were relatively short-lived, however, and when Henri Coandă joined the Filton design staff in 1912 his two-seat monoplanes began to replace them.

In addition to the two flight training schools in England, February 1912 saw Bristol establish schools at Cuatro Vientos in Spain and at Halberstadt in Germany, followed, in August, by a third at Mirafiore in Italy. Apart from providing instruction, the German enterprise, the *Deutsche Bristol Werke Flugzeug GmbH*, was a little different in that

it was partially capitalised by local businessmen and was additionally contracted to build Bristol aeroplanes.

The Royal Flying Corps was formed on 13 April 1912 and its first commander, Major Sir Alexander Bannerman,[3] gained his RAeC Certificate at Bristol's Brooklands School on the 30th of that month. Nos 1 and 2 Sqns were formed at Farnborough in May, along with No 3 Sqn, actually the first to fly aeroplanes, at Larkhill. Until the CFS opened at Upavon, also in May, the flying training of the majority of military pilots had been carried out by the Bristol Schools at Larkhill and Brooklands, and for some time afterwards most still continued to gain their RAeC Certificates from commercial schools.

On 10 September 1912, the company suffered its first fatal accident when one of its instructors, Lt Edward Hotchkiss of the RFC Reserve, died, along with his passenger, Lt Claude Bettington. Having taken off from Larkhill, their Bristol-Coandă Monoplane suffered a structural failure while approaching to land at Oxford.

There was a fairly liberal interchange of company pilots between the Filton factory, where flight testing was being conducted, and the two schools. The numbers of pupils increased steadily and between August 1913 and August 1914 six additional instructors were added to Chief Pilot Warren Merriam's staff at Brooklands.

A notable graduate of the Brooklands school was Frank Halford (later of de Havilland engine fame) who borrowed £75 from his mother to fund his flight training. Gaining his certificate in October 1913, he promptly joined the company at a salary of £1/9/9d per week. He proved to be so competent that in December he was appointed as assistant instructor to Merriam, in succession to Robin Skene, who had left to fly with Martin & Handasyde.[4]

With the political situation between England and Germany worsening in the summer of 1914, the RFC held a 'Concentration Camp' at Netheravon and conducted exercises over Salisbury Plain. The conduct of flying training was clearly incompatible with this military activity and on 14 June the War Office took control of the Larkhill site. The school's machines, instructors and pupils were all transferred to Brooklands but that arrangement did not last long. On 17 August, just two weeks after the outbreak of war, the RFC took over Brooklands as well, although tuition of existing pupils continued until the end of September.

The connection with the German enterprise had already been terminated on 23 June (just five days before the assassination of Archduke Franz Ferdinand) as a result of pressure being exerted on the joint company, *Deutsche Bristol*, to build aircraft other than Bristol designs. The newly independent German company became the *Halberstädter Flugzeugwerke GmbH*. Interestingly, after another World War and several changes of ownership, what had been the Halberstadt company eventually became *Rolls-Royce Deutschland*.

The standard of tuition in the Bristol schools which operated between 1910 and 1914 was unmatched. Bristol had trained 182 pilots at Brooklands and 127 at Larkhill before the outbreak of the First World War. Those 309 pilots constituted a remarkable 46% of the 664 who had learned to fly at British schools. The next most significant school, Vickers, had trained just 77, so Bristol could reasonably claim to have provided the foundation on which the RFC had been built.

1914 to 1918

Following the outbreak of war, although some basic flying training continued to be undertaken by civilian contractors for a while, it became an increasingly military affair. Once the RFC had taken over at Brooklands, Bristol withdrew from the training game and focused its energies on aircraft design and production. Its other wartime contribution was to create Filton airfield which was laid out under contract to the War Office at a cost of a little over £5,000. The first military unit, No 20 Sqn, arrived in December 1915 to be followed by several others until 1917 when the site became an Acceptance Park, in effect a storage depot for newly built aircraft pending issue to users. When the RAF moved out in 1919, the airfield became the company's flight test centre.

That said, while the company was no longer training pilots itself, it could claim, at least, a tenuous connection with the fully developed military training system that was introduced in 1918. This major reorganisation was implemented in order to introduce professional instructional techniques, and to impose a structured sequence, in place of the previously somewhat *ad hoc* approach to flying training. This innovation was based on the gospel being preached at the School of Special Flying which had been set up at Gosport in August 1917 under the direction of Major Robert Smith-Barry, one of the pre-war

The Bristol Type 83 Lucifer, also known as the PTM (Primary Training Machine), six of which were built for the Reserve Flying School; this one, G-EBFZ, was in use from 1923 to 1931.

graduates of Bristol's Larkhill school.

Between the Wars

In 1919 the Air Ministry announced that most pilots in the peacetime air force would be officers serving on (initially three- but later four- and five-year) short-service commissions with a subsequent reserve obligation. The first intake would leave the Service in 1923 so, to administer them, the Reserve of Air Force Officers (RAFO) was established in that year. Practical training facilities were also required and this led to commercial contracts being placed with five civilian operated Reserve Flying Schools, one of them being run by Bristol at Filton. The nominal obligation was for each pilot to keep his hand in by flying 12 hours per year.

Two types were operated by the Bristol school, the Type 83 Lucifer for primary training and two variations on the Bristol Fighter theme for more advanced work. The first four Fighters were Puma-engined Type 81s but these were soon replaced by Jupiter-powered models, the Types 89 and 89A. The original flying staff comprised Cyril Uwins, the company's Chief Test Pilot, doubling as CFI, with Thomas 'Jock' Campbell and Cyril Holmes joining later in the year. The instructors spent much of their time recovering aircraft flown solo by pilots who had landed in various parts of the West Country due to poor navigation. On one occasion a Fighter took off on a Friday

Originally intended to be the fourth Type 81 Puma-Trainer for the Bristol Reserve School, G-EBIH was completed as the first Type 89 Jupiter-Trainer. First flown in 1923, it was lost in a mid-air collision with a Lucifer over Filton in 1929. (MAP)

afternoon to do a local flight and, in spite of RAF and police searches, it was not traced until Saturday evening when the aircraft was found in a field near Oxford. There was no trace of the pilot but he was eventually run to earth in the local pub. The pilot, who had landed several times before his final landing, did no further flying with the Reserve!

Apart from ex-short-service officers with a reserve obligation, the RAFO was open to volunteers, although a dwindling proportion of its early members were veterans of WW I. By 1925 the reserve was still more than 200 pilots short of its target strength, so it was decided to accept untrained volunteers, which meant introducing a 30-hour course of *ab initio* instruction. Some foreign students were also accepted, notably two Turks, one of whom managed to crash two aeroplanes without injuring himself, an experience that he appeared to regard as a rite of passage that he had quite enjoyed, somewhat to the consternation of his instructors and superiors!

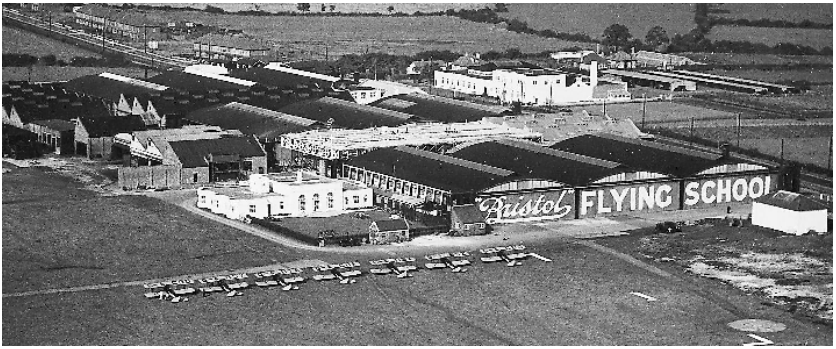
The last of the Bristol Fighters continued to fly at Filton until 1934. Meanwhile, the little Type 83s had been superseded by the ubiquitous

Some of the Bristol Flying School's Tiger Moths lined up at Filton.

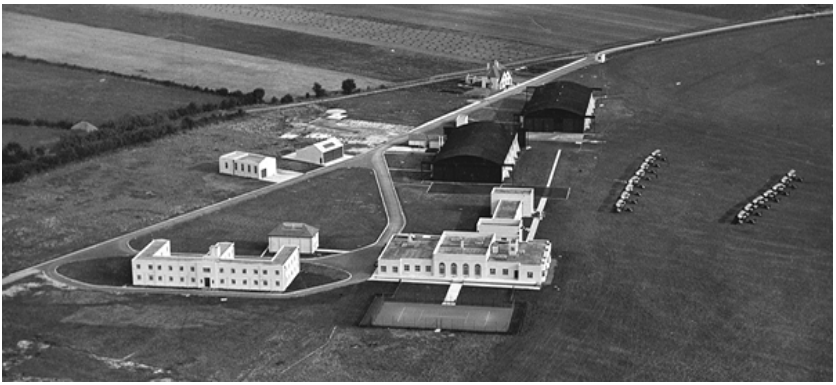
Tiger Moth in 1932. From 1933, with most of the Reserve Flying Schools now standardising on the far more economical Tiger Moth (and, to a lesser extent, the Blackburn B.2) the allocation of refresher hours was raised to 20 per year, to include exercises in navigation, photography, reconnaissance and blind flying, and the *ab initio* syllabus to 50.

The next major change occurred in 1935 when, partly in response to the demands of the Expansion Schemes, the Air Ministry introduced an entirely new flying training sequence. From then on, apart from Cranwell cadets, *all* RAF pilots were to undergo the first 50-hour phase at one of thirteen civilian schools run on Air Ministry contracts. Nine of these schools were to be newly established, the other four were the remaining Reserve Flying Schools that dated from the mid-1920s. Among the notable pilots who would be trained at Filton under this scheme were 'Sailor' Malan, of Biggin Hill fame, and Flt Lt Kenneth Doran who was decorated with one of the first two DFCs to be awarded in WW II.

As part of this expansion, towards the end of 1935 the Air Ministry contracted with Bristol to open a second school. The company acquired part of the site of the WW I aerodrome at Yatesbury, known as West Camp, where it refurbished some of the existing facilities and contracted En-Tout-Cas Co Ltd to build some rather splendid new ones. The school opened in January 1936 with *Flight* magazine later observing that its fleet of Tiger Moths was 'painted waspishly in black and yellow' and commenting that Bristol had 'made at Yatesbury a model school whose pattern few will equal and none will excel.'[5]



Above, the Bristol Flying School, later No 2 ERFTS, at Filton and below the rather stylish facilities that were built for what became No 10 ERFTS at Yatesbury.



Having opened with just four instructors, when *Flight* made its visit in November the staff included Jock Campbell as Chief Instructor, Percy Clayson as Chief Ground Instructor and at least ten flying instructors. One of Yatesbury's notable pre-war graduates was Guy Gibson.

The establishment of the RAFVR in 1936, created a demand for yet more capacity from 1937 onwards. Another consequence of this development was that all of these essentially civilian organisations now acquired quasi-military status when they were designated as numbered Elementary and Reserve Flying Training Schools, Bristol's pair becoming No 2 ERFTS at Filton and No 10 at Yatesbury. Apart from each individual school expanding, their original civil-registered

The Yatesbury instructional staff in 1936, with their RAFO ranks. Standing left to right, are Flt Lt S J H Carr DFC; Flt Lt E G Sharp; Flt Lt F H Bugge; Mr W Miller; Flt Lt P J Clayson MC DFC (Chief Ground Instructor); Fg Off L H Mason and Flt Lt W J Pearson. Seated are Fg Off W L B Palmer; Fg Off T W Campbell (Chief Instructor); Fg Off W G Stevenson; Flt Lt H W Raeburn and Fg Off W N L Cope.

fleets being supplemented by additional aeroplanes provided by the Air Ministry, the whole organisation continued to grow until there were more than forty ERFTSs by the time that war was declared. Apart from extending the operating hours, to permit reservists to fly in the evening and at weekends, VR pilots were trained beyond the 50-hour elementary syllabus and catering for the more advanced phase meant that the Tiger Moths were supplemented by Harts and Audaxes and, eventually, a few Ansons.

By the end of 1937 the RAF was reluctantly being forced to accept that its previous policy of misemploying airmen on a part-time basis to fly as observers and gunners would not work (indeed it never could have worked – **Ed**) in wartime. Furthermore, the technical complexity

The flight line at Yatesbury circa 1938. Now reinforced by additional RAF-supplied Tiger Moths, most of the original two dozen civil-registered aeroplanes will be in this picture (the nearest one is G-ADNZ), albeit all now camouflaged and sporting RAF roundels.

of the latest generation of aeroplanes was making it increasingly difficult to release sufficient airmen from their primary duties to provide the numbers of aircrew that were required by the expansion programme. The upshot was that the Air Ministry was obliged to introduce direct recruiting of civilians to fly as observers. They were to be trained under contract at one of (initially) four schools. One of these, No 2 Civil Air Navigation School (CANS) opened on 26 September 1938 at Yatesbury whence its Ansons were operated by Bristol alongside No 10 ERFTS's fleet. Graduates of the twelve-week navigation phase, moved on to a Recruit Depot to be issued with uniform and given a fortnight's military induction and from there they proceeded to a Service-run Air Observers School for instruction in bombing and gunnery and more navigation practice.

Having decided to introduce full-time, direct entrant observers into the regular air force, it followed that, like regular pilots, they too would need to be backed up by reservists. Recruiting of RAFVR aircrew other than pilots, gunners as well as observers, began in November 1938, the first ones appearing at Filton in the spring of 1939.

The Second World War

On 1 November 1940 all ten CANS were restyled as Air Observers Navigation Schools (AONS), retaining their original numbers. Despite their new titles, however, these units continued to be commercially operated, although reports of civilian instructors experiencing disciplinary problems with, now uniformed, trainees led to most of the instructional staff being commissioned into the RAFVR on 1 January 1940. So far as Bristol was concerned, No 2 AONS and its dozen or so Ansons continued to provide *ab initio* navigation training until a revision of the overall scale and sequence of aircrew training rendered it surplus to requirements. No 2 AONS was accordingly disbanded in December 1940, by which time a total of 248 observers had been trained at Yatesbury.

Prior to this, on the outbreak of war, the 'R' in the ERFTS of all such units had immediately been dropped so those at Filton and Yatesbury promptly became Nos 2 and 10 Elementary Flying Training Schools (EFTS). As with the switch from CANS to AONS, however, these units continued to be run by the original contractors. As implied

A well known picture of a Dominie of Yatesbury's No 2 Signals School. (MAP)

by the change in the title, facilities for reservists to fly were no longer required so the heavier types, the Harts, Audaxes and Ansons, were withdrawn leaving a considerably expanded fleet of Tiger Moths at both schools. As with the AONS, most of the instructional staff had been commissioned into the RAFVR, so while No 10 EFTS was still being run by Jock Campbell he was now doing it in uniform as a squadron leader, assisted by one of the instructors who had been at Yatesbury since 1936, Harold Raeburn, who had also been elevated to squadron leader.

Another early wartime development was that No 2 Electrical and Wireless School, which had opened at Yatesbury at the end of 1938 to train additional RAF wireless operators, introduced practical airborne work, the first aircraft arriving in October 1939. The unit was redesignated as No 2 Signals School in August 1940 and again in January 1943 when it became No 2 Radio School. The initial establishment had called for forty Proctors and a dozen Dominies which were to be operated and maintained by Bristol, although the fleet grew considerably until July 1945, when the unit's function was changed to the training of ground personnel only, by which time it had no fewer than 104 Proctors on charge. Despite the poor serviceability of the Proctors, largely due to the lack of adequate hangar space,

One of the scores of Proctors that constituted the bulk of No 2 RS's fleet. (Yatesbury Association)

between 1940 and 1945, Yatesbury had flown 224,181 hours in the course of training 18,500 wireless operators.

Meanwhile, pressure on space and the steady growth of the flying task associated with the ever expanding wireless operator training commitment meant that No 10 EFTS had to move out. In September 1940 Jock Campbell took his school to Weston-super-Mare, leaving Harold Raeburn to supervise activities at Yatesbury. A year later No 10 EFTS and its fifty-four Tiger Moths moved again, this time to a new aerodrome at Stoke Orchard, to the north of Cheltenham, which was supposed to have more accommodation. However, the construction of the camp, for both military trainees and civilian staff, was incomplete, resulting in an uncomfortable winter for all concerned. Nevertheless, training continued uninterrupted, despite having to share the airfield with early Typhoons being test flown by Glosters who were assembling them at their Stoke Orchard shadow factory.

By this time there had been a major change in the role of an EFTS. In 1941 'grading' had been introduced, a short preliminary course involving up to 12 hours in the air, possibly including going solo, to confirm that a cadet who had been selected for pilot training really did have a reasonable chance of success. In 1942, by which time practically all flying training was being conducted overseas under the Empire Air Training Scheme, grading became an integral part of the selection process. Thereafter, unless there were medical or other

considerations that ruled them out, all 'PNB' candidates (those identified as prospective pilots, navigators or air bombers) were given the opportunity to demonstrate their specific potential as pilots. Those who failed to display the necessary degree of aptitude could then be trained in another category from the outset, thus saving both time and treasure by reducing the failure rate. This meant that the numbers of cadets passing through an EFTS had increased substantially but that they were now being given only (up to) 12 hours of airborne time each, compared to the 50 required by the elementary syllabus. The overall result was an excess in training capacity and the system began to contract. The first EFTS to disband, No 12, closed down as early as March 1941 and No 10's turn came on 21 July 1942 when its place at Stoke Orchard was taken by the newly formed No 3 Glider Training School.

Since its formation in 1936, the school had trained 2,100 *ab initio* pilots, given 250 pre-war reservists their annual refresher flying and provided facilities for pre-war RAFVR trainees in the course of which it had flown 104,072 hours. No 10 EFTS's CO, now Wg Cdr, Jock Campbell, transferred to No 2 EFTS, together with several instructors, while Bristol maintenance staff went back to work at either Yatesbury or at one of the company factories at Filton or Weston-super-Mare.

Like No 10, No 2 EFTS had also been obliged to vacate its peacetime location. The increasing wartime output from the factory, and the associated production test flying, and the provision of a protective balloon barrage all served to complicate the conduct of elementary flying training at Filton. So, led by Sqn Ldr H M Kerr, the school moved to Staverton in August 1940. This proved to have been a rather unfortunate choice, however, as runways were being laid and their hard surfaces were unkind to the Tiger Moths. The answer was to leave the HQ, the aircraft maintenance and ground school facilities and the domestic accommodation at Staverton but to conduct flying operations from a grass airfield at Worcester (Perdiswell Hall). The ground staff and cadets were bussed to and from the airfield each day while the instructors ferried the Tiger Moths back and forth. It sounds a little complicated, but no more so than flying from a Relief Landing Ground (RLG), which was standard practice at practically all FTSs in order to relieve congestion in the circuit. Even Perdiswell Hall had an RLG – Littleworth.

In September 1941 command passed to Sqn Ldr Morgan Griffiths, another pre-war Filton instructor, and shortly after that the unit's function changed from elementary training to the training of instructors. This was reflected in a change in its title and in November No 2 EFTS became No 6 (Supplementary) Flying Instructors School (FIS) and it began to operate Magisters in addition to its Tiger Moths. In April 1942, by which time its title had undergone another subtle change to No 6 Flying Instructors School (Elementary), the connection with Staverton was severed and the whole operation was conducted from Worcester where adequate accommodation had since been provided.

The RAF's appetite for additional instructors having presumably been satisfied, the school reverted to its original designation of No 2 EFTS in July 1942 and, as previously noted, Wg Cdr Campbell arrived from Stoke Orchard to assume command. With a reduced establishment of thirty-six Tiger Moths, it resumed the flying of cadets – although by this time it would have been providing only the short grading course. The small dimensions of the landing ground, and the consequent frequency of incursions into boundary hedges, had sharpened the reaction times of the airfield fire and rescue service to such an extent that more than one visiting pilot, finding himself in similar circumstances, expressed his gratitude on finding the ambulance and fire tender alongside his aircraft almost as soon as it had come to rest. Fortunately, the school never experienced a fatal accident.

As an aside, it is perhaps worth noting here that Flying Training Command had experienced problems at some of its schools which were manned on a shared civilian/RAF basis. There were many points at which friction could occur, with disputes most frequently arising from such issues as discipline, working hours, restrictive practices and pay, in all of which the conditions of servicemen compared unfavourably to those of civilians. By April 1942 the situation had become serious enough to warrant its consideration by the Air Council. Its conclusion was that a training unit could be either civilian- or Service-manned but that joint-manning was impractical. The outcome was that all EFTSs and Nos 4, 5 and 6 Flying Instructors Schools were to remain under exclusively civilian management, as was No 2 Signals School at Yatesbury. This was very significant for

Bristol, of course, as it meant that they would continue to manage flying and aircraft maintenance for No 2 Signals/Radio School and No 2 EFTS for the rest of the war.

There is one vaguely Bristol-related anecdote that deserves to be told, if only because it is so remarkable – and true. One of the cadets to be 'graded' by No 10 EFTS at Worcester in 1941 was Thomas Dobney who went solo in 12 hours. He was duly despatched to Canada where he completed his flying training and returned to the UK as a sergeant pilot. He embarked on a Whitley OTU course, but the Whitley's withdrawal from operations led to his being posted to a unit earmarked to take its Blenheims to the Middle East. At this point his father became aware of the situation and informed the authorities that his son was *very* seriously under age. In fact this captain of a bomber crew had been just 15 years 4 months and 9 days old when he had gained his wings – and a year younger than that when he had enlisted. Dobney was promptly discharged but, a year later, he did it again, claiming to be 18. He did not get far on his second attempt and he was discharged again. Once he did come of age, however, he realised his ambition, became a fully fledged service pilot and flew Yorks on the Berlin Airlift.

Post War

While No 2 Radio School was still at Yatesbury, it had, as previously noted, ceased to be a flying unit in July 1945. Since it was no longer using the airfield, No 2 EFTS moved in from Worcester. There was a huge surplus of qualified aircrew awaiting demobilisation, however, so there was little requirement for *ab initio* pilot training. The introduction of an all-through training sequence in 1947, which involved a student progressing from initial training to 'wings' at a single unit, rendered No 2 EFTS redundant and it closed down at the end of September. During the twelve years that Bristol had managed the flying and maintenance facilities at Yatesbury the company had built up an impressive reputation for its expertise and the reliability of the service it had provided and had established a good working relationship with its RAF customer.

Since the Yatesbury site was no longer required by the post-war company, it decided to give it all away, including the magnificent buildings that had been erected for the Bristol Flying School. On

behalf of the Directors, therefore, Mr Verdon Smith opened the Bristol Malcolm Club at a ceremony held at Yatesbury on 10 September 1947. Air Cdre Walter Seward, AOC 27 Gp, accepted this very generous gift on behalf of the President of the Malcolm Clubs, Lord Tedder. The club's facilities were freely available to the thousands of airmen who would pass through Yatesbury (and Compton Basset) until 1954 when the Air Ministry purchased the old Flying School buildings from the Malcolm Clubs. Renamed as RAF Cherhill, they were used to house the staff of HQ 27 Gp until it closed down in 1958.

In 1965 the RAF withdrew from Yatesbury altogether. The Flying School buildings were sold by auction in 1966 but the rest of the vast hutted camp was more or less abandoned. After a half-hearted attempt at demolition, it was left in a derelict state until 1970 when the site was purchased from the MOD by the County Council. Two years later, after the eyesore had been cleaned up, it was sold on as agricultural land. From time to time, various schemes were proposed for the old Bristol buildings but none have ever borne fruit; they still stand, unoccupied and sadly decayed.

The reconstitution of a peacetime RAFVR in 1947 created a requirement for twenty-four Reserve Flying Schools (RFS) to be run by civilian contractors. One of these, No 12, was to be managed by Bristol and it opened for business at Filton on 1 April 1948 under the direction of Mr C T Holmes with Mr H M Kerr as CFI and Messrs Miller and Cubitt as Flying Instructors, all of them veterans of one or other of the pre-war Bristol Flying Schools.

No 12 RFS began operating with six Tiger Moths and by the end of 1948 it had eighty-four reserve pilots on its books. Navigators and signallers began to be accepted in January 1949 and a pair of Anson Is was taken on charge for their benefit with Mr E I Owen as the staff pilot and Messrs Ottewell and Martin as navigation and signals instructors respectively. Mr Messiter, a pre-war Filton instructor, joined the staff during 1949 and by the end of that year the unit's strength in registered reservists stood at 136 pilots plus 48 navigators and signallers. Mr H H Thompson replaced Mr Cubitt in 1950 by which time the fleet had grown to a dozen Tiger Moths and the two Ansons.

Previously conducted at the Reserve Centre at RAF Pucklechurch, in 1951 responsibility for the ground training of VR personnel was

A post-war Bristol UAS was re-formed in November 1950 at Filton whence it flew Tiger Moths, Chipmunks and Bulldogs until 1992 when it moved, via a brief interlude at Hullavington, to Colerne. (MAP)

transferred to the company at Filton, along with maintenance of Bristol University Air Squadron's Tiger Moths. Later that year Mr Ottewell was appointed as Chief Ground Instructor and Messrs Milner and Belton joined the flying staff while Chipmunks began to replace the Tiger Moths. Increasing numbers of navigators led to the acquisition of a third Anson, by now T.21s, and a flying commitment created by co-operation work with No 3507 Fighter Control Unit added an Oxford which was flown by an additional staff pilot, Mr Hendy.

Owing to ill health, Hamish Kerr resigned as CFI, the position being taken by Wilfred Miller, an old-hand from Yatesbury in 1936. The work associated with the Fighter Control Unit ended in April 1952 by which time the RFS was providing air experience flights for Air Training Corps cadets, some of whom received as much as ten hours of dual instruction supervised by reservist QFIs or the civilian staff pilots. Providing ATC and CCF cadets with hands-on experience was a policy decision that, it was hoped, would encourage them to volunteer for aircrew training when they were called up for their National Service and it proved to be very successful. No 12 RFS played its part in this programme by flying some 688 cadets during 1952 alone.

The Korean crisis had precipitated major changes in policy relating to the way in which the Cold War front line was to be reinforced if a

nuclear WW III appeared imminent. This involved a major reduction in the overall size of the VR and this, along with the growing irrelevance of maintaining currency on Chipmunks while the front-line was about to introduce transonic swept-wing jets, meant that the RFSs had outlived their usefulness. No 12 RFS fell victim to the first cull which was announced in December 1952 and it disbanded on 31 March 1953, but it was soon followed by the others and the last RFS closed in July 1954.

Thus it was that the 'Bristol' school ceased operations thirty years after opening its original Reserve Flying School on 28 May 1923. Throughout that time the company had carried out work of inestimable value for the nation in training aircrew for the Royal Air Force. In the process it had established a reputation for quality second to none in the field of flying training.

Acknowledgement. The author wishes to acknowledge the work of Mr John Heaven in assembling data on the pre-1914 flying training activities of the British & Colonial Aeroplane Company and Mr Geoff Lonsdale in the creation of a permanent record of the recollections of Leslie Charles Hayes, personal assistant to Bristol's Chief Test Pilot, Cyril Uwins, who was also CFI of the Bristol Flying School from 1923.

Notes:

[1] For ease of reference, whether the company was entitled The British & Colonial Aeroplane Co or the subsequent Bristol Aeroplane Co or even Bristol Aircraft Ltd and the British Aircraft Corporation, it will be referred to here as 'Bristol', for Sir George was unique in insisting that his company did not carry his family name, as most others did, but was always to be known by the name of the city of his birth.

[2] The intention to introduce the £75 refund was announced in the House on 30 October 1911 (TNA ZHC2/539), the arrangements were promulgated by a Special Army Order of 24 November and published as Army Order 342 on 1 December.

[3] Having previously commanded the Balloon School, which morphed into the Air Battalion in 1911, Maj Bannerman's command of the RFC was brief at best, as he was effectively supplanted on 15 May 1912 when Lt Col Frederick Sykes was appointed CO of the Military Wing. Bannerman withdrew from the RFC, and active service, on 28 August 1912.

[4] Skene had the unfortunate distinction of becoming the first pilot to be killed flying with the wartime RFC when his Blériot stalled on a climbing turn out of Netheravon en route to France on 12 August 1914.

[5] *Flight*, 19 November 1936.

BRISTOL'S PISTON ENGINES AND THE RAF – AN OVERVIEW

Patrick Hassell

An aerodynamicist and specialist in certification, Patrick Hassell worked on a variety of aircraft programmes, including the Jetstream, Concorde and Britannia. After a stint with Douglas at Long Beach he went to Sweden to work on the Saab 340 before joining Dowty Rotol in England, becoming Business Development Manager for Dowty Propellers before retiring early to pursue his own interests, particularly aviation history. He is presently vice-chairman of the Rolls-Royce Heritage Trust at Bristol.

The Bristol Aeroplane Company created its Engine Department in 1920 by purchasing part of the bankrupt Cosmos conglomerate from its Receiver.

It was a somewhat reluctant purchase, done at the request of the Air Ministry who did not want to lose the promising new Cosmos Jupiter radial engine. This had been designed by Roy Fedden and Bunny Butler at Fishponds in East Bristol. This firm, originally Brazil Straker, was famous before the war for Fedden's Straker Squire sports cars. It was well known to the Ministry and to the Bristol Aeroplane Company since the great majority of the Rolls-Royce Falcon engines for Filton's Bristol Fighters had been built there. It was the only firm to which Rolls-Royce Derby would grant a licence having found that Fedden's obsession with quality at least matched their own.

Bristol's directors agreed to buy the business provided that Fedden came with it. He did, and with thirty-two others from Fishponds, he set up shop in the north east corner of the airfield, in the RFC's old Aircraft Acceptance Park hangars at Patchway, way down the hill from the aircraft factory at Filton, in what became known as the West Works. Within two years Fedden had spent all of the £200,000 the Directors had allotted to complete development of the Jupiter and had sold – just eleven engines. They nearly pulled the plug, but fortunately the Gnome-Rhône Company, seeing the promise of the design had

Roy Fedden headed Bristol's engine division from 1920 to 1942.

purchased a licence to build the engine in France, allowing development to continue.

In parallel, the RAF had been trialling some of the early Jupiters. The first service type with a Bristol engine was J2405, a Gloster Nieuport Nighthawk, followed by two more Jupiter III-powered Nighthawks which were renamed the Gloster Mars VI. These were sent out to the North West Frontier for field trials. Another of the engines was installed in the Hawker Woodcock, replacing its Armstrong Siddeley Jaguar radial. This proved a success, resulting, at last, in an order for 81 Jupiter IV engines to power the Woodcock II which went into service in May 1925. From that day to this, the RAF has never been without engines designed and built in Bristol.

The Jupiter was a single-row air-cooled radial with nine cylinders and a total displacement of 28·7 litres. Its 440 shp represented the remarkable power-to-weight ratio of 1·6 lbs/shp. Its great competitors in the 450 shp class were the water-cooled Napier Lion with its twelve cylinders in broad-arrow layout and the Armstrong Siddeley Jaguar, with fourteen air-cooled cylinders in two rows. The Cosmos bankruptcy helped give both of its rivals a head start, but the Jupiter gradually overtook them and by the end of the 1920s it was the clear favourite, both in military and airline use.

Following the Woodcock the RAF immediately ordered the Gloster Gamecock with the Jupiter VI and both were replaced from 1929 by Bristol's own Bulldog with the Jupiter VII, the first supercharged Bristol engine to enter service. These fighter engines were all direct-drive but for larger types Fedden obtained a licence for the Farman-type gearbox and introduced it on the Jupiter VIII. The RAF used this and its related marks in many famous types, including the Handley

Jupiter production under way in the West Works in 1928.

Page Hinaidi and Clive, the Boulton & Paul Sidestrand, and the omnipresent Westland Wapiti which soldiered on forever in the Middle East and India with over seventy of them still operational when war was declared in 1939.

So the Jupiter established Fedden and Bristol as pre-eminent suppliers of high power radials for the RAF but in the mid-1920s, the mood in the Air Ministry was swinging in favour of the in-line water-cooled engine, particularly if high speeds were required. Fedden believed that the air-cooled radial could outmatch them but many in the RAF were not persuaded – at least, not until the appearance of the Focke Wulf 190.

Fedden first attempted to convince them otherwise with the Short-Bristow Crusader for the 1927 Schneider Trophy race in Venice. It was powered by the Mercury I, the first of Bristol's second-generation engines with a big supercharger and the new 'penthouse' cylinder heads. This engine had a 6·5-inch stroke, an inch shorter than the Jupiter's to make it more compact, and for racing gave 900 shp,

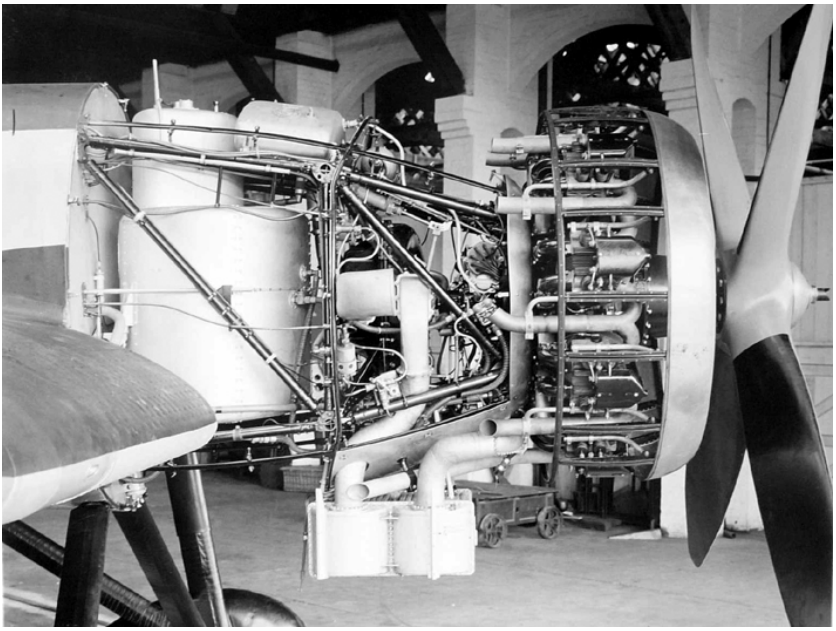
A Jupiter-powered powered Bulldog of No 54 Sqn. (MAP)

despite its smaller capacity of 24·9 litres. The Crusader was competitive but crashed before the race after someone crossed the aileron wires on re-assembly at Venice.

The Mercury was fitted to a wide range of fighter prototypes including the Hawker Hoopoe and the delightfully named Gloster Gnatsnapper, none of which was ordered. It was not until long-stroke versions were offered in 1932 that the Ministry finally ordered the engine and, to avoid confusion, decided that these required a different name. Thus the Mercury V, VI and VII became the Pegasus I.S, I.U and I.M respectively, to the confusion of historians ever since, particularly when the original Mark numbers were re-used for new versions of the 6·5-inch stroke Mercury engine!

These early Pegasus supplanted the Jupiter in many RAF types such as the Vickers Vincent and Valentia. With the Pegasus, the Sidestrand became the Overstrand and the Wapiti became the Wallace some of which were operated by Filton's own Auxiliary Air Force unit, No 501 Sqn.

The Pegasus and Mercury were developed alongside each other, the more compact engine aimed primarily at fighters and the larger Pegasus at bombers and transports. The 'lightened series' of 1936 took advantage of the 87 octane leaded fuel which was finally available in quantity and had become useable, thanks to advances such as sodium-cooled exhaust valves and NiCrMn valve seats. So the



The two-staged supercharged Pegasus installation in the one-off Bristol Type 138A.

Mercury VIII could now offer 840 shp to an altitude of 13,000 ft and the Pegasus X a take off rating of 960 shp.

These engines bridged the transition from biplane to monoplane, the Mercury powering Gloster's Gauntlet and Gladiator but also the Blenheim. The Pegasus powered interim bombers like the Wellesley which the RAF also used to break the world distance record in November 1938, flying the 7,158 miles from Egypt (Ismailia) to Australia (Darwin) non-stop. It took them 48 hours.

This was not the first record RAF pilots had captured using Bristol Pegasus engines. In September 1936 a Pegasus with an intercooled two-stage supercharger in the Bristol 138A had taken Sqn Ldr F R D Swain to almost 50,000 ft to retake the world altitude record from the Italians (who had used an Alfa Romeo-built Pegasus in a Caproni biplane). Nine months later Flt Lt M J Adam took the 138A, slightly modified, to 53,937 ft to take the record again.

But the Pegasus was intended as an engine for transports and

Above – In 1920 Bristol's engine factory, later to be known as the West Works, was established in two, of the three, triple-coupled 1917-pattern General Service Aeroplane Sheds that had been built for the RFC's No 5 AAP; the single triple-shed in the foreground is still in use in 2010. Below – The East Works, built between 1936 and 1938. The old GS sheds, now with the intervening spaces roofed over, can still be discerned in the small block to left of the road (A38) that bisects the site; sadly this historic building was demolished in 1996.

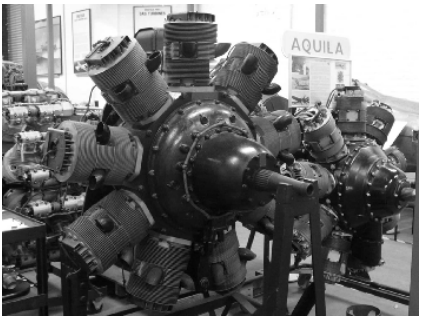
bombers and its ultimate version was the Mk.XVIII with its two-speed supercharger to give the aircraft good performance at altitude *and* at takeoff. This was used in the Handley Page Hampden, the in early Wellingtons and Sunderland flying boats, and with a takeoff rating of 1,065 shp it almost reached the magic target of one horsepower per pound weight.

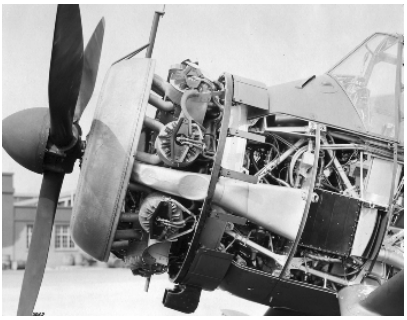
With the build-up of the RAF from 1935 on, demand for these engines required a massive increase in production capacity. In 1928 Bristol had experienced difficulty in building five engines a week to support Bulldog production. Now the Ministry was asking for production of eighty-five engines a week by the end of 1937. To satisfy that demand the company built four huge new factory buildings, the East Works, and between 1936 and 1938 changed from what was relatively a cottage industry to a true mass-producer.

But this would still not be enough and Bristol was first into the shadow factory scheme, working with Austin, Daimler, Humber, Rover and Standard to produce the engines in the numbers required. As a result, on the day war broke out about 85% of the RAF's twin-engined monoplane bombers were powered by Bristol Mercury and Pegasus engines. And by that time shadow production was up to 110 engines a week.

But Fedden had effectively abandoned further development of these engines in 1936. Back in the 1920s he had been seduced by the appeal of the sleeve-valve. The Burt-McCollum single-sleeve system that is, not the oil-burning double-sleeve Knight type used in big Daimler cars. Fedden had always reasoned that high power demanded good breathing so he had always used four-valve heads (two inlet, two exhaust) ever since the first Jupiter. The single-sleeve promised even better breathing with rapid port opening and large port areas. It dispensed with floppy pushrods and bouncing valve springs. And Harry Ricardo had shown that on a given fuel it could run at higher compression by one whole ratio (say 6:1 compared to 5:1) before detonation occurred. It was irresistible.

The first experimental test unit was a V-twin, a 'slice' of an inverted V-12 which was schemed. This ran in late 1927. But after a few years development of the sleeve concept Fedden reverted to the nine-cylinder radial and the prototype Perseus, with the same bore and stroke as the poppet-valve Mercury, ran in 1932. Perseus were tested





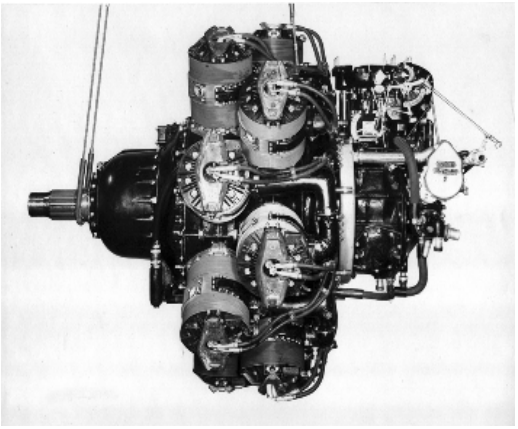
Left – The prototype Perseus, the first of more than 70,000 Bristol sleeve-valved engines on display in the Rolls-Royce Heritage collection at Patchway. Right – The neat Perseus installation in a Lysander II.

in service by Imperial Airways and by the RAF in the re-engined Vildebeest IV. They proved to be smooth-running, economical and reliable. But all of these early engines had matched pistons, sleeves and cylinders – they were hand finished.

Mass production of interchangeable sleeves proved a nightmare. It is said that over 1,100 combinations of alloys and heat treatments were tried by Firth Vickers. A particular problem was restoring the sleeves to true roundness after machining and heat treatment. While this development continued Fedden was busy with new sleeve valve designs: the little Aquila with its 5-inch bore, and two fourteen-cylinder, two-row engines: the Taurus, using Aquila-sized cylinders, and the Hercules, with Perseus cylinders.

Aircraft were being committed to production while the sleeve manufacturing problems remained. They were finally solved, but only just in time to meet production schedules. By 1939 the 900 shp Perseus was too low-powered for front-line types. Apart from the Vildebeest IVs of No 42 Sqn, the RAF used the Perseus only in the unloved Blackburn Botha, the Westland Lysander II and the impressed DH Flamingo transports

The 1,100 shp Taurus was rushed into production to replace the Perseus in Bristol's own Beaufort torpedo bomber as the amended Specification 10/36 resulted in a heavier aircraft. The Beaufort was urgently needed to replace the archaic Vildebeest (and the Anson) but



The Hercules I.

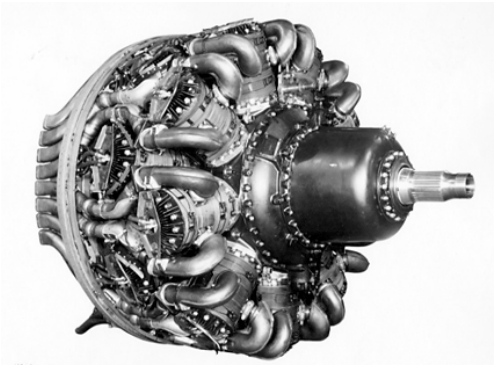
the Taurus was under-developed. It proved unreliable, and without feathering propellers there were many crashes due to engine failure. The Australians used Pratt and Whitney's Twin Wasps in their locally-built Beauforts as did Bristol for the RAF's Mk IIs. The Taurus problems were fixed but its reputation never recovered.

However, the bigger fourteen-cylinder engine fully restored Bristol's reputation. The Hercules was the company's biggest contribution to the war effort. By VJ-Day over 60,000 of them had been built. Originally designed as a bomber/transport engine giving 1,350 shp it first ran in January 1936. It entered RAF service just three and a half years later in yet another failed aircraft, the Saro Lerwick, but this was followed in 1940 by the first Beaufighters and Stirlings and in 1941 by the Wellington III. The Hercules gave the Wellington a new lease of life and 7,328 were built, more than twice as many as with the original Pegasus engines.

Hercules greatly improved the Halifax too but they gave little overall advantage in the Mk II Lancaster and only 300 of these were built. That said, Merlin-Lancaster ground crew may have been disappointed; with 192 tappets per aircraft to check, they probably dreamed of sleeve-valves. Aircrew too had a high regard for the Hercules; Sgt Harry McLean of No 427 Sqn was quoted recently as saying: 'There was nothing wrong with the Merlins but an air-cooled Bristol would get you home if half the cylinders were shot off.'

By this time the Hercules was giving over 1,700 shp which would grow to almost 2,000 shp in post-war variants for the Vickers Varsity and a little less in the Hastings, both of which flew on into the 1970s, giving the engine a service life of over 35 years.

The ultimate Bristol piston engine was the Centaurus. Eighteen



Last of the line, the Centaurus.

cylinders and a 7-inch stroke gave it a capacity of 53·6 litres against the Hercules' 38·7. It began life at 2,000 shp and grew to almost 3,000. It actually passed its first Type Test in October 1939 but was then so mishandled by MAP that it made almost no contribution to the war effort. It was built in small numbers for aircraft which were consigned to secondary duties such as the Vickers Warwick and Bristol Buckingham. Its most promising application was the Hawker Tornado fighter and from this eventually emerged the Tempest II. It was the most powerful fighter in the RAF and almost the fastest. With its long range it was intended for the war in the Pacific. But it didn't enter service until August 1945 and was soon replaced by the first jets.

The Centaurus continued in service until 1953 in Bristol's Brigand, which saw action in 1950-53 during the Malayan Emergency. Then, in 1956, it began a new life powering the mighty Blackburn Beverley, both east and west of Suez. Comparing the ungainly looking Beverley with the Tempest II, one is tempted to say 'from the sublime to the ridiculous', but the Beverly was far from being ridiculous and Fedden's ultimate engine helped to provide the RAF with an airlift capability that it had never previously enjoyed. The Beverleys were retired in 1968, appropriately perhaps, as it was the same year that the name 'Rolls-Royce' went up on the works at Patchway signalling the end of the Fedden era.

AIRFRAME DESIGN, DEVELOPMENT AND PRODUCTION 1919-45

by Peter Coombs

Following a student apprenticeship with the Filton Division of the British Aircraft Corporation, 1965-70, Peter Coombs gained an MSc in aircraft design at the Cranfield College of Aeronautics before joining the UK Accidents Investigation Branch in 1972. Since then he has participated in over 250 investigations into aircraft accidents, both civil and military, at home and abroad. Currently licensed to fly single- and multi-engined light aircraft and helicopters, his interest in the Bristol company's history stems from his father who joined its design staff under Barnwell in 1932 and retired forty years later as a senior engineer on the Concorde project. Peter is currently a Director/Trustee of the Bristol Aero Collection.

The first flight carried out by the RAF, on 1 April 1918, was by a Bristol F2B Fighter. Bristol aircraft remained in the inventory of the new service for the next fifty-seven years, and it would be more than seventy years before the last Bristol guided missiles were withdrawn. More than 4,700 examples of the extremely capable Bristol Fighter would be built and they would remain in service until long after the war.

The Royal Air Force had been formed as a consequence of the failure of the other two Services to counter successfully the air raids conducted against this country in 1917. Following the establishment of a dedicated Air Ministry in January 1918, in addition to improving air defence, attention was focused on other, increasingly specialised, aspects of air power. This included the development of large bomber aircraft, one of which was a four-engined Bristol triplane, the Braemar, which had been designed, like the Bristol Fighter by a small team led by Chief Designer, Captain Frank Barnwell.

Barnwell and his brother, Harold, had built their first aircraft as early as 1908. Having joined Bristol in 1911, Frank spent the first year of the war flying with the RFC before returning to the company to

The very ambitious, Liberty-powered, Braemar II triplane.

resume his design work in 1915. The experience he had gained on active service on the Western Front with No 12 Sqn provided the inspiration that produced both the iconic Bristol Fighter and the innovative M.1 monoplane.

Bristol built two more wartime Barnwell designs, the single-seat Scout F and the two-seat Badger, but neither was successful, largely because of their unsatisfactory power plants – the scarcity of the intended Hispano-Suizas and Salmsons, the vibration that plagued the Sunbeam Arab and the general unreliability of the ABC Dragonfly. Solutions might have been found, but the Armistice brought an end to both programmes. The same fate inevitably befell the Braemar, only two examples of which were flown.

Practically overnight, the British aircraft industry shrank, almost to vanishing point, the imposition of an Excess Profits Duty on armaments manufacturers serving only to increase their difficulties. Bristol's approach to the problem was facilitated by decisions taken by the company's founder, Sir George White, back in 1910 when he had created both the Bristol Aeroplane Company and the British and Colonial Aeroplane Company, actually trading under the latter name. It proved to be financially advantageous, in the context of taxation, to dissolve British and Colonial, transfer its fixed assets to Bristol Aeroplane and then to relaunch the latter with a new rights issue. As the company's products had always been known simply as 'Bristol'

Business was sustained in the early post-war years by the Bristol Fighter. This one, J7635, wearing No 2 Sqn's triangle on its fin, was one of a batch of 215 ordered in 1920. (P H T Green)

aeroplanes, this change was virtually seamless and it attracted little interest beyond the confines of Filton. While 'Bristol' remained the internationally recognised shorthand for the company's name, closer to home the acronym BAC soon became the standard local term used to describe all industrial activity in the Filton area, including the newly acquired Engine Department.

The bankrupt Fishponds company of Cosmos Engineering, previously Brazil-Straker, was reluctantly purchased by the Bristol Board in 1920 and with it came, as Chief Engineer, the dynamic Roy Fedden. With wartime engine production orders long since gone, engine building prospects looked dubious and it was, therefore, essential that all new designs from the aircraft works should utilise Fedden's new Bristol engines.

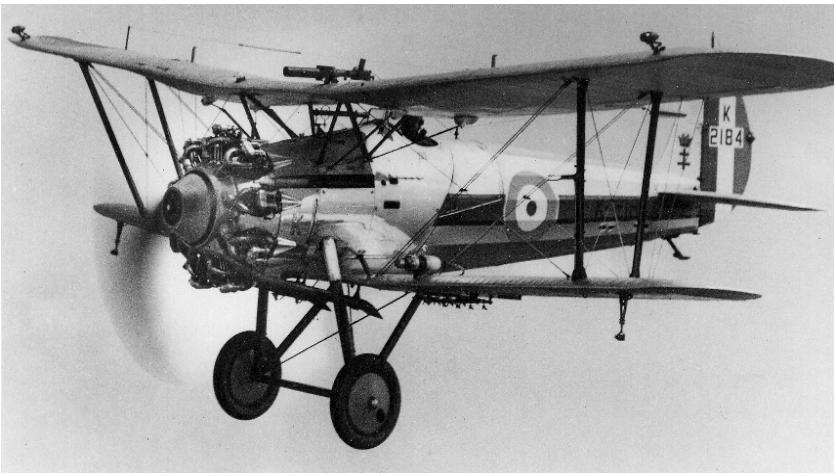
The aeroplane business at Filton struggled throughout the first peacetime decade, surviving, initially, on overhaul contracts for Bristol Fighters and limited production of new-build machines, some 379 being ordered between 1920 and 1926. Fortunately the RAF found the F2B was adaptable enough to make it a handy general purpose type for use overseas in the air policing role that had been promoted by Trenchard. This kept the Bristol Fighter viable for

several years and new variants were still being developed in the mid-1920s.

Ironically, the company's wartime success proved to be a post-war handicap, because the spacious facilities which had turned out thousands of aircraft were costly to maintain and unsuited to the small production runs that the Ministry was likely to order in peacetime – assuming, of course, that an acceptable design emerged. Unfortunately, that proved not to be the case, as Captain Barnwell (and his short-term replacement Wilfred Reid) seemed unable to recapture Bristol's earlier ascendancy. By 1927 the company had built prototypes of six completely new military aircraft, some to meet official specifications, others to satisfy perceived Service requirements. Sadly, none of these had attracted a production contract and, since civil aviation barely existed in the 1920s, there was little prospect of orders from that quarter. Frustratingly for those concerned with the airframe side of the business, the upshot was that it was increasingly overshadowed by the success, and consequent growth, of the new engine department. As Bristol Fighter-related work tailed off, the workshops were kept occupied between 1928 and 1930 by the award of three contracts which covered the building of a total of eighty-three of Armstrong Whitworth's Siskins.

Meanwhile, during the early 1920s, the company had devoted a great deal of effort to designing racing aircraft. Before 1914 Fedden had built a number of competition cars that had performed successfully in races and hill climbs as a means of publicising the Brazil-Straker company. Apparently believing that a similar approach could be applied to aero-engines, he pressed Barnwell and Reid to produce racing machines using his Bristol power units. These aeroplanes did achieve some success, although the benefit was almost entirely to the advantage of the engine division in that it stimulated the sale of Fedden's engines. There was no market for specialised racing aeroplanes, however, and building one-off examples did little to fill Barnwell's empty factory buildings.

Having been corresponding with the SBAC over the desirability of a switch to metal construction for some years, the Air Ministry began to increase the pressure in 1927 when it advised industry that the primary structure of all future RAF aircraft (other than light trainers) should be made of metal, rather than wood. This innovation was



The classic Bulldog constituted the backbone of the RAF's air defence force in the early 1930s. This one belonged to No 41 Sqn. (MAP)

introduced because supplies of appropriate grades of wood, especially spruce, could be erratic, and because wooden components were relatively short-lived and responded poorly to adverse weather conditions, especially in the tropics. There had been some early opposition in some quarters, because of the capital outlay involved in new plant and the industrial upheaval that would be involved in abandoning traditional carpentry skills and adopting black-smithing and metal-working instead (this applied equally to the Service, of course), although there would still be a substantial requirement, at least for a while, for wooden fixtures that constituted non-load-bearing elements of an airframe. Since the Ministry was the only likely source of work, however, the aircraft manufacturers had little option but to conform – and the change was clearly inevitable at some stage.

Fortunately, Bristol had already been working on a form of metal construction, developed by Harold Pollard, and this had been largely perfected by 1925. It used thin-gauge, stove-enamelled, rolled-steel sections, riveted or folded together to form individual members. Most Bristol designs tendered to Air Ministry specifications during the next six years were to utilise these sections, with traditional fabric covering.

Relief from this depressing period finally came in 1928 with a

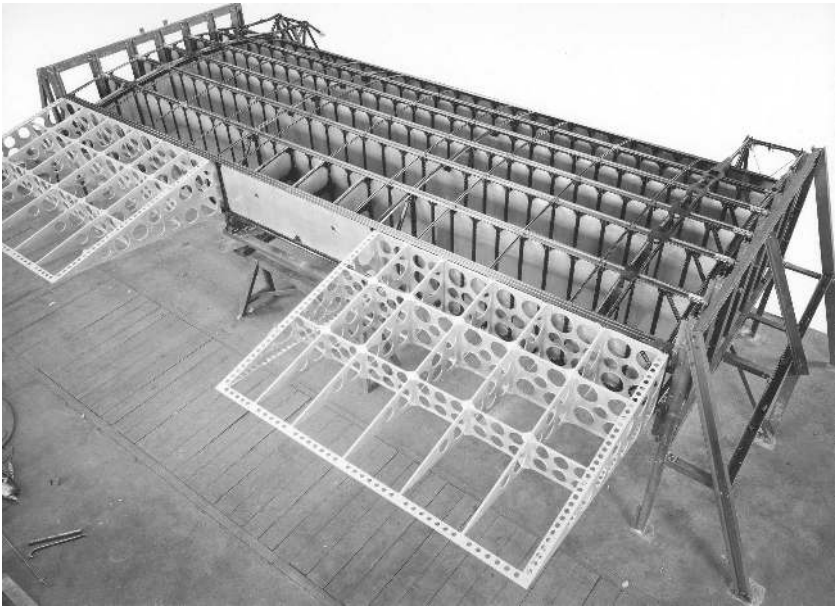
production order for the Type 105 Bulldog, and the fact that it was powered by a Bristol Jupiter pleased everybody. Following official rejection of an initial proposal, based loosely on the Badminton racer, the Type 105 had been designed by Barnwell's deputy, Leslie Frise (inventor of the eponymous aileron) and the prototype was built as a private venture at company expense to meet the requirements of Specification F.9/26 for a day and night zone fighter.

A prototype of an interceptor fighter, the Type 107 Bullpup, powered by the smaller diameter Bristol Mercury, was built at much the same time as the Bulldog but problems with this new engine led to delays which curtailed the Bullpup's chance of success. The Bulldog, by contrast, after the inevitable design changes that resulted in the production model, became the RAF's standard fighter and maintained the tradition of spectacular formation aerobatic displays at the annual Hendon Air Pageants. Well over 400 Bulldogs were built and, because the design had been a private venture, the company was at liberty to seek export orders and Bulldogs were eventually supplied to seven overseas customers. Late production, Mercury-powered versions, delivered to Finland between 1935 and 1936, were actually used in combat when war broke out with Russia in 1939. Despite their obsolescence, the Finnish Bulldogs achieved some success against more modern Russian aircraft.

Shortly after the Bulldog had made its first flight in 1927, a rather less successful Bristol prototype took to the air. Designed to meet an improbable Air Ministry specification, it was a twin-engined monoplane fighter that was intended to be armed with two upward-angled shell-firing guns. In the event the Type 95 Bagshot, suffered wing torsional flexing, causing aileron reversal which rendered it uncontrollable at speeds above 100 mph. It was the dramatic failure of this aircraft which led to the evolution of the principles that dictated the structural design of all Bristol military aircraft of the WW II era.

The Bagshot, with its fabric-covered, two-spar wing, using similar rolled-steel sections to the Bulldog, was soon abandoned and a new wing was designed. Still to be fabric-covered, and using rolled-steel structural elements as before, it had no fewer than seven truss-type spars with diagonal bracing in plan. An example was built at Air Ministry expense for static testing.

It was then learned that alclad sheet, a duralumin alloy coated in

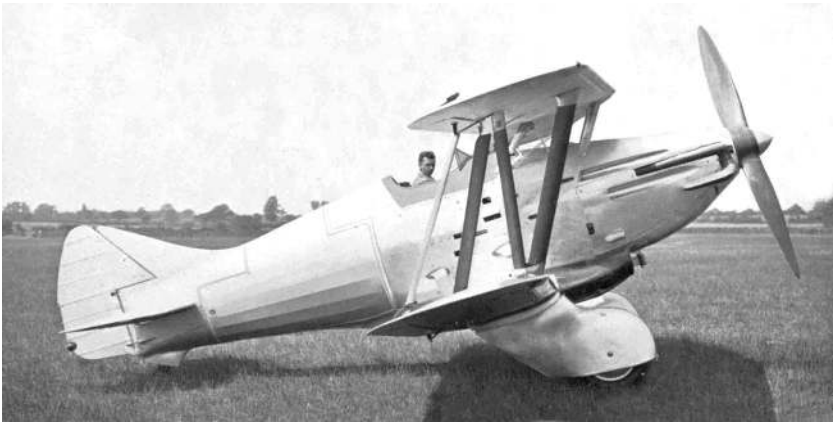


The un-skinned centre section of the seven-spar wing of the Type 130. The black members are rolled steel, the lighter material is thin gauge alclad sheet.

pure aluminium to resist corrosion, was about to be manufactured in the UK. By replacing the fabric wing covering with alclad, a smooth finish was achieved, thus reducing drag. More importantly, the torsional stiffness derived from the wing's internal diagonal bracing could now be achieved by using the shear load-carrying properties of the alclad skin. This rendered the diagonal members lying in the horizontal plane redundant, allowing them to be deleted. Furthermore, the new wing had also featured diagonal bracing in the vertical plane within each of the spars and this too could be replaced by alclad sheet webs.

The result was a much lighter wing structure retaining adequate, and more predictable, torsional stiffness. The principle was also applied to other structures and an alclad stressed-skinned Bulldog fuselage was built for test purposes. This also demonstrated a significant weight saving along with adequate strength.

These construction principles were first applied to the Type 130, a



The rather racey-looking, Goshawk-powered, Type 123.

large troop carrier, powered by a pair of Pegasus engines, that had been ordered by the Air Ministry in 1933.

Meanwhile, in late 1931, the Air Ministry had issued specification F.7/30 for a new four-gun, day and night fighter. A paper produced in 1929 by Prof Melville Jones had drawn attention to the poor aerodynamic form of most existing aircraft, emphasising the drag contribution of most engine installations then in use. At about this time a new Rolls-Royce evaporatively-cooled engine, the Goshawk, was being developed. Many designers saw the low installed drag characteristics of this engine as a valuable contribution to the improved performance sought by the Service. Most companies submitted designs to satisfy F.7/30, the Goshawk engine being the most popular power unit. Barnwell drew up three distinct proposals, using both the Roll-Royce engine and the locally preferred Mercury. None of these designs was accepted, but Leslie Frise's biplane project fared rather better. Following design changes made at official request, the company was invited to construct a prototype for consideration as a private venture. The resultant Type 123 used a hybrid of rolled-steel members and duralumin box structures, together with a Goshawk engine, armament and other operational equipment provided by the Ministry on 'embodiment loan'.

Aside from its troop carrier and fighter projects, the company had a third string to its bow in the early 1930s – the Types 118 and 120,

conventional single-engined, two-seat biplanes built to meet a requirement, Specification G.4/31, for a general purpose aircraft. It is indicative of the intensity of the competition for production orders, still scarce at the time, that nine manufacturers submitted no fewer than seventeen designs, examples of ten of which were actually built, seven of them as company-funded private ventures. Other than contracts to purchase a selection of the prototypes, no orders were placed. While the Type 120 had been unsuccessful, it was significant in that it had pioneered the fully enclosed gun turret which, in a more sophisticated form, would be a standard feature of all RAF bombers a decade later. The armament development work that began with this aircraft would eventually see Bristol become a major producer of turrets.

In the meantime, to support the company's early attempt at developing a two-row radial engine, the Hydra, the Air Ministry had ordered a prototype of a two-seat fighter monoplane, the Bristol Type 132, to be powered by this new engine. By this time increasing doubts were being expressed over the viability of the complex steam cooling system associated with the Type 123's Goshawk – not least by Fedden, who was firmly wedded to air cooling. Unfortunately, test bed running of the Hydra revealed a fundamental shortcoming which led to the engine's being abandoned and with it the Type 132 project.

Not a man to be discouraged, however, Fedden lobbied for the design work already invested in the Type 132 to be salvaged and adapted to create a Mercury-powered *single*-seater incorporating a retractable undercarriage, which would, in most respects, match the F.7/30 specification. This would become the Type 133. As with the Type 123, the Ministry paid for the engine and armament of the otherwise private venture prototype – which the company felt able to fund on the strength of the recently awarded contract for the prototype Type 130 transport, and the prospect of a substantial follow-up production order.

Although the Type 130 had been built around the new seven-spar Bristol wing, which incorporated the use of alclad, it was quite clear that the potential of this material had not been fully exploited. Even with the alclad, a *seven*-spar wing was unnecessarily complex, and heavy. Bristol had, therefore, designed a much lighter, stressed-skin, two-spar wing and a specimen had already undergone successful

The prototype Type 130, later the Bombay.

structural testing before the Type 130 had been ordered, begging the question – why did the Type 130 have seven spars? In short, because it was what the Air Ministry had said that it wanted and no one at Filton was inclined to hazard the prospect of a major production contract by suggesting that there might be a better way of doing it! With the Type 130 prototype order safely secured, however, the company felt able to provide the private venture Type 133 fighter with the new, and much lighter, two-spar wing.

In 1933, Barnwell's busy drawing office schemed a small twin-engined monoplane airliner, the Type 135, which also featured the new two-spar wing and had a retractable undercarriage. Although not built in its original form, a faster derivative, with a smaller fuselage and more powerful Mercurys, in place of the projected 135's Aquila engines, appeared as the Type 142. This remarkable aeroplane was ordered, and paid for, by the newspaper magnate, Lord Rothermere. Rothermere had been the first Air Minister in 1918 and, although his tenure in post had been brief, he had subsequently maintained a close interest in aviation and had used his *Daily Mail* to criticise both the British aircraft industry and the Air Ministry, which he held responsible for the unsatisfactory state of affairs in the 1930s. Dissatisfied with the performance of the available commercial

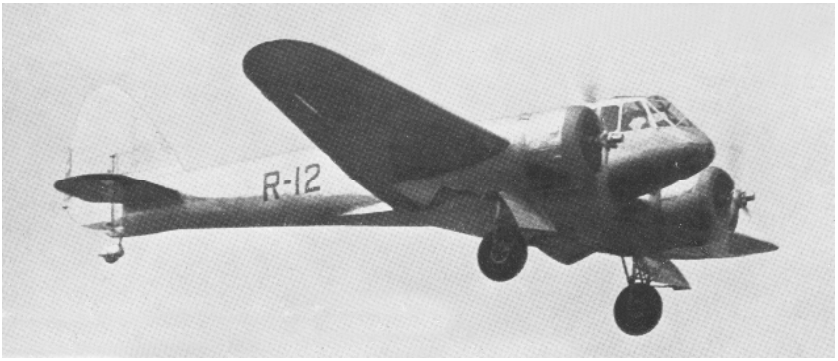
The rather chunky, and ill-fated, Type 133.

aeroplanes, Rothermere had commissioned Bristol's 142 to demonstrate what could be achieved by a state of the art design.

The prototypes of the two fighters being prepared for the F.7/30 competition were completed in 1934. The Type 123 biplane was flown for the first time by Cyril Uwins on 12 June. It proved to be the last biplane that Bristol would build and it was a major disappointment, technical difficulties with the steam-cooling system being compounded by unsatisfactory handling characteristics. Some attempt was made to alleviate these problems but, despite its rather stylish appearance, the aeroplane was not a likely prospect and, on Uwin's recommendation, it was soon abandoned in favour of the far more promising Type 133.

The company had high hopes for the Type 133 which presented the possibility of the RAF's receiving its first four-gun monoplane fighter with a retractable undercarriage and tentative plans were prepared for quantity production to replace the ageing Bulldog. Sadly, in February 1935, on the eve of the Air Ministry's fly-off competition, the prototype was lost in a spinning accident. The Ministry made the best of a bad job and ordered the traditional, but obviously dated, Gloster Gladiator biplane, albeit with a Bristol Mercury engine.

The RAF would not receive a modern fighter until it began to take



The remarkable Type 142 'Britain First'.

delivery of Hurricanes in 1938. It is arguable that, had the Type 133 been ordered, the improvements later achieved in the Mercury, coupled with a general cleaning-up of the airframe could have produced a fighter with performance and fire-power comparable to that of the early Jumo-engined versions of the Messerschmitt 109. Had large numbers of this hypothetical 'Type 133 Mk II' been in service in 1938 Chamberlain might not have felt obliged to sign up to the notorious Munich Agreement.

The failure of the Type 123 and the loss of the 133 were devastating blows to the company. It still had the Type 130 in hand (although this would not fly until June 1935) but salvation would come in the unexpected form of the Type 142 which flew for the first time in April 1935. It demonstrated such exceptional performance that it soon attracted the attention of the Air Ministry who expressed an interest in evaluating it. Rothermere promptly presented his aeroplane, by now proudly named *Britain First*, to the Air Council while Barnwell prepared performance estimates for a bomber version.

Adapting the design for military purposes involved raising the low wing to the mid position, to create space for a bomb bay, and adding a gun turret. The Air Ministry was so impressed with the projected capabilities of this aeroplane that 150 were ordered 'off the drawing board' in September, permitting a production line to be set up with minimum delay. The first aircraft – the Blenheim – flew on 25 June 1936. It was the precursor of a range of twin-engined Bristol aircraft which would be built by the thousand, in five countries, before and

The Type 138A which set an altitude record of 53,937 feet in 1937.

throughout the Second World War.

Meanwhile, in June 1934, Bristol had received an Air Ministry order for a purpose-built, high altitude research aircraft – the Type 138A. Barnwell designed a large wooden monoplane, with a fixed undercarriage, powered by a Pegasus, which had already established a sound reputation as the engine fitted to a variety of aircraft types that had captured a series of world's altitude records. In the Type 138A its performance was boosted by a two-stage supercharger. The pilot wore a sealed rubber pressure suit and helmet, the predecessor of the 1960's spacesuit. First flown in May 1936, the one-off aeroplane was operated by the RAE and, in the hands of RAF pilots, it broke the world's altitude record twice. On the second occasion, which was in June 1937, Flt Lt Maurice Adam set the bar at just below 54,000 feet, still some 10,000 feet above the service ceiling of a modern long-haul airliner.

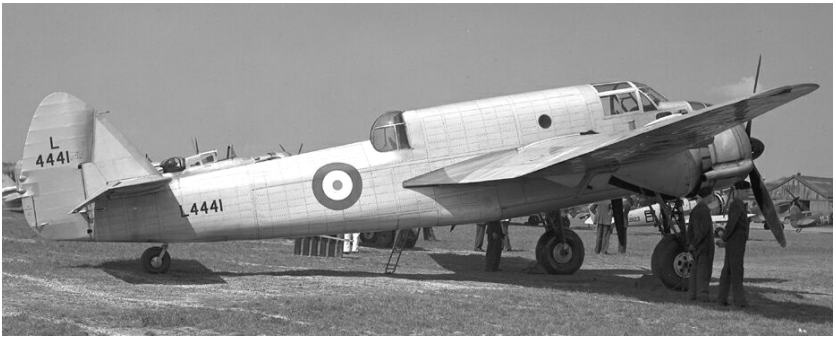
By this time, the original Filton assembly shops were far from being the empty liabilities that they had been in the early 1920s. Extensive alterations and extensions had been made and these were sufficiently advanced to permit dramatically increased production rates when deliveries of Blenheims began in 1937. Impressive as this was, the Air Ministry had realised that the, still relatively small, aircraft industry would be unable to build aircraft rapidly enough if another war broke out. They therefore proposed that 'Shadow Factories' be set up, managed by the motor industry, as well as by other aircraft companies. The Mercury was the first Bristol engine to go into production in the shadow programme, rapidly followed by the

Blenheim Is in production at Filton; by December 1937 they were being turned out at a rate of sixteen per month.

Blenheim. Thus the early Bristol-built Blenheims with locally produced Mercurys were bolstered by a flow of similar aircraft entirely built by shadow factories.

Because the Filton workshops were fully occupied with Blenheims, the production contract for the Type 130, by now known as the Bombay, had been awarded to the newly established Short Bros and Harland Ltd who were to build them at a shadow factory in Belfast. In all, far more Bristol aircraft would be 'shadow' built than were built at Filton.

In 1935 the Air Ministry had issued specifications for a torpedo bomber and a coastal reconnaissance aircraft. Barnwell considered that both requirements could be satisfied by a single aeroplane which would eventually materialise as the Type 152 Beaufort. Since design and development of both the airframe and its equally new Taurus engines would take some time, an interim solution was proposed in the form of a minor variation on the Blenheim theme. This, the Type 149, had a lengthened nose, to provide a dedicated station for the observer ahead of the pilot, and increased fuel tankage, and was initially named the Bolingbroke. This name was short-lived, however,



L4441, the Type 152 Beaufort prototype in May 1939.

and by the time that it entered squadron service in January 1939 it had been redesignated to become the Blenheim IV which soon displaced the Mk I on the Filton production line and at other plants where the Blenheim was now being mass produced in factories run by Avro and Rootes. By September 1939 the RAF had more than 1,200 Blenheims on charge, more than any other type in its inventory. The Blenheim was also built under licence in Canada, Finland and Yugoslavia. The Canadian Mk IVs (the RCAF stuck to the original name of Bolingbroke) were employed on anti-submarine patrols off the Atlantic and Pacific coasts and in Alaska. .

The success of the *Britain First* had led Barnwell to scheme what would have amounted to a stretched Blenheim with four engines but, perhaps because it considered Bristol to have enough on its plate already, the Air Ministry showed little interest in this proposal.

On the other hand, the Beaufort project had made satisfactory progress. The prototype eventually flew in 1938 with wings that featured a new style of construction made possible by the development of new materials and new industrial processes. In place of the laminated rolled steel that had been used to create the wing spar booms of earlier types, the Beaufort's wings were built around 'T' section spars constructed from extruded and machined, high-strength aluminium alloy. The resulting structure was significantly lighter, permitting yet more savings in empty weight which could be converted into payload. This advance was offset, to a degree, by the temperamental nature of the two-row, sleeve-valve Taurus engines, a problem that was eventually overcome by substituting the Pratt and

R2052, the prototype of the Type 156 Beaufighter.

Whitney Twin Wasp which powered the 700 Beauforts built in Australia and the British-built Mk 2.

During the lean years of the 1920s and early '30s, Bristol's directors had struggled to maintain the company's financial health and little cash could be spared to attract new engineers. Its fortunes were reversed by the RAF's Expansion Schemes which produced contracts to build 141 Hawker Audaxes in 1936 followed by large scale orders for Blenheims. That took care of the production side of the business but if that was to be sustained with aircraft and engines bearing the Bristol trademark, the company needed a vibrant and innovative design staff and there was now a shortage of suitable talent within the rapidly expanding aviation industry. As a result, neither Fedden nor Barnwell were able to bolster their staffs with new recruits and the knock on effect within the drawing offices severely delayed the development of both airframes and engines. This was particularly evident in the cases of the Type 146, a single-seat, eight-gun fighter, and the Type 148 army co-operation aircraft, neither of which progressed beyond the prototype stage.

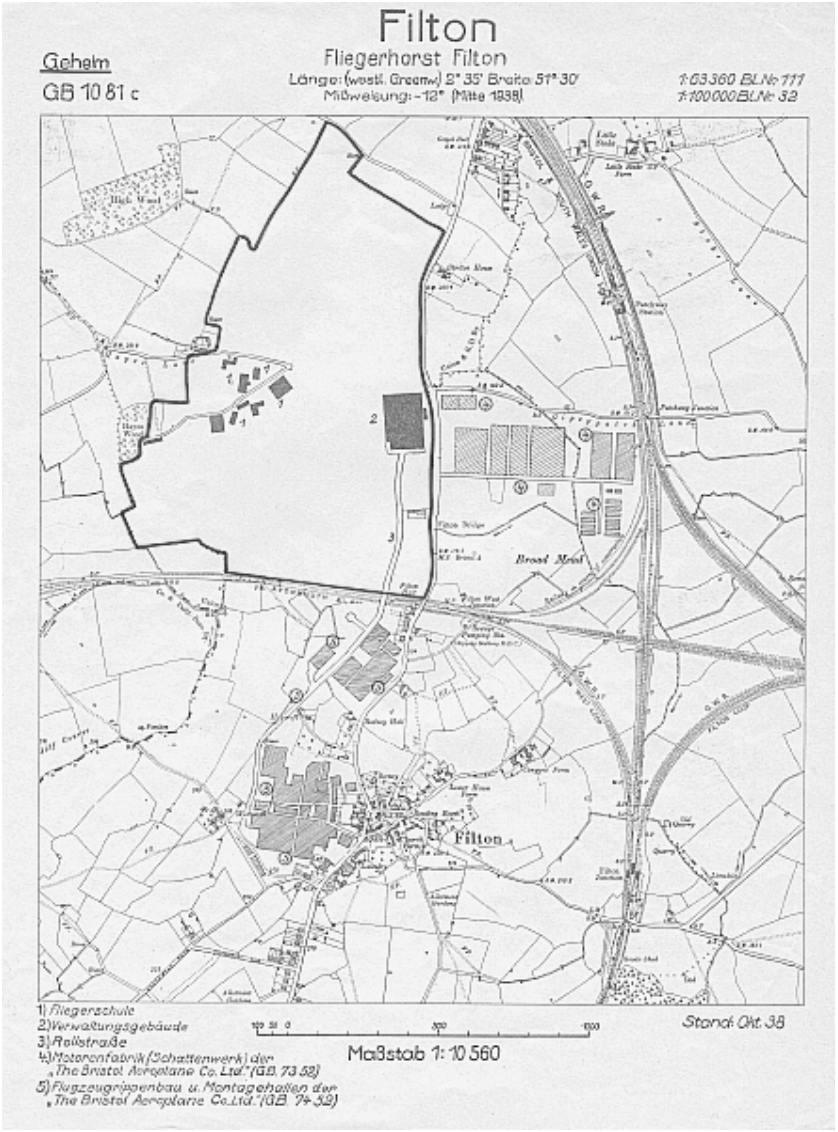
Sadly, the company was to lose one of its mainstays in 1938 when Captain Barnwell died in a flying accident. His brother Harold had already been killed in the prototype Vickers FB26 when it crashed in 1917. All three of Frank's sons would lose their lives flying with the RAF during the early years of WW II. Thus did one family pay a terrible price for the nation's freedom.

Barnwell's place was taken by Leslie Frise who combined the wings and tail of the Beaufort with a new slim fuselage and a pair of

Mock ups of (at the rear) the Type 159 to Specification B.1/39 and, in front, the Type 162 to B.7/40 – see page 117.

Hercules to create the Type 156 – the Beaufighter. Conceived, built and flown in the space of just six months, it became an excellent and very heavily armed (four cannon and six machine guns) radar-equipped night fighter, as well as a very effective maritime strike aircraft, replacing the Beaufort in that role.

At the end of 1938 the Air Ministry invited industry to submit proposals for a heavily-armed, four-engined 'Ideal Bomber' that could replace all other heavy and medium types. At least nine firms worked on this rather optimistic concept which was eventually expressed as Specification B.1/39. In July 1939 prototype contracts were issued to Handley Page for its HP 60, an advanced derivative of the Halifax, and to Bristol for its entirely new Type 159. Bristol devoted a great deal of effort to the Hercules-powered Type 159 but it was overtaken by events. Following the fall of France in May 1940, the overriding need to prepare for the anticipated onslaught against Britain, led to the creation of the Ministry of Aircraft Production which promptly directed that priority should be devoted to just five types, the Spitfire, Hurricane, Whitley, Wellington and, of particular significance to Bristol, the Blenheim. All long-term development projects were to be shelved – not cancelled, postponed. Work accordingly stopped on the Type 159. Before it could be resumed, however, the lessons taught by wartime experience meant that the requirements of B.1/39 had been superseded by later specifications and the mock-up was eventually dismantled in January 1941.



Luftwaffe target map for Filton airfield (GB 10 81). The rectangular buildings running east/west in the centre are the Bristol engine production sheds at Patchway (GB 73 52); the aircraft plant (GB 74 52) was in the shaded buildings to the south, adjacent to Filton village

Although the drawing office worked on a number of wartime specifications, the only one that materialised as hardware was the Centaurus-powered Buckingham. By the time that it was ready for production, however, requirements had changed and it was no longer needed. Most of the relatively few Buckinghams that were built were completed as fast courier transports but none of them ever saw productive service, although a post-war role was found for the Buckmaster, a dual-control trainer version, that was used to support Brigand-equipped units.

That said, Bristol's failure to produce a post-1939 war-winning design was hardly unique. The fact is that, with the exception of the Mosquito and Tempest, WW II was fought with aeroplanes that had been designed to pre-war requirements and, in most cases, had flown before September 1939. Once war had been declared, Bristol's major contribution was to introduce improvements to existing types and to increase output.

The British aircraft industry was of particular significance to the enemy, of course, and the Bristol factories were on the *Luftwaffe's* target list, eg Filton airfield was Target *GB 10 81* and Weston-super-Mare *GB 10 240*. Filton was the specific objective for a daylight raid on 25 September 1940 which caused extensive damage and disrupted Beaufighter production. Within the factory seventy-two people were killed and 166 injured, nineteen of whom subsequently died, and there were further casualties, including another fifty-eight fatalities, outside the works.

There were more night raids during the winter of 1940-41 but, despite these interruptions, the rate of production actually increased. By the middle of the war the combined output of Filton and the company's shadow factory at Weston-super-Mare exceeded forty aircraft a week, predominantly Beaufighters. At its peak, the company was employing more than 52,000 people. With the phasing out of the Blenheim and Beaufort, the Beaufighter remained in production at Filton, Weston-super-Mare and in other factories throughout the UK, as well as in Australia, until 1945.

MORNING DISCUSSION PERIOD

Bob Turner. I would like to ask Bill Morgan about Yatesbury. A few years ago I drove down a lane to discover that those beautiful flying school buildings were still there, but overgrown with brambles and obscured by self-seeded trees. It seemed such a shame and with so many historic sites being preserved, this one appeared to be retrievable and I wondered whether there was any possibility of that happening.

Bill Morgan. I can shed only a little light. There is a 'Yatesbury Historic Society' of some kind. I'm not sure of its precise title, but it endeavours to support the facilities. The land is now owned by a Jordanian businessman who wants to develop the site which would, in the process, preserve the buildings, including the hangars, but at the moment I understand that he is not making much headway with Wiltshire County Council.[1]

Ian Coleman. I was there a few years ago when there was a proposal for the establishment of a 1940s-themed hotel, but they couldn't get planning permission. There were signs up saying 'Dangerous Buildings – Keep Out'. Ignoring those, I went inside – and fell through the floor into the cellar! (*Laughter*)

Chris Farara. I noticed that, in discussing the Centaurus, Patrick Hassell did not mention the Sea Fury. Was that because it was a naval, rather than an RAF, aeroplane?

Patrick Hassell. Yes. In order to stay within my allotted time constraints, I had to be quite rigorous in tailoring my presentation. The Sea Fury, fine aeroplane though it was, did not fit comfortably within an RAF context, so it had to go.

Arthur Spencer. As a member of a local history group, I was asked to investigate the origins of Bristol Airport. What I found led me to speculate that if Sir George's great grandfather had lived into his late 70s, instead of his early 60s, Bristol Airport might well have been here at Filton, and not on top of a hill in north Somerset.[2]

Sir George White. I think that is probably right. He certainly started down that route in 1911 when he advertised Filton, Larkhill, Brooklands and Eastchurch as the world's first 'air stations' – as he called them. His plan was, I think, to provide all the facilities that

would be needed, accommodation, workshops and so on, to permit people to fly across country. With the experience of his tramway system to build on, had the First World War not intervened, I fancy that he would indeed have established a network of airports – and what a tragedy it is that Filton is not a part of that.

Maurice Budd. Does the Bristol Aeroplane Company still exist – in any form?

Hassell. Yes it does; but it's complicated. Bristol Siddeley was owned 50:50 by the Bristol Aeroplane Company and the Hawker Siddeley Group. To consolidate the engine industry in one business, Rolls-Royce bought Hawker Siddeley's share outright but the whole Bristol Aeroplane Company actually merged with Rolls-Royce. As a result, the shareholders of Bristol Aeroplane acquired about one-third of the equity of the enlarged Rolls-Royce Group which, in turn, owned Bristol's 20% share of British Aircraft Corporation and its shares in Shorts, Westlands and so on. This was in 1966 and until 1968 Bristol-Siddeley continued to operate as a separate division within Rolls-Royce. Bristol Aeroplane Company also survived as a subsidiary but, some time after Rolls' bankruptcy and nationalisation in 1971, Bristol Aeroplane was wound up and it is no longer among the trade names that Rolls has on its list of dormant corporate organisations – whereas de Havilland Engines and Bristol Siddeley Engines are still acknowledged. Noticing this anomaly, one of the Directors of Bristol Cars thought that it would be prudent to claim the redundant title so, as I understand it, the Bristol Aeroplane Company name is now owned by Bristol Cars. Is that right George?

Sir George White. I think that it belongs specifically to Toby Silverton – who runs Bristol Cars.

Maurice Budd. When Rolls-Royce acquired Bristols, did that include all the patents taken out by the original company?

Hassell. I believe that the intellectual property associated with the Bristol Aeroplane Company resides with Rolls-Royce – and that would include, for instance, the copyright to many of the photographs that we have been looking at this morning.

Andrew Dow. Just to amplify that point – the Bristol Aeroplane

Company was formally wound up by Rolls-Royce and a year later they decided to destroy all of its records. Fortunately, before that could be done, seventeen tea chests full of documents were recovered from a warehouse in London and much of this material has been preserved by the Rolls-Royce Heritage Trust.

[1] Formal planning permission for redevelopment of the Yatesbury site (a scheme that would have included 12 houses and 50 apartments and provided for the refurbishment of the Grade II listed WW I-era hangars) was granted in 2007 and work did start – as indicated by this 2008 picture of the scaffolding-clad Flying School buildings. Sadly, however, the subsequent banking crisis caused RBS to withdraw its funding and an alternative source of finance would seem unlikely until the economic climate improves. In the meantime, one of the hangars collapsed in 2010. **Ed**

[2] Filton and Whitchurch were both considered but, to avoid the growing urban development of Bristol, the ex-RAF airfield at Lulsgate Bottom became Bristol Airport in 1957. **Ed**

BRISTOL AIRCRAFT IN WORLD WAR TWO

Air Cdre Graham Pitchfork

Following an initial Canberra tour in Germany, in 1965, Graham Pitchfork, a Cranwell-trained navigator, was seconded to the FAA to fly Buccaneers. Thereafter his career was inextricably linked with that aeroplane, culminating in command of No 208 Sqn. He later commanded RAF Finningley and RAF Biggin Hill before a final tour as Director of Operational Intelligence. Since retirement he has written several books on aviation-related topics, been an officer of the Aircrew Association and is a regular contributor to the Daily Telegraph's *obituary column.*

Bristol aircraft flew with a number of air forces during WW II but I am going to concentrate on their service with the RAF and those Commonwealth squadrons that flew under the command of the RAF. Furthermore, in restricting my address to aircraft, I am very conscious that the Bristol Company made a massive contribution to the RAF's efforts with its wide range of aero-engines and other ancillary equipments including the design and development of power-operated gun turrets.

The RAF Expansion Schemes of the mid- and late-1930s had seen a huge boom in the production of aircraft for the RAF and the Bristol Company made a major contribution. Requirements for aircraft far outstripped capacity and many were built in Canada and in Australia in addition to numerous shadow factories in this country. By the end of the war in 1945, over 14,000 Bristol aircraft had operated in every theatre of war and seen action at sea, over land and in air combat.

When war broke out in 1939 the dominant Bristol aircraft serving with the RAF was the Blenheim, which equipped a number of squadrons in Fighter, Coastal and Bomber Commands in addition to squadrons in the Middle East and the Far East.

However, before looking at the Blenheim's role in more detail, brief mention should be made of another Bristol aircraft that was in service as war broke out – the Bombay.

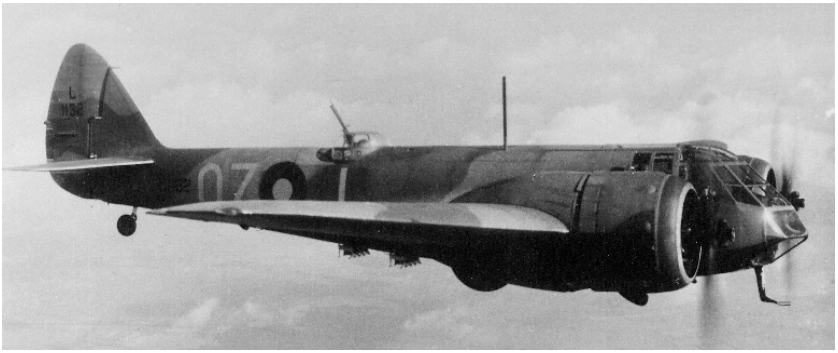
A Bombay of the Egypt-based No 216 Sqn.

Bombay

The first of fifty Bombays entered service with 216 Squadron in Egypt in September 1939 before equipping two other squadrons both based in UK. The UK-based Bombays of No 271 Sqn were in use for almost four years as transports and gave valuable support within the UK to RAF forces and, in the spring of 1940, to the British Expeditionary Force. However, most of the aircraft's operational service was with 216 Squadron during the Libyan Desert campaign as a night-bomber but to a greater extent as a transport aircraft carrying supplies to the front and returning to Egypt with battle casualties.

In May 1941, the squadron's aircraft assisted in the evacuation of Greek refugees, including the Royal Family, to Egypt and flew British troops into Habbaniya to reinforce the garrison that was under siege from Raschid Ali's Iraqi forces. Later in the year they were heavily engaged in the renewed advance into Libya, supporting RAF units and aircraft operating up to 200 miles behind enemy lines.

On 7 August 1942, a Bombay of No 216 Sqn was shot down by Messerschmitt 109s over the Western Desert and amongst those killed was Lt Gen Bill Gott who was travelling to take command of the 8th



A pre-war Blenheim I of No 82 Sqn. (MAP)

Army. He was replaced by General Montgomery and, who knows, perhaps the course of the war was changed.

When Hudsons arrived to replace 216 Squadron's Bombays, the remaining aircraft were transferred to No 1 Australian Air Ambulance Unit, evacuating over 2,000 casualties from North Africa and Sicily and later carrying nursing sisters to Italy after the Anzio landings. They continued with casualty evacuation in Italy until 1944.

The Blenheim in North West Europe

The Blenheim had entered service with the RAF in 1937 when its high performance enabled it to outpace contemporary fighters, but by the outbreak of the war it soon became obvious how quickly this advantage had been lost.

In August 1939, more than a dozen squadrons overseas were equipped with the Mark I but the sixteen bomber and two army co-operation squadrons based in the UK were being replaced by the long-nosed mark IV, initially named the Bolingbroke, a name retained by the Canadians. In Fighter Command seven squadrons were equipped with the Mark IF, a bomber adapted to take a gun pack of four fixed Browning machine guns mounted below the fuselage.

On the first day of the war, during a reconnaissance sortie, a Blenheim IV of 139 Squadron was the first British aircraft to cross the German frontier. The next day, fifteen Blenheims carried out Bomber Command's first raid of the war – a low level attack on the German Fleet in the Schillig Roads. Five failed to return, an ominous, and in the event, accurate indication of what the future would hold.

A long-nosed Blenheim IV of No 110 Sqn being loaded with 250 lb GP bombs and, in the foreground, a pair of Small Bomb Containers.

Six Blenheim IV squadrons accompanied the British Expeditionary Force to France in September and flew reconnaissance sorties over Germany but it was soon apparent that they were no match for the Messerschmitt fighters. The aircraft's armament was inadequate, as was the lack of armour plate and self-sealing fuel tanks. Subsequent modifications to remedy these deficiencies added to the all-up weight of the aircraft, which, in turn, adversely affected the aircraft's performance.

During the so-called Phoney War, the seven squadrons in 2 Group had as their primary role anti-shipping sorties of all kinds, often called North Sea Beats. However, the German invasion of the Low Countries on 10 May 1940 saw all squadrons thrown into the battles over Northern France. Losses amongst the Blenheim crews were grim. On 17 May, twelve aircraft of 82 Squadron attacked a German armoured formation near Namur; only one returned. In the nine days that the aircraft operated up to 22 May, forty-four Blenheims were lost with more than 100 aircrew killed. By the end of the month, 150 had been lost, the equivalent of nine squadrons.

Soon after becoming operational again, the massacred 82 Squadron suffered a further tragedy on 13 August. Eleven aircraft attacked the Danish airfield at Aalborg. None returned. The cruel losses of 1940

graphically highlighted the dangers of daylight bombing operations.

During this early period of the war, the Blenheim IFs played a pioneering role in the development of airborne interception radar (AI) and, in April 1940, the Fighter Interception Unit was formed. Success was limited but on the night of 22/23 July, Flying Officer Ashfield and his crew were vectored towards a contact and they shot down a Dornier 17 into the Channel. This was the first successful night interception ever carried out using airborne radar. Throughout the Battle of Britain, Blenheim night fighters were on patrol at night but few successes were achieved – just five.

An indication of the difficulties that faced the Blenheim night-fighter crews is illustrated by the events of 14/15 November when more than 400 German bombers devastated Coventry. On that night, thirty-nine individual night interception sorties were flown by Blenheim crews. Two fired their guns, but none achieved a victory.

In early 1941 Fighter Command went on the offensive over Northern France. Small formations of Blenheims, escorted by up to eight fighter squadrons, were used as bait to entice German fighters into the air so that they could be engaged by elements of the fighter escort. So, the 'Circus' operation was born.

As 1941 progressed, the 'Circus' operations increased and varied in scope with as many as twenty-four, and sometimes even more, Blenheims, flying in 'boxes' of six, escorted by over 100 fighters. Time prevents discussing these and other daylight raids, such as the long-range attack by fifty-four Blenheims against the power stations at Knapsack near Cologne, in any detail. Typical of these low-level daylight operations was that against the docks at Bremen on 4 July, which resulted in Wing Commander 'Hughie' Edwards, the CO of 105 Squadron, being awarded the Victoria Cross.

He led a formation of twelve Blenheims across the North Sea flying at very low level. The anti-aircraft fire around Bremen was intense and tethered balloons flying up to 500 feet added to the perils for the bombers flying at 50-100 feet. Edwards jinked between the obstacles and headed for the centre of the dock area where he released his bombs. Still under intense fire, he circled the target to assess the results despite his aircraft being damaged and his gunner wounded. The aircraft, some trailing telephone wires and electricity cables, weaved to escape the intense *Flak*. There was no cloud cover and the

A Blenheim I of No 211 Sqn in Greece. (MAP)

survivors escaped individually at low level. Edwards purposely flew due north to confuse the enemy radars before turning west to head for base. Five aircraft were lost.

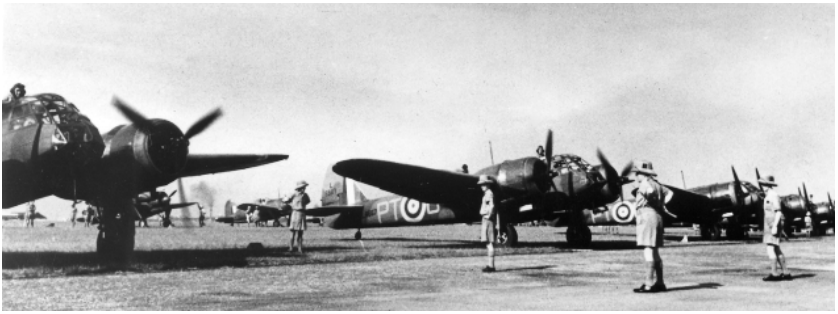
Before leaving the European theatre, mention must be made of the considerable role played in the maritime arena. From early 1940 Coastal Command squadrons patrolled the waters around the UK and provided vital convoy escorts. Blenheims of 2 Group flew many anti-shipping strikes, attacking at mast height when, again, they suffered terrible losses. Some months the losses were as much as 16% and in August it rose to almost 30%, despite the presence of fighter escorts.

By the end of 1941 it was clear that the Blenheim was no longer viable as a bomber in the North-West European theatre and it was withdrawn as the Bostons, Venturas and Mosquitoes started to appear on the scene.

The Blenheim Overseas

Jeff Jefford's paper, which focuses on the experiences of a squadron that operated in the Middle and Far East (see page 102), will serve to illustrate many aspects of the Blenheim's fortunes when operating in the wider world, but I will preface this by filling one or two gaps with some general points on overseas operations.

At the outset of the war, all overseas squadrons were equipped with the Mark I. When Italy entered the war on 10 June 1940, there were 102 Blenheims in the Middle East. The following day, some were in action as the desert campaign started. With the invasion of Greece,



Blenheim Is of No 27 Sqn, probably at Kallang.

four squadrons were sent there from Egypt to stem the Italian advance. Through the bitter winter of 1940/41, they achieved some success but the arrival of the *Luftwaffe* in March 1941 saw the losses increase dramatically. On 13 April 1941, No 211 Sqn was virtually wiped out when a whole formation was shot down by Messerschmitt 109s.

The Mark V variant of the Blenheim, also known as the Bisley, entered the North African battle during Operation TORCH in November 1942. Heavier than its predecessors, it was not a popular aircraft. On 4 December 1942, Wing Commander Hugh Malcolm, the CO of No 18 Sqn, led an unescorted daylight raid against a forward landing ground in Tunisia. All eleven Bisleys failed to return with Malcolm's one of the last to fall to a force of more than fifty *Luftwaffe* fighters. Malcolm was awarded a posthumous VC for his tenacity and fearlessness, the only graduate of the RAF College at Cranwell to receive that honour. The 'Malcolm Clubs' were established in his memory.

Finally a brief look at the Far East where four squadrons were based in Singapore in 1940. On the day that Japanese forces commenced operations against Pearl Harbour and Malaya, the Blenheims attempted to intercept and disrupt the amphibious forces approaching the east coast of Malaya. They were decimated, both on the ground and in the air. On 9 December 1941, Squadron Leader Arthur Scarf, a Flight Commander on No 62 Sqn, was the sole survivor of a force sent to attack an occupied airfield. Despite being severely wounded, he pressed on against all odds and dropped his bombs. He managed to bring his Blenheim back and make a crash landing, which saved his crew, but a few hours later Scarf succumbed

to his wounds and died. After the war, when his actions became known, he was posthumously awarded the VC, the third and last of the Blenheim VCs.

The Blenheim went on to play a prominent role during the early battles of Burma and some of this will be discussed by my colleague.

Beaufort

The Beaufort was originally intended to re-equip the RAF's torpedo-bomber strike force in the Far East, while Coastal Command was to receive the Botha. The failure of the Blackburn aircraft resulted in a change of plan with the British-built Beauforts being diverted to Coastal Command and the Far East commitment being met by Beauforts built in Australia.

Although ordered in 1936, it was not until November 1939 that the first Beauforts entered RAF service with 22 Squadron and it was to be another six months before the aircraft flew its first operational sortie. The early Taurus engine was underpowered and plagued by mechanical failures and cooling problems but successive developments did little to improve the aircraft's performance or reliability. The following excerpts from the pilot's notes for the Beaufort I vividly illustrate the problem:

- If an engine fails during take off with rpm at about 3,300 or with flaps partly down, a rapid swing and roll will develop which cannot be stopped by rudder or aileron.
- It is not advisable to land the Beaufort on only one live engine.
- Except when lightly loaded, it is usually impossible to climb on one engine.

Operationally, of course, the aircraft never was 'lightly loaded'. The problems were eventually solved by the introduction of the Twin Wasp-powered Beaufort II which began to enter service with 217 Squadron in October 1941.

Another of the Beaufort's deficiencies was its poor armament. Like most bomber or torpedo aircraft in the RAF at that time it was completely outclassed by German fighters and its poor self-defence led to many losses. On the other hand, the Beaufort did have some strong points. It performed well at low level. It was strongly built; it

A Beaufort I of the Torpedo Development Unit.

could take a lot of punishment and its crew of four were well catered for in the cockpit.

Although designed as a torpedo-bomber, in the early days the aircraft was more often in action dropping conventional bombs on enemy ports and dock installations, and on mine-laying sorties. On the night of 14 April 1940, it was Beauforts of 22 Squadron that laid Coastal Command's first air-dropped magnetic mines in an operation off the mouth of the River Elbe.

In May 1940, 22 Squadron dropped the first 2,000lb armour-piercing bombs during an attack on Nordeneny off the Dutch coast and, for the next twelve months, until the 4,000 lb 'Cookie' entered service with Bomber Command, the Beaufort was the only aircraft which carried every weapon in Britain's offensive armoury.

Late 1940 saw the introduction into service of the first of the 'Blockbuster' high capacity bombs called Magnum. There were two forms; the Imp with an instantaneous fuse and the Tim, which had a time delay. They were actually modified and strengthened sea mines and were dropped on the main naval ports such as Bremerhaven and

Brest. For an aircraft designed primarily to be used for anti-shipping operations, the need to use Beauforts as bombers is a further indictment of the limited capability of Bomber Command at this stage of the war.

By 1941 the Beaufort was being employed on 'Armed Rovers', reconnaissance flights over the sea during which targets of opportunity would be attacked with torpedoes or bombs. Torpedo successes were rare. The first had been on 17 September 1940 when a small merchant ship was sunk in Cherbourg harbour.

More notable was a courageous attack on 6 April 1941. Flying Officer Kenneth Campbell of 22 Squadron was the pilot of one of six Beauforts sent to attack, at first light, the German battlecruiser *Gneisenau* docked at Brest. For various reasons, including poor weather, only Campbell arrived at the RV on time and after waiting in vain for the others, he decided to attack. Against intense anti-aircraft fire he released his torpedo at very close range. The *Gneisenau* suffered severe damage and was out of commission for six months. Campbell was posthumously awarded the Victoria Cross.

Another noteworthy torpedo success was achieved by Flight Sergeant Ray Loveitt of 42 Squadron who crippled the pocket-battleship *Lutzow* off Norway on 13 June 1941, the result of an Enigma intercept.

Beauforts were on standby during the infamous 'Channel Dash' of the *Scharnhorst* and *Gneisenau* on 11 February 1942 but some chaotic operational planning and inaccurate reconnaissance reports rendered the powerful Beaufort torpedo force ineffective. Some did take off, from Thorney Island, and one or two intercepted the German fleet off Holland but no damage was inflicted.

The expansion of the UK-based Beaufort force was slow, just four squadrons, Nos 22, 42, 86 and 217, by the end of 1941. The last Beaufort torpedo attack in home waters, a poorly co-ordinated twenty-seven-aircraft strike against the *Prinz Eugen* in the North Sea, was launched on 17 May 1942. Despite anti-*Flak* support provided by Beaufighters, 42 Squadron lost three of its twelve aircraft while four of 86 Squadron's also failed to return. Only 42 Squadron had succeeded in launching its torpedoes but no hits had been achieved. It had been a costly failure, but by this time the Beaufort had already started heading east, first to the Mediterranean, where maritime attack

A Beaufort I of No 42 Sqn.

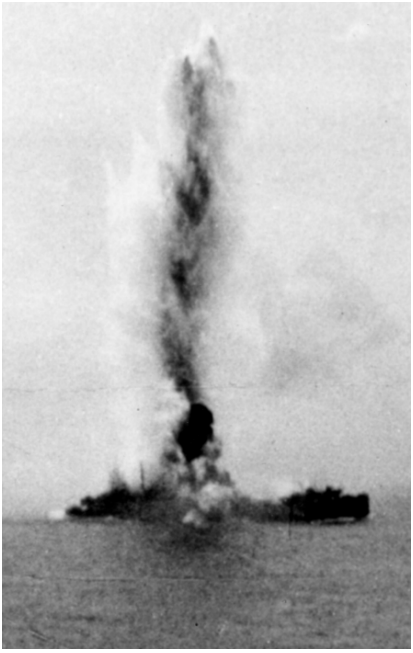
tactics would finally be perfected, and later to Ceylon.

While the Beaufort had achieved very modest success in Coastal Command the opposite would be the case in the Mediterranean where the aircraft made a major contribution flying from Malta and from Egypt, albeit, again, at a very great cost in crews.

In Malta, three squadrons operated in support of Allied convoys and against the ships supplying Rommel's armies in North Africa. On 15 June 1942, Flight Lieutenant Arthur Aldridge and his crew took off with the rest of No 217 Sqn to search for the Italian Fleet. Aldridge was the first to spot the enemy and, without waiting for the others, he closed on the 10,000-ton *Trento* and his torpedo struck home. The disabled and blazing cruiser was eventually sunk by a submarine.

Over the next few months, the Beauforts took an increasing toll on Rommel's supply ships but the losses were crippling. By late August, the surviving aircraft and aircrew reinforced No 39 Sqn, which continued to operate from Malta and Egypt under the inspired leadership of Wing Commander Pat Gibbs.

In August 1942, No 47 Sqn, based in Egypt, was the last to receive the Beaufort and it soon had a spectacular success when it sank the tanker *Prosperina* on 26 October. Sometimes referred to as 'Rommel's Last Tanker', it was by no means the Beaufort's largest victim, but it was arguably the most important, since it was Rommel's only source of fuel as the Battle of El Alamein opened.



The victim of a Beaufort strike in the Mediterranean.

Operating from Malta, the Beauforts of No 39 Sqn achieved other major successes against re-supply tankers in early 1943 as Rommel's armies retreated towards Tunisia. The last vessel to be sunk by an RAF Beaufort was the *Aquino* on 24 April.

Beauforts were also deployed to Ceylon where Nos 22 and 217 Sqns constituted a potent strike force, although no targets had presented themselves before the last Beauforts were withdrawn in the latter part of 1944.

One of the factors which had prevented the formation of more front-line units was the widespread use of the Beaufort in the training role – many with dual controls. Production ended in April 1944 after 1,429 had been delivered. A few were still in service in training units at the end of the war and the aircraft was finally retired in December 1946.

Before leaving the Beaufort, and despite its being outside my remit, I should mention the role played by the Beaufort with the RAAF in the south-west Pacific. Seven hundred Australian-built Beauforts saw service, the first, albeit briefly, with the RAF's No 100 Sqn in Singapore as the Japanese invasion commenced. Having withdrawn to Australia, No 100 Sqn was transferred to the RAAF which eventually formed another dozen or so Beaufort squadrons. Initially used for coastal patrols and in the anti-submarine and anti-shipping roles, the Beaufort was also put to work as a bomber, ground attack and reconnaissance aircraft. Australian squadrons made a major contribution to victory in the Pacific and the aircraft remained in service until the end of the war.

An early Beaufighter IF of No 604 Sqn.

Beaufighter

For many, the mighty Beaufighter ranks as one of the truly great RAF aircraft of WW II. Its pugnacious appearance was in stark contrast to the aesthetic beauty of the Spitfire or the Mosquito. It looked a brute and it had a deadly fighting ability, which packed the most lethal punch ever fitted to an RAF fighter at the time. This toughness was not limited to its appearance; the Beaufighter was constructed like the proverbial brick-built outhouse and was able to absorb a staggering amount of damage and still get its crew home.

After a few early hiccups, the Beaufighter was to go from success to success in many roles and theatres. It equipped more than forty squadrons in various RAF Commands plus a number of Commonwealth squadrons and four in the USAAF. Apart from its significant role in fighter and anti-shipping operations in Northern Europe, the Beaufighter became the scourge of shipping in the Mediterranean and Aegean Seas, a night fighter and strike aircraft in North Africa and an army support and strike aircraft in Burma. The Australians built it and used it in their strafing and bombing attacks on the Japanese enemy in the Pacific. To the Japanese, the Beaufighter was known as the 'Whispering Death' on account of its quiet and stealthy approach.

The prototype made its maiden flight on 17 July 1939 and within a year, at the height of the Battle of Britain, the first aircraft were delivered to the Fighter Interception Unit at Tangmere. The first operational sortie was flown on the night of 3/4 September and before the end of the month small numbers had begun to be issued to four

A Merlin-engined Beaufighter II of No 255 Sqn. (MAP)

night-fighter squadrons. The first enemy aircraft to be destroyed at night by a Beaufighter using the secret airborne interception (AI) radar (in this case AI Mk IV) was a Junkers 88 shot down by Flight Lieutenant John Cunningham of 604 Squadron on 19 November.

The Beaufighter had thus added a new chapter to RAF history by becoming the first night-fighter with a sufficiently high performance to be able to exploit the full potential of AI radar and this, combined with the firepower conferred by four 20 mm cannons and six ·303" machine guns, made it a formidable aeroplane. By the end of May 1941 over 200 had been delivered, and successes against German night raiders were mounting.

In the meantime, Beaufighters had been entering service in the Middle East as long-range day fighters in the Western Desert and in May 1941 they began operating from Malta with great effect, both as a fighter and as a strike aircraft.

In December 1940 the Beaufighter began replacing the Blenheim IVF as the standard long-range fighter of Coastal Command. Known as the Mark IC, it was fitted with additional radio and navigation equipment and it started operations in March 1941. Flying from airfields in Devon and Cornwall, it was a key element during the major anti-submarine battles over the Bay of Biscay and it enjoyed many successes against Ju 88s attempting to interfere with Coastal Command's campaign against U-boats transiting the Bay from their French Atlantic ports.

Powered by Rolls-Royce Merlin XX engines, the Mark IIF entered

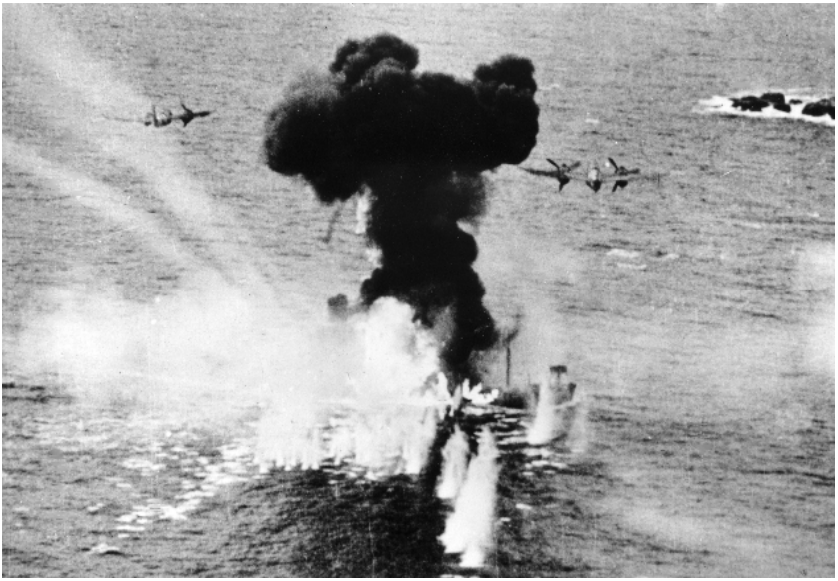
service with eight night fighter squadrons, beginning with 600 Squadron in April 1941. One of the modifications introduced in the Mark IIF, and subsequently standardised in almost all Beaufighters, was a 12° dihedral ltailplane, which improved longitudinal stability. The Beaufighter also had a strong tendency to swing on take off, a problem that was eventually alleviated by the additional keel area provided by a substantial dorsal fin extension.

Constant improvements were made to the AI radar and the early 'bow and arrow' type of aerial, was replaced by a scanner in a nose fairing, the 'thimble' nose that later characterised the Mosquito night fighter.

The Mark VI, which appeared on the scene in 1942, reverted to the Hercules radial engine, this time the Mark VI, which was rated at 1,650 hp. Another innovation was the provision of a rearwards-firing Vickers K machine gun in the navigator's dorsal hatch. The fighter version of the Mark VI was supplied to fourteen UK-based night fighter squadrons and it remained in service until July 1944 by which time they had all been replaced by the Mosquito. The night fighters also enjoyed considerable success in North Africa, particularly following the Operation TORCH landings in November 1942 and, later, throughout the Italian campaign.

A spectacular success was achieved during the early hours of 1 May 1943 by Flt Sgt Alwyn Downing and Sgt John Lyons of 600 Squadron. They were on a pre-dawn patrol south of Sardinia when they encountered five Ju 52s laden with troop reinforcements bound for Tunisia. In the space of ten minutes they shot down all five. Both were awarded the DFM.

Mention has already been made of the highly successful fighter version serving with Coastal Command but perhaps the Beaufighter will be best remembered for its role with the Command's Strike Wings. As early as March 1942 an aircraft had been tested as a torpedo-carrier and it soon became apparent that the Beaufighter was the ideal aircraft to replace the Beaufort in this role. Tactics developed by the Beaufort squadrons, particularly those operating in the Mediterranean, were studied and by November 1942, the North Coates Strike Wing of three Beaufighter squadrons was formed. Initial attacks failed until Wing Commander 'Nebby' Wheeler (later Air Chf Mshl Sir Neil Wheeler) was appointed to command and he would transform



Shipping under attack by Beaufighters.

the fortunes of the Strike Wing.

After a concentrated period of training, the Wing mounted its first operation on 18 April 1943. An important and large convoy had been spotted sailing north from the Hook of Holland and it was shadowed. With Wheeler leading the strike, nine 'Torbeaus' of No 254 Sqn, each carrying a Mark XV torpedo, and twelve anti-*Flak* aircraft from Nos 143 and 236 Sqns took off at 1320 hrs. The rendezvous with the large fighter escort went perfectly. The convoy was found and a co-ordinated attack was set up with the cannon-armed and bomb-carrying *Flak* suppression Beaufighters going in first and attacking the escort ships. Flying in pairs, the Torbeaus headed for the freighters and released their torpedoes from 120 feet at 800 yards range. It was estimated that three torpedoes hit a 4,900-ton ore carrier, and it was later confirmed that it had sunk A number of other merchant ships and their escorts were badly damaged. The attack was completed in four minutes and without loss. The operation was a resounding success and justified the formation of other strike squadrons.

This brilliant attack set the tone for the success of the other Strike Wings in operations off the Dutch coast and off Norway that

A rocket-armed Beaufighter X of No 404 Sqn at Davidstow Moor in August 1944 still wearing full D-Day warpaint.

continued until the end of the war. The introduction a few months later of the 3-inch rocket added even greater firepower and by the end of the war, the combination of rockets and cannon had become the Beaufighter's standard weapon load.

By June 1943, the most widely used Beaufighter of all, the Mark X, was entering service with Coastal Command. Powered by 1,770 hp Hercules engines, the aircraft could deliver torpedoes, bombs and rockets and an ASV radar was carried in a thimble nose radome. More than 2,200 Mark Xs were produced and it proved to be a formidable anti-shipping aircraft. In March 1945, those of Nos 236 and 254 Sqns sank five U-boats in two days using rockets.

The value and effectiveness of the Strike Wings are often underestimated. Their toll on the convoys from northern Norway to the Dutch ports, carrying the crucial raw materials for German industry, was very significant, despite the high cost.

Although the Beauforts had done well in the Mediterranean, the Beaufighter brought a new dimension to the anti-shipping role in the Middle East. This was never in better evidence than operations in the Aegean where the marauding Beaufighter squadrons based in Egypt wrought havoc amongst the merchant ships and their escorts, which were sustaining the German garrisons in the Dodecanese Islands. They took such a heavy toll of enemy shipping that the German troops on the Aegean islands were running short of supplies and all types of ships were pressed into service. These included the traditional caiques

A Beaufighter of No 217 Sqn off Ceylon.

which endeavoured to hide during daylight hours and sail at night, but the Beaufighters ferreted them out with daily sweeps around the islands and night intruder sorties over the sea-lanes. Bombs and torpedoes were soon replaced by rockets as the weapon of choice for shipping attacks, but bombs were still used against land targets.

With the formation of the Balkan Air Force in June 1944 to support the Yugoslav partisans, the Beaufighter was to play a prominent role attacking lines of communication on the mainland and shipping in the Adriatic. On 8 September 1944 eight Beaufighters of No 272 Sqn attacked the 51,000-ton Italian liner *Rex* anchored near Trieste. The liner capsized after being hit by 59 rockets, with 25 lb armour-piercing heads, thus preventing it from being used as a block-ship in Trieste harbour.

In September 1942 the first Beaufighters reached India where they entered service with No 27 Sqn, which specialised in attacks on enemy airfields and against shipping. As the war in Burma developed, the Beaufighters ranged far and wide attacking Japanese supply routes with rockets and cannons, some at very long range from their airfields in Assam. As the Japanese retreated, the effectiveness of the Beaufighter squadrons, and the damage they inflicted on the supply routes on land and at sea, undoubtedly hastened their demise.

FOCUS ON A BLENHEIM SQUADRON

Wg Cdr Jeff Jefford

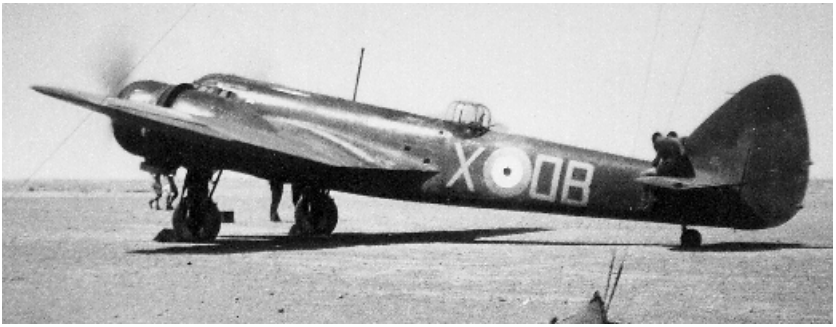
'Jeff' joined the RAF in 1959 as a pilot but (was) soon remustered as a navigator. His flying experience included tours with Nos 45, 83 and 50 Sqns and instructing at No 6 FTS. Administrative and staff appointments involved sundry jobs at Manby, Gatow, Brampton and a total of eight years at HQ Strike Command. He took early retirement in 1991 to read history at London University. He has three books to his credit and has been a member of the Society's Executive Committee since 1998; he is currently editor of its Journal.

The nature of today's proceedings means that we are focusing on the design, development and production of Bristol aeroplanes and engines. But, since the RAF was always the company's main customer, we thought it appropriate to highlight that association by taking just one Bristol-equipped unit and examining its experience in a little more detail – to quantify what was involved and perhaps to add a human dimension to the machinery.

I chose No 45 Sqn for two reasons. First it was one of very few squadrons to engage the Germans, the Italians, the Japanese and the Vichy-French – and to do it all with Blenheims – and secondly, its history has been relatively well-documented.[1]

No 45 Sqn spent the1930s in Egypt flying a succession of biplanes, culminating in the Vincent. In 1937 these were replaced by Wellesleys and in mid-1939 by Blenheims. So it had progressed from a conventional single-engined, fixed undercarriage biplane to a high performance, twin-engined all-metal monoplane with variable pitch props, flaps, wheels that went up and down and a powered gun turret in just eighteen months – December '37 to June '39 – and it had all been done in-house; there were no conversion courses in those days.

So who were the men who constituted this first generation of Blenheim pilots? Apart from the CO, Sqn Ldr Noel Moreton, they were all first tourists who had arrived on the squadron as acting pilot officers on various dates during the previous three years or so. In order to create some sort of a hierarchy three of the more likely prospects



A Blenheim I of No 45 Sqn at Fuka in 1939.

were given accelerated promotion; the most senior of them, Fg Off George Bush, was bumped up to *acting* flight lieutenant to become OC C Flt, while Plt Offs Harold Pleasance and Patrick Troughton-Smith became *acting* flying officers and OCs B and A Flts respectively. And that is how the squadron went to war. An experienced CO, by then Sqn Ldr Eric Webb, and a bunch of first tourists led by best of the rest. I should perhaps make the point that No 45 Sqn was far from being unique in this respect – this sort of thing was happening right across the air force.

The overall strength of the squadron ran to 112 personnel. This total included fifteen officers, all of them pilots, five sergeant pilots and three of the recently introduced (since January 1939) full-time, badged sergeant observers. At this stage all of the WOp/AGs and most of the observers were still aircraftmen drawn from a variety of ground trades who flew on a part-time basis.

The recently appointed CO picked up the first Blenheim for the squadron in June 1939 and, with no dual-controlled variant, everyone had gone solo in little more than a week and no one had made any terribly expensive noises. That could not last, of course, and the first Blenheim accident occurred in July when one was ground looped landing at Amman and its port undercarriage folded up.

In August 1939 the squadron moved forward to Fuka, closer to the Libyan border, but the declaration of war on 3 September proved to be something of an anti-climax, because there were no Germans within a thousand miles. There was a brief increase in the alert state but this was soon relaxed and routine training resumed. The monotony was

The domestic site at Fuka. Living conditions of this kind – tents or bashas, rarely a proper roof.– were pretty much par for the course for No 45 Sqn throughout most of the Blenheim era.

relieved by fire power demonstrations and massed formation flypasts laid on to impress the Egyptians and to dissuade King Farouk from getting too cosy with the Italians.

The routine was further enlivened by the occasional crash, some of which were quite spectacular, although there were no fatalities, and by crews being sent back to the UK to ferry additional aeroplanes, mostly Wellesleys, out to Egypt.

Fuka had no permanent facilities. It was a random patch of desert, indistinguishable from any other, that some anonymous pre-war staff officer had selected as being a suitable location for a landing ground. The squadron set about making itself more comfortable. All domestic accommodation was in tents. There was no hangarage, so all servicing was carried out in the open. A screen was erected for an open-air cinema and one or two huts, largely constructed from discarded packing cases, began to appear to provide an airmen's canteen and an Officers Mess bar. There were also trenches to be dug.

After the squadron had spent almost a year in the desert, waiting for something to happen, the Italians finally declared war on 10 June 1940 and the following day No 45 Sqn flew the first offensive mission of the North African campaign – an attack on El Adem airfield .

It turned out to be a baptism of fire. Eight of the nine planned aircraft got airborne. Two were shot down, another was written off in a crash landing and two others had sustained damage. Six men were dead. It had been a small-scale affair, of course, but it had involved a 25% loss rate in crews and approaching 40% in aircraft.

Flt Lt Rixon flying 'The Cheddar Cheese' over Abyssinia in 1940. At this stage of the war, each of the squadron's aeroplanes carried the name of a UK pub on the panel below the windscreen.

A six-aircraft night attack on Tobruk on the 12th was a shambles – no one found the target. Three aircraft were sent to Sidi Azeiz on the 13th and one of those was shot down. Clearly, this was not going to be easy.

Already down to half strength, a few days later the squadron withdrew to Helwan, on the right bank of the Nile, to lick its wounds before sending, a detachment to the Sudan. At this stage all of the tradesmen who were still flying were formally remustered as full-time observers or WOp/AGs so that, when the whole squadron moved to the Sudan in September all of its crews were either officers or sergeants. In all No 45 Sqn would contribute 163 sorties to the East African campaign, at a cost of four more aeroplanes, twelve more men killed and one taken prisoner. The odd number is accounted for by the fact that the squadron's Intelligence Officer, Plt Off L S Roberts had volunteered to fly on an operational sortie, a decision that had cost him his life.

The fact that the squadron had an Intelligence Officer is worthy of comment as it was symptomatic of the failure of the pre-war

Cpl R Anderson, Cpl P Hodkinson and LAC J Starr of C Flight playing dress-up in captured Italian kit at Menastir, December 1940.

Trenchardian ideal that had assumed that a General Duties officer, ie a pilot, would be able to do anything. This concept had simply failed to withstand the pressures of war. This was entirely predictable, of course, as it was a lesson that had been taught (but clearly not learned) by the experience of WW I. The only people of any consequence on an RFC squadron in 1914 had been its commissioned pilots. By 1918 even a single-seat fighter squadron required at least three officers to keep it running smoothly, a Recording Officer (ie an Adjutant), and two Technical Officers, one dedicated to looking after its armament, the other to deal with matters arising from supply and general engineering. Apart from its officer pilots now being matched by a similar number of commissioned observers, a two-seater squadron might have additional Technical Officers to deal with signals and/or photography. All of this had been quickly forgotten. Having entered WW II with no dedicated aircrew other than pilots, and no supporting staff at all, by 1941 No 45 Sqn had a full complement of professional observers and gunners, many of the former being commissioned, plus an Adjutant, an Equipment Officer, an Intelligence/Cypher Officer and its own Medical Officer. And so the wheel turns.

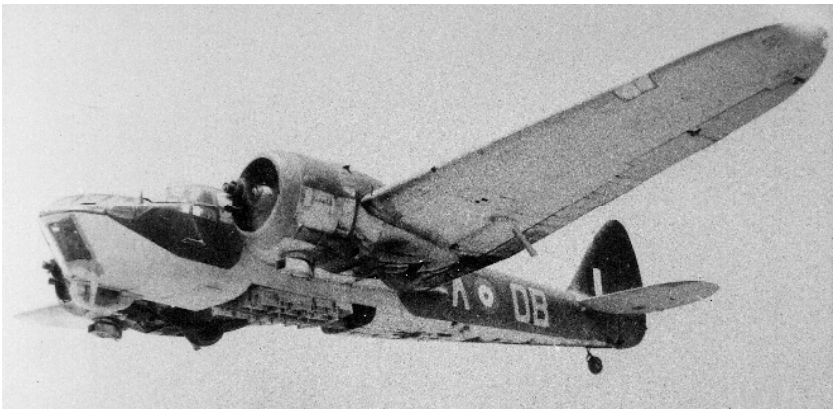
The squadron was back in the Western Desert before the end of 1940, in time to help ‘Wavell’s 30,000’ eject the Italians from Cyrenaica – Operation COMPASS. This involved an intensive burst of operations and a number of rapid moves, first to Qotafiyah with the squadron finally taking up residence for three weeks at Menastir, which the Italians had evacuated in some haste, permitting the ground crew to dress up in Italian uniforms and play with some abandoned

An ex-Italian ambulance, commandeered by No 45 Sqn to supplement its organic MT, en route Menastir-Helwan in December 1940.

equipment, notably motor bikes. In February 1941 the squadron withdrew to Helwan again, some of it travelling in commandeered ex-Italian MT.

Having been re-equipped with long-nosed Blenheim IVs, the squadron had just begun to move to Greece to support the recently despatched British Expeditionary Force, when it was urgently redirected to Cyrenaica, in the unsuccessful attempt to prevent Rommel's newly arrived *Afrika Korps* from recovering the territory recently lost by the Italians. The first week of April involved a hectic scramble from one landing ground to another – the only available groundcrew being the handful who had been squeezed into the aeroplanes when the air echelon moved forward. With only eight aircraft, the squadron flew 67 sorties in eight days, surprisingly without loss.

In the meantime, the bulk of the groundcrew, who had been boarding an Athens-bound ship at Alexandria, had been diverted to Tobruk. After a month within the perimeter, they were evacuated to rejoin the air echelon which had now taken up residence at its pre-war landing ground, Fuka, where it was formally re-established on a mobile two-flight basis with its CO elevated to wing commander. One



When the disposable load was too light to overcome the tension in the bungee cords that kept the Blenheim's bomb bay doors closed, the doors could be left off. This is No 45 Sqn's Z5888, OB•A.

flight was equipped with Mk IVF fighters, with four Brownings in a belly gun pack, which it first used to cover the British forces now evacuating through Crete while the bombers started to drop 'spikes' or 'prickles' (technically caltrops) on German-held landing grounds.

Caltrops have been used for 2000 years or more as a counter to the use of horses on the battlefield – but they do equally well against pneumatic tyres. The Blenheim's bomb bay doors were held shut by bungee cords and opened by the weight of the bombs falling on them when they were released. Like the incendiaries which were carried in Small Bomb Containers, 'spikes' lacked the weight to do that so some missions were flown with the bomb doors removed.

Operations over Crete had been costly and by the end of May the squadron was down to eight aircraft and just six effective crews. Pulled back to the delta to refit, the squadron was committed to action again almost immediately and before it had had a chance to work-up its new personnel. This time it went to Palestine, to take part in Operation EXPORTER – the occupation of Vichy-held Lebanon and Syria in the course of which it got a particularly bloody nose on 10 July when it sent twelve aircraft to attack Hammana. Despite being escorted by Tomahawks, they were engaged by six French Dewoitine 520s which shot down three Blenheims and damaged six others, a seventh being written off in a crash-landing.

The ground echelon taking a break en route Habbaniya-Fuka in September 1941.

Having, spent a few weeks at Habbaniya, during which it participated in Operation COUNTENANCE, the invasion of Iran, the squadron retraced its steps to Egypt (Fuka again) in September. This was a relatively straightforward exercise for the aircrew, of course, but for the ground echelon it involved another gruelling 1,300-mile, nine day, cross-country marathon. One of the participants, LAC Len 'Oscar' Wilde, describes the experience thus:

> 'There was no road as such, and transport making the trip simply followed the pipeline which traversed the desert carrying oil to Haifa. About every 150 miles there was a pumping station and these were the daily 'targets'. The 'road' could be up to half a mile wide as each lorry tried to avoid the soft churned up sand and stay clear of the clouds of dust. Fifteen to 20 mph was good going, and travelling in the back of a bumping, swaying lorry, covered in swirling dust for hours at a time was a journey of some considerable discomfort, not to say hardship. Water was available at the pumping stations and after a swill and a meal everyone would crawl under the trucks in an effort to take shelter from the sun. The only other vehicles we encountered were the RAF Regiment's Armoured Cars which constantly patrolled the pipeline. Daytime temperatures were always well over 100°F and once reached 128°F. A peculiarity of a convoy

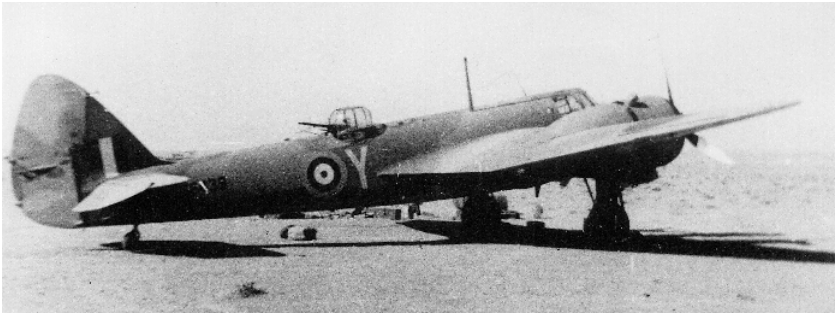
Date	Type Theatre	Total aircrew	RAAF	RCAF	RNZAF	SAAF	% Dominion
Apr 41	Blenheim Egypt	69	-	-	5	2	10%
Nov 41	Blenheim Egypt	75	28	2	-	3	44%
Feb 42	Blenheim Burma	72*	36	3	2	1	58%
*Air echelon only. At least 27 more went by sea; 63% of whom (13 × RAAF & 4 × RCAF) were from the Dominions.							

Fig 1. Dominion aircrew manning in No 45 Sqn, 1941-42

was the fact that, if the leading truck set the pace at, say, 20 mph, the breakdown vehicles bringing up the rear would often have to do 30 mph just to keep up. This was due to the varying speeds and constant deviations of the vehicles in between, which never maintained a constant speed or heading. At times the whole business would look like a cavalry charge as each truck edged outwards, away from the dust and debris of the one in front so that what started out as a column would often turn into line abreast.'

The constitution of the squadron's air echelon had changed significantly during 1941 – see Figure 1. The first South Africans and New Zealanders had been posted-in in April. By the autumn, 'colonials' constituted almost 50% of the aircrew strength and by February 1942 it was well over half.

The next British offensive, Operation CRUSADER, began on 18 November by which time the squadron was established at LG 75, another featureless stretch of desert, so unremarkable that it lacked even a name. Before the end of the month the squadron had lost seven aircraft in action, eleven more men were dead and five were PoWs. By this time the Blenheims were being escorted, but the *Luftwaffe* was now flying the very capable Bf 109F, which was more than a match for the RAF's Hurricanes and Tomahawks. It was on one of these sorties, on 22 November, that the squadron lost its CO, Wg Cdr James Willis, and his crew, Plt Off Lawrie Bourke RNZAF and Sgt Michael



Above: No 45 Sqn lost four Blenheims on 22 November 1941, including this one, Z6439/Y, which was being flown by the CO, Wg Cdr James Willis. Below: F/Sgt Dave Cliffe who was credited with a probable Bf 109F on 20 December 1941.

'Paddy' Carthy. Willis' log book, which is in The National Archives at Kew, shows that he had flown no fewer than 58 operational sorties in his eight months as OC 45 Sqn.

The squadron was involved in a spectacular tragedy on 4 December. All four units of No 270 Wg, Nos 14, 45 and 84 Sqns and the Free French *Groupe Lorraine*, were to take part in a thirty-aircraft raid. Take offs were to be in vics of three but, due to a misunderstanding, the French took off in the opposite direction from the rest and two aircraft collided head-on. One member of the French crew died, the others were severely injured while 45 Squadron's aeroplane simply exploded, killing all on board. The carnage on the airfield prevented eleven aircraft from getting airborne, but the seventeen that were already up, pressed on with the raid.

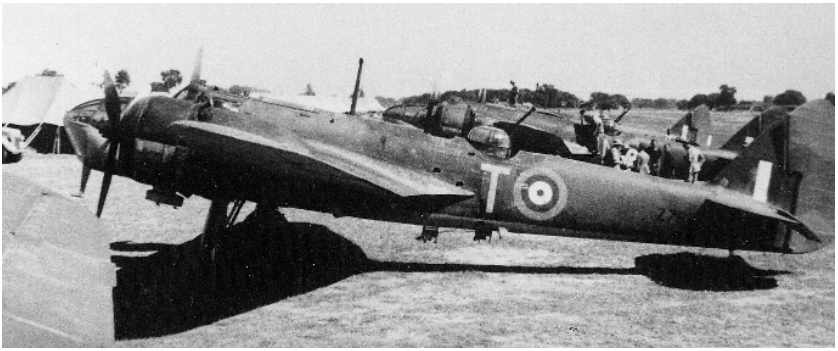
Three days later the Japanese attacked Pearl Harbour and within hours rumours began to spread about the squadron being deployed to the Far East, but nothing happened, and they were still in the desert for Christmas, but shortly afterwards the rumours came true and the squadron was withdrawn to the delta to prepare for the move.

The field modification that provided the 20 mm cannon which was supposed to give the Blenheim IVF a notional anti-tank capability. It didn't. Note the four ·303" Brownings in the belly pack.

There was one more brief desert deployment before the squadron left Egypt. Rommel had opened another offensive and, in a rather desperate response, some Blenheim IVFs were armed with a 20mm Hispano and the crews were told to go tank-busting. Several squadrons were involved in this escapade but a lash-up of this nature was never really going to work, especially without the necessary tools. Despite the best efforts of the armourers, these aeroplanes never saw action and, and in practice firings, none of No 45 Sqn's crews managed to get more than six rounds off before the gun seized.

Between January and March 1942, five of RAFME's Blenheim squadrons moved east, each one despatching sections of about six aircraft at a time at roughly weekly intervals, so there was a long trail of Blenheims stretching from Egypt via Iraq, the Gulf and India to Burma, with the leaders getting as far as Singapore and Sumatra, before the Japanese foreclosed on that option.

No 45 Sqn's aircraft began to reach Burma in mid-February. They initially set up camp on a primitive airstrip at Zayatkwin where accommodation was what you could find – bashas or tents. Because the bulk of the squadron (ten officers, twenty-five airmen aircrew and, by this time, nearly four hundred groundcrew) went by sea, and did not reach Calcutta until it was all over, the only available dedicated technical support was provided by a handful of groundcrew who had flown out on the Dickie seats – one airman in most of the twenty-four



Z7981 at Allahabad en route Burma.

aeroplanes. There was some support from airmen belonging to locally-based units who gradually became available to assist as their own squadrons began to run out of aeroplanes, but this assistance was intermittent and unreliable and aircrew were often obliged to do their own refuelling and rearming. The lack of technical facilities meant that snags had to be carried, or rectified using some pretty agricultural techniques.

Because of the loss (or lack) of unit records, the official history has very little to say about the Blenheim's participation in the fall of Burma, but I have been able to establish that in the thirty-four days between 16 February and 21 March No 45 Sqn flew more than 200 offensive and reconnaissance sorties, several priority missions conveying senior commanders from place to place, and many non-operational flights, evacuating service and civilian refugees.

Having withdrawn to Magwe in central Burma, on 21 March the squadron mounted a successful nine-aircraft raid on the enemy-held Mingaladon aerodrome at Rangoon, but the Japanese retaliated in overwhelming strength that same afternoon and six Blenheims were lost on the ground. That was more or less the end for the RAF in Burma; from then on it was all about evacuation.

The surviving aeroplanes were flown out to Akyab, and on to India, leaving behind Wg Cdr Charles Wallis, the CO, along with the Adj, Flt Lt Philip Butters, twenty-six assorted aircrew and the twenty-one tradesmen who had flown out from Egypt. They joined what remained of the rest of BURWING which began to leave Magwe on 23 March travelling by road to Lashio where the RAF maintained a

Magwe, following the Japanese air raid on 21 March 1942 which effectively ended the RAF's ability to participate in the defence of Burma.

foothold in Burma for another month or so until the advancing Japanese obliged it to retreat further east to Loiwing in China. Even that was insecure, however, and by 2 May the party had split in two. One half, including fourteen of No 45 Sqn's men, went deeper into China and finished up in Kunming. While the rest headed west back into Burma, Having made their way to Myitkina, an epic journey that is worthy of a presentation in its own right, they were eventually flown out to India.

This was the end of the Blenheim era for No 45 Sqn, however. There were insufficient aeroplanes to re-equip all of the Blenheim units, so No 45 Sqn's personnel were temporarily dispersed to the four winds, found temporary appointments or attached to other units until November when it began to reassemble itself at Cholavaram where it was to be remounted on Vengeances.

What the squadron had achieved in purely statistical terms can be summed up in the table at Figure 2, which reflects only conventional bombing sorties. It does not include sorties flown delivering 'spikes, dedicated reconnaissance flights or the many sorties flown by crews in Mk IVFs ostensibly operating as fighters or as cannon-armed quasi-

Type	Where	When	Sorties	Bombs
Mk I	Egypt/Libya	Jun 40	23	
Mk I	Sudan	Jul-Aug 40	21	
Mk I	Sudan	Sep-Dec 40	142	
Mk I	Egypt/Libya	Dec 40-Feb 41	212	
		Total Mk I	**398**	**380,000 lbs**
Mk IV	Egypt/Libya	Apr-May 41	277	
Mk IV	Syria	Jun-Jul 41	172	
Mk IV	Iran	Aug 41	39	
Mk IV	Egypt/Libya	Sep 41-Jan 42	411	
		Total Mk IV ME	**899**	**800,000 lbs**
Mk IV	Burma	Feb-Mar 42	180	
		Total Mk IV FE	**180**	**180,000 lbs**
		Total Blenheim	**1,477**	**1,360,000 lbs**

Fig 2. No 45 Sqn's effort on Blenheims in terms of bombing sorties.

tank busters. Owing to a lack of fully comprehensive records, there are some assumptions embedded within the table but, where this has been necessary, they have been derived from known typical contemporary bomb loads and they will not have distorted the overall picture.

In round figures, therefore, No 45 Sqn's effort on Blenheims amounted to about 1,500 bombing sorties, with perhaps another 500 in other roles, in the course of which it is unlikely to have delivered much less than 700 short tons of bombs. In the course of doing that it had worked its way through no fewer than 160 Blenheims.

In a little over eighteen months, most of it spent living and fighting under the most arduous of conditions, eighty-four of the squadron's aircrew had died. In other words the squadron had lost the equivalent of its entire fighting strength roughly twice over; three times over if those who had been wounded or who had become POWs are added to the total.

Over the same period its personnel had been awarded just two DFCs and one DFM, little enough recognition for sacrifice on that scale. But the Blenheim was the RAF's mainstay during the years of defeat and medals are for winners.

[1] Jefford, C G; *The Flying Camels* (privately published, 1995).

BRISTOL AND THE RAF IN THE COLD WAR – THE CINDERELLA YEARS, 1946-1960

Prof Duncan Greenman

For biographical note – see page 16.

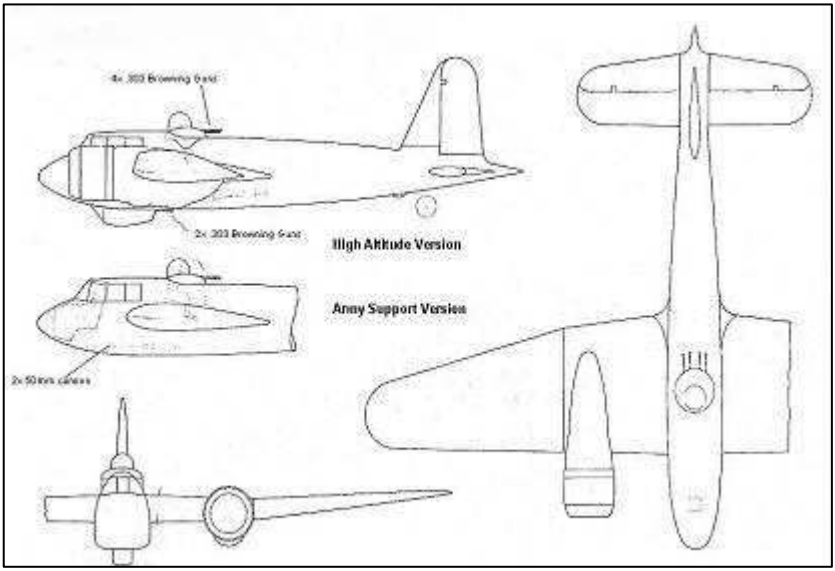
Recession hit the UK aircraft industry in 1945, just as it had in 1919 – too many aircraft manufacturers, not enough work. The Bristol company responded in the same way as it had in 1919 – by expanding its other product lines, particularly cars and pre-fabricated aluminium buildings. It eventually established car, missile and composite material companies in addition to its Aircraft and Engine Divisions, all of which survive into the 21st Century in some form.

The number of Bristol aircraft employed by the RAF declined sharply after 1945, although the Engine Department continued to be a major provider and remains so today. Although the company continued to design potential fighter and bomber projects, from 1945 onwards production focused increasingly on transport aircraft. Filton was very busy developing the giant Brabazon, the biggest commercial transport aircraft ever built up to that time, and the Type 170 Freighter/Wayfarer, but neither of these would be operated by the RAF.

This paper will look at the final range of Bristol bombers descended, at least in spirit, from the Blenheim and Beaufort. It will then consider the Sycamore and Belvedere helicopters and the Bloodhound surface-to-air missile. All of these were operated by the Royal Air Force during the so-called Cold War and grew out of, often innovative or visionary, work carried out at Filton. Although these products gave the RAF years of solid and successful service, they were overshadowed in the public imagination by the more glamorous jets – the Hunters, Lightnings, Victors and Vulcans. Hence my title – the 'Cinderella Years'.

The Type 163 Buckingham

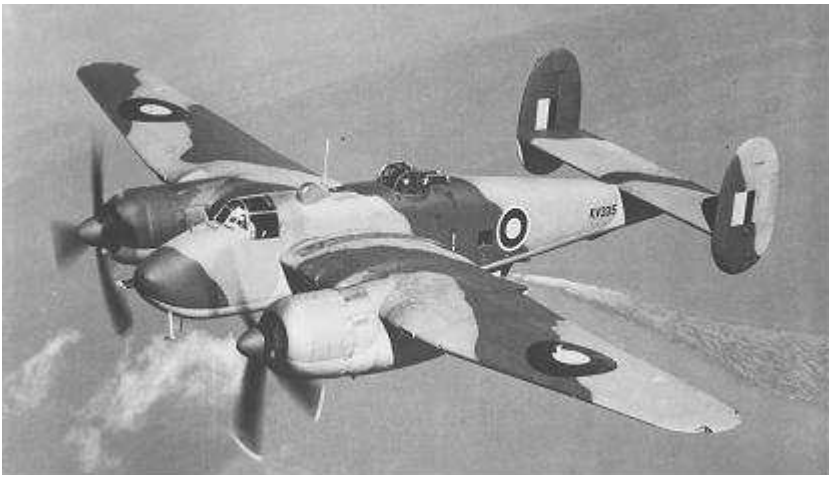
A proposed bomber version of the Beaufighter was never followed up but, in 1940, Specification B.7/40 was issued calling for a four-seat light bomber to replace the Blenheim in the close-support, dive-bomber and high level bombing roles. Bristol's response was to scheme the Type 161, which would have been powered by either



The Bristol Type 161.

Bristol Hercules or Rolls-Royce Merlins.[1]

None of the proposals submitted to B.7/40 was ordered but Bristol's Chief Designer, Leslie Frise (successor to Frank Barnwell who had died in a flying accident on 2 August 1938) continued to work on the project which evolved into the three-seat Type 162, the Beaumont. This was considered by the Air Ministry where it generated sufficient interest to warrant construction of a mock-up (*see page 78*) to meet an early draft of Specification B.2/41. Subsequent refinement, to include Centaurus engines and twin fins and rudders, and with close support and dive-bombing no longer required, resulted in the Type 163 Buckingham. This was so promising that the final version of B.2/41, calling for a range of 1,000 miles with a 2,000 lb load and a top speed of 370 mph, was written around the Bristol submission.[2] This was issued to the company in August 1941 and covered an order for four prototypes that had already been placed in the previous month. Further changes led to this eventually being superseded in August 1942 by Production Specification Buckingham I/P1 which covered both the four prototypes and 400 production machines.



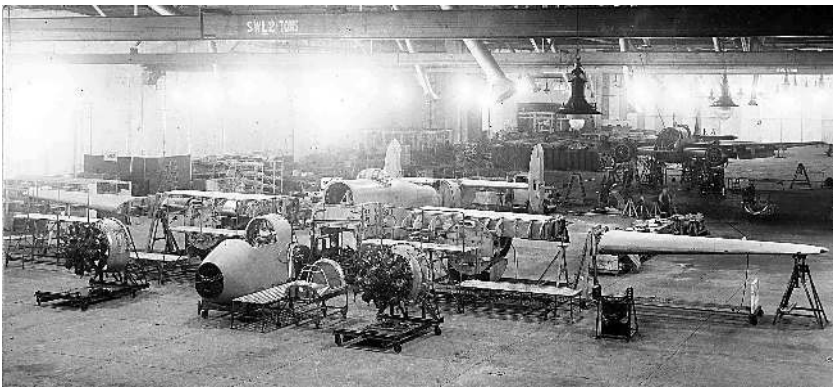
A production standard Buckingham.

Sir Henry Tizard wanted the aircraft in service as quickly as possible. So, at his urging, to accommodate the Buckingham production line, the company, somewhat reluctantly, stopped building Beaufighters at Filton and moved Beaufort production to Banwell. A feature of the Buckingham design concept was that it was to be manufactured using a modular approach. This involved external contractors delivering to Filton pre-wired and fitted-out sub-assemblies on specially designed trolley jigs which fitted together to produce a finished aeroplane.

While this technique is relatively commonplace today, it represented a remarkable technical achievement for 1943 and it should have resulted in a very high rate of production. Unfortunately, however, the effort had been wasted 'because the RAF's night bombing offensive became more effective than expected after adopting radar and Pathfinder techniques, and day bombing by unarmed Mosquitos was more successful than foreseen.'[3] This had effectively rendered the Buckingham redundant and orders were cut to 300. Deliveries were slowed down and a tropicalisation programme implemented to prepare the aircraft for service in the Far East, the only theatre in which it might still be used.

In its final form, the Buckingham had a top speed of 330 mph, which still made it the fastest defensively armed British bomber of its

Above, a centre fuselage on its wheeled jig and below, looking rather like an overgrown Airfix kit, the component parts of a Buckingham awaiting assembly.



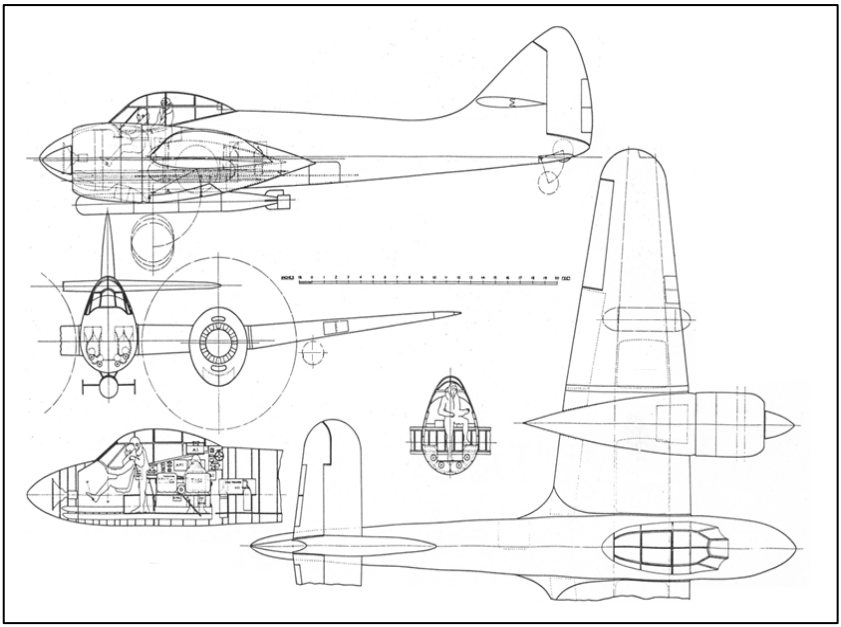
time, but the defeat of Japan cut the total number actually built to 119. Of these, 54 had been delivered as bombers by the end of 1944; the remainder were converted into fast courier transports with the armament removed, seating for four passengers, a crew of three and additional fuel tanks to give a range of 3,000 miles. Even so, while a number of Buckinghams were flown by units such as the A&AEE, RAE, Handling Squadron and the Transport Command Development Unit, none ever saw squadron service.

That being the case, the Buckingham can hardly be counted as one of Filton's successes, but its relative failure was more to do with changing operational requirements, and the ready availability of alternatives (notably the Mosquito and the American B-25 Mitchell – or, better still, the A-26 Invader) than to any defects in the basic design.

The Type 164 Brigand.

In July 1942, following the extremely successful adaptation of the Beaufighter as a torpedo bomber, a Buckingham II armed with a pair of torpedoes had been considered. However, this was dropped, as even the Centaurus could not produce the power required to drag its mighty bulk through the air fast enough at the inevitably low operating altitudes.

The Type 161 project had shown a lot of promise, however, and this promise was to be developed in a second derivative concurrent with, but independent of, the Buckingham. Crew communication and coordination had been difficult in the Beaufighter because of the structural configuration, so Clifford Tinson drafted a single-torpedo aircraft, tentatively named the Buccaneer, with the three crew members grouped together in a forward cabin. A mock-up, designed to a draft specification, S.7/42, was examined on 21 August 1942. After the inevitable revisions, the definitive specification, by then H.7/42, was issued to the company in December.[4] By now named the Brigand, the design as submitted was similar to the Beaufighter, but had a slimmer fuselage. The weight of over 26,000 lb, however, proved to be too much for the nominated Hercules engines, which would have been unable to produce the required speed of 300 mph, and an increase in weight arising from the addition of ASV radar would have resulted in a marginal single-engined performance.



The 'Buccaneer' as submitted to Specification H.7/42.

The answer was to combine the Brigand's fuselage with the Buckingham's engines, wings and tail and in April 1943 this became the Type 164. There was an associated requirement for a dual-control trainer version, the Type 165 Brigand II, but this was not followed up as the company wished to avoid the diversion of development effort that this would have involved.

The prototype Brigand (MX988) first flew on 4 December 1944. After early handling trials, the original Centaurus VII engines were replaced in the production aircraft by Centaurus 57s with methanol-water injection. One of the advantages of the revised Brigand configuration was that it could use the same modular production jigs as the ill-starred Buckingham.

The first batch was delivered as torpedo-fighters which had been intended to replace the Beaufighter TF Xs of Nos 42 and 236 Sqns, but the Air Staff had already decided to abandon the role and the Brigand TF 1 never saw squadron service. Instead, from the fifteenth aircraft onwards Brigands were delivered as light bombers. As such,

Brigands of No 45 Sqn over Malaya. (R Whittam)

they entered service with No 84 Sqn at Habbaniya in February 1949, followed by No 8 Sqn at Khormaksar in June. The third unit, No 45 Sqn, was at Kuala Lumpur when its first Brigand was received in September 1949 but it had moved to Tengah before it was fully re-equipped. It was from there that its last pair of Beaufighters, RD805 and RD852 – the last operational Beaufighters in the RAF – was withdrawn from service in February 1950.

No 45 Sqn had also been intended to operate the specialised Brigand Met 3 on weather reconnaissance duties from Ceylon but by the time that the first one arrived in May 1949, the squadron had moved to Malaya. As a result, No 1301 (Met) Flt was formed at Negombo as an independent unit on 1 May and it flew the Met 3s from there until it disbanded at the end of November 1951.[5]

The Brigand B.1 was flown operationally in Malaya until 1953, whilst others were used in the UK as test-beds and trials aircraft. The T.4 trained radar operators on AI Mk 10 with No 228 OCU from July 1951 onwards and three years later these were supplemented by the AI Mk 21-equipped T.5s of No 238 OCU. Before the last of them was withdrawn from service in 1958, Brigands operating from Leeming, Colerne and North Luffenham had trained approximately 600 radar operators.

Only 147 Brigands were built and they were the last twin piston-engined bombers operated by the RAF. They were better suited to a tropical climate than the wooden Mosquito, as they possessed the

RP198 was No 45 Sqn's Buckmaster from 1949 until 1952.
(P H T Green)

definite advantage of not coming unglued in the heat and humidity. Their jet-age replacement would be the English Electric Canberra.

The Type 166 Buckmaster

As already noted, the company had not pursued the Brigand II trainer option. Instead, in August 1943, it proposed a trainer version of the Buckingham. It was to have dual-control for the pilots, in a side-by-side seating arrangement, with the radio operator placed behind; all armour, armament and other unnecessary military equipment was deleted.

Two partially completed Buckinghams were converted into prototype Type 166s to Specification T.13/43. The first aircraft (TJ714), by now christened the Buckmaster, flew for the first time on 27 October 1944. Like the Buckingham, the Buckmaster was not destined for a sparkling career but it did see productive service for check rides with the three operational Brigand squadrons while others flew with the night-fighter Operational Conversion Units. The last RAF examples were withdrawn from No 238 OCU at Colerne in 1956, although a couple were retained for a while at Filton for a range of experimental and test-bed work being undertaken by the company.

The Type 171 Sycamore

Despite popular belief, Leonardo da Vinci did *not* invent the helicopter! In its toy form, it has been around for over a thousand years, but the full-sized machine owes its existence to men like Juan

de la Cierva and Igor Sikorsky. The Second World War added impetus to the development of a successful helicopter and, in England, a lot of experimental work was carried out at the Airborne Forces Experimental Establishment (AFEE).

The AFEE design team was led by Raoul Hafner, who had experimented with helicopters in his native Austria before coming to the UK in 1933. This programme had produced a gyroplane, similar to Cierva's, but with the tilting rotor hub replaced by a sensitive cyclic pitch control. However, the successful employment of gliders for airborne assaults in 1944 reduced the priority afforded to Hafner's work and when Bristols began recruiting staff for its new Helicopter Department, part of the Aircraft Division, Hafner and some of his colleagues were released from the Army to establish a design team.

Work began in mid-1944 but, because the company did not have an engine of its own in the required power bracket, it had to look elsewhere. A number of alternatives was considered, but the choice finally settled on the proven 450 hp Pratt and Whitney Wasp Junior and this became the engine for Bristol's initial response to Specification E.20/45, the Type 171. Design and testing of components took two years and included the construction of the world's first rotor test tower.

The complete aircraft was ready for its first ground run in May 1947. There were some early problems with blade flutter but the prototype (VL958) eventually made its first flight on 27 July in the hands of H A March who, amazingly, even carried passengers on some of the several short hops that he made later that day! A second Mk 1 joined the programme in February 1948, by which time the first machine – now named the Sycamore, because of its tree seed-like shape – had safely logged over 40 flying hours.

The Mk 2, powered by a 550 hp Alvis Leonides, appeared in the summer of 1948 and, after a troubled start (technical problems delayed the first flight until September 1949 – when the rotor disintegrated!), this became the standard power plant for all subsequent Sycamores. Further refinement resulted in the initial production model, the Mk 3, which had a wider cabin, to accommodate a fifth seat, and a shorter nose, to improve visibility. At this point, the military began to show real interest.

Taken on charge by the RAF in 1951, the one-off HC Mk 10,

A Sycamore HR14 of No 103 Sqn in 1961. (MAP)

which was fitted out for casualty evacuation work, was closely followed by four HC 11s for the Army optimised for air observation and liaison duties. The Mk 10 prototype was sent to Malaya in 1953 for field trials and successful comparison with the only viable alternative, the Dragonfly.

In the meantime, four HR 12s had been delivered to Coastal Command. Of these: two were fitted out for transport/communications duties; one had an hydraulic winch for air-sea rescue (ASR) trials and the fourth was equipped for experiments with dunking sonar. The HR 13 was another air-sea rescue variant, two of which were delivered for trials with Fighter Command. The lessons drawn from the experience gained with the Mks 10-13 were incorporated in the main production model – the HR 14 of which eighty-nine were built.

In mid-production, in March 1955, the company centralised all aspects of helicopter design, development and manufacturing at Old Mixon, near Weston-super-Mare, and the ninety-fifth and all subsequent Sycamores were built there. Sycamore production eventually ran to 178 aircraft (of which 100 were supplied to the RAF and/or Army) which saw service all over the world, in both commercial and military applications.

So far as the RAF was concerned, the Mk 14 entered service with

A Belvedere of No 66 Sqn at Kuching in 1966. (MAP)

No 194 Sqn in Malaya in April 1954 and with Fighter Command's No 275 Sqn for ASR duties later that year, followed by No 284 Sqn in Cyprus in 1956. Meanwhile, in April 1955, the RAF/Army Joint Experimental Helicopter Unit had been formed at Middle Wallop and after five years of development and trials work it was redesignated in 1960 to become Transport Command's No 225 Sqn. Other units which would operate the Sycamore included Nos 22, 32, 84, 103, 110, 118 and 228 Sqns, the CFS and several independent flights. The last example was not withdrawn, from No 32 Sqn, until as late as 1972, marking the end of a long career in which the Sycamore had been instrumental in permitting the RAF to develop new techniques and exploit new capabilities in the entirely new field of rotary winged air operations.

The Type 192 Belvedere

The next Bristol helicopter, and the first British tandem rotor design, was the Type 173. Again, a revolutionary concept, it amounted, in essence, to installing a Sycamore engine and rotor at either end of a long fuselage. The first aircraft flew on 3 January 1952 and, although five were built, none joined the RAF.

The Type 192 was a larger, gas turbine powered (Napier Gazelles) development of the Type 173 and the first aircraft (XG447) made its first ascent from Old Mixon on 5 July 1958. It was followed by nine pre-production aircraft, which tested a variety of detailed differences in aerodynamic configurations and climatic operating conditions

before the final production standard was reached. In service it became the Belvedere HC 1, resuming Bristol's practice of giving its aircraft names beginning with 'B' – a tradition that had clearly been broken by the Sycamore.

In October 1960 three aircraft were delivered to the Belvedere Trials Unit at Odiham. By that time (since February 1960) the Bristol Helicopter Department, and with it Raoul Hafner, had been taken over by Westlands, so it was as the Westland Belvedere that the aeroplane actually served with the RAF. The trials unit was redesignated as No 66 Sqn in September 1961 and it was later joined by Nos 26 and 72 Sqns. Although only twenty-six Belvederes were ever built, and they had all been withdrawn by the end of the 1960s, the type had quite a hectic career seeing action in Aden during the Radfan campaign and in Borneo and Malaya during the 'Confrontation' with Indonesia.

The Bloodhound

The story of the Bloodhound Surface-to-Air Guided Weapon (SAGW), to use the contemporary jargon, began in March 1949 when serious consideration began to be devoted to introducing what would later be called Surface-to-Air Missiles (SAM) for air defence. Three projects emerged. English Electric handled air defence for the Army in the field via the RED SHOES project, which entered service as Thunderbird, while Bristols did some initial work on a naval missile, as an alternative to what would become Armstrong Whitworth's ship-based Seaslug. This was soon abandoned, however, in favour of a joint programme with Ferranti called RED DUSTER that would eventually become Bloodhound, a ramjet-powered, twist and steer missile with semi-active radar homing.

It is in the nature of ramjets that they have to be flying at high speed before they can function, so Bloodhound was provided with four solid-fuelled Bristol Aerojet Gosling rocket motors which boosted it to Mach 2 in four seconds, at which point they fell away to allow the missile to cruise on the power of its two Bristol Thor ramjets. Incoming targets were to be tracked by a Type 82 ORANGE YEOMAN S-Band radar at a Tactical Control Centre which allocated the engagement to a specific missile site.[6] Guidance was provided by a Type 83 YELLOW RIVER target illuminating radar with the missile

Bloodhound Is of No 62 Sqn at Woolfox Lodge. (Arthur Elsey)

homing onto the reflected return signals. Being a pulse radar, however, it was susceptible to jamming and suffered from ground clutter, severely limiting its use against low-flying intruders. That said, Bloodhound Mk 1 had a fair chance of coping with a high flying target delivering a free-fall weapon, which was the threat at the time.

Early firings of experimental test vehicles were conducted in the UK but in 1953 the trials programme, which would eventually run to more than 500 launches, moved to Australia. Operational launchers were delivered between June 1958 and December 1960 and missiles between September 1958 and March 1962, the production lines being at Cardiff and Wythenshawe rather than Filton. The system entered service with No 264 Sqn which was formed at North Coates in December 1958.

With a range of only 25 miles or so, Bloodhound I had to be deployed selectively, the aim being to preserve the UK's ability to launch a nuclear strike, which meant protecting the sixty Thor IRBMs, which were distributed across twenty launch sites, and the V-bomber main bases, all of which were in eastern England. Over the next two years, ten more Mk 1 sites were commissioned. Organised into four wings, the missiles were operated by Nos 62, 94, 112, 141, 222, 242, 247, 257, 263 and 266 Sqns. Routine training firings conducted between August 1959 and November 1963 confirmed that the system exceeded its specification, in that it could successfully engage targets below the lowest nominated altitude and up to 53,000 feet. With Soviet bombers now being armed with high-performance, long-range air-launched missiles, however, the Mk 1 had outlived its usefulness

The Type 86 INDIGO CORKSCREW radar was vehicle mounted on a trailer to confer the degree of mobility required to support the Army's Thunderbird in the field. When used by the RAF at fixed sites, it was sometimes raised on a 30' platform, as here at Wattisham, to increase its low-level cover. (Nick Catford)

and it was withdrawn from service in 1964.

Bloodhound I, with its operational limitations was clearly a first generation SAM and a great deal of design and development effort was expended with a view to enhancing the overall capabilities of the system. The ultimate projection, BLUE ENVOY, would have been a delta-winged, ramjet-powered missile of stainless steel construction, capable of Mach 3 with a range of up to 200 miles, employing continuous wave (CW) radar and, in all probability, the option of a nuclear warhead. This was stretching the technological envelope a little too far in the 1960s, however, and BLUE ENVOY was eventually cancelled.

What emerged as hardware was Bloodhound II. To look at, it was little more than a stretched Mk 1 but it represented a substantial increase in capability. It had almost three times the range against a high level target and employed CW, rather than pulsed, radar. Apart from being relatively ECM-proof, by exploiting the Doppler principle, CW radar also solved the ground clutter problem, making the Mk 2 viable as a low-level system. Furthermore, compared to the Mk 1's fixed sites, the Mk 2 system had a reasonable degree of mobility and, once in service, this flexibility would occasionally be exercised.

For target detection, Bloodhound II relied on the early-warning radar system and there were two options for missile control and

A Bloodhound II of No 112 Sqn at Paramali in Cyprus with a massive Type 87 BLUE ANCHOR radar in the background. (Stuart Baines)

guidance. One, the Type 86 INDIGO CORKSCREW, was an air transportable X-band CW radar optimised for tactical use in the field with the Army's equivalent Thunderbird II, but also employed by the RAF. The alternative was another X-band CW radar, the Type 87 BLUE ANCHOR which was far more substantial and robust but correspondingly massive. Since the Type 87 weighed about 50 tons it was only suitable for permanent sites, although it could be moved by sea and it was deployed overseas as well as at home.

Deliveries of Bloodhound II began in November 1962 (launchers) and March 1963 (missiles) and the system entered service in October 1963, just as the Mk 1s were running down. The last of the Thor IRBMs had been returned to the USA in September, so they were no longer an issue and, since the Mk 2 had a much greater range, it was not necessary to activate so many sites. Only two units were required to cover the, already contracting, V-Force – No 25 Sqn at North Coates and No 41 Sqn at West Raynham. Even this was a relatively short-lived task, however, as the Navy assumed responsibility for maintaining Britain's nuclear deterrent in 1969. Not long afterwards,

therefore, No 41 Sqn disbanded and No 25 Sqn moved to Europe to provide air defence cover for the RAF's airfields in Germany.

This was not the only overseas deployment, however, as the increased flexibility of the Mk 2 had permitted it to be deployed in Malaysia (No 33 Sqn at Butterworth, 1965-70), Singapore (No 65 Sqn at Seletar, 1964-70) and Cyprus (No 112 Sqn at Paramali, 1964-75). With the introduction of Blindfire Rapier for airfield defence in Germany, No 25 Sqn's Bloodhounds were brought back to the UK in 1983 where, supplemented by those of No 85 Sqn, they provided coverage of airfields in East Anglia. Despite its age, Bloodhound was still a very effective system and there were plans to re-acquire additional redundant missiles from overseas operators to extend its life but the ending of the Cold War made this unnecessary and Bloodhound was finally withdrawn from service in 1991.

Notes:

Unless otherwise noted, the photographs illustrating this paper are the copyright of Duncan Greenman, Bristol AiRchive, who wishes to acknowledge the assistance of Jeff Jefford in drafting the section of this paper dealing with Bloodhound.

[1] Meekcoms, K and Morgan, E; *The British Aircraft Specifications File* (Air Britain, 1994) p284

[2] Meekcoms and Morgan, *op cit*, pp 296-297.

[3] Barnes, C; *Bristol Aircraft since 1910* (Putnam, London, 2nd Edn, 1970) p314.

[4] Meekcoms and Morgan, *op cit*, pp304-305

[5] Jefford, C G; *The Flying Camels* (High Wycombe, 1995) p328.

[6] The four Type 82s, one for each of the four Bloodhound I wings, were located at the Tactical Control Centres (TCC) at Watton, Lindholme, North Luffenham and North Coates. Following the withdrawal of Bloodhound I in 1964, the first three of these very capable installations were redesignated as Area Radars and provided a very efficient air traffic control service until 1990.

BRISTOL TO ROLLS-ROYCE – THE GAS TURBINE STORY

Gp Capt Jock Heron

Jock Heron emerged from Cranwell in 1957 to fly Hunters and, during a USAF exchange tour, F-105s. Following a stint working on the MRCA project he spent ten years in the Harrier world, flying it in Germany, and as a staff officer at both Rheindahlen and MOD. He commanded RAF West Drayton and RAF Stanley before leaving the air force to spend the next ten years with Rolls-Royce as their Military Affairs Executive. As Vice-Chairman of this Society and a Director/Trustee of the Bristol Aero Collection, he has been the mastermind behind the planning of today's seminar.

I shall review the Bristol gas turbine engine programmes which were active at the end of the Second World War before describing those which were destined for the Royal Air Force during and beyond the Cold War. By Bristol, I am referring to the Bristol Aeroplane Company Engines Division which became Bristol Siddeley in 1959 and finally today's Rolls-Royce which absorbed Bristol Siddeley in 1966.

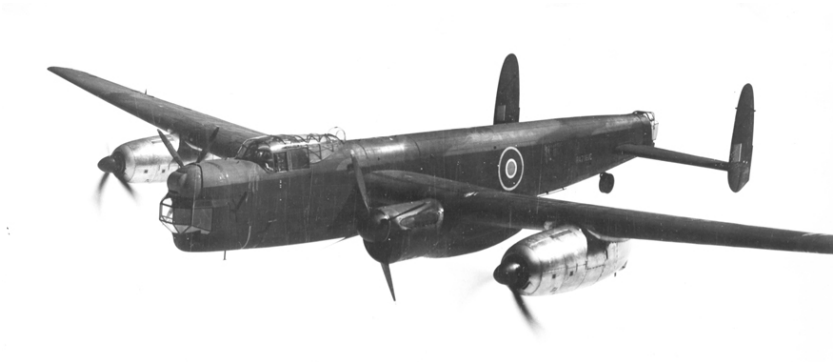
In parallel to his commitment to the successful range of piston engines and in particular his sleeve valve designs, Roy Fedden, Bristol's aero engine supremo, and his deputy, Frank Owner, were aware of Frank Whittle's work on the jet engine from the early 1930s. Whittle had visited Bristol in 1931 to brief them but Owner's opinion was that the gas turbine was 'entirely sound in principle and will certainly come to pass.' He estimated that this would not happen for another ten years or so. Around the time of the E.28/39's first flight in May 1941, Fedden and Owner had visited Whittle at Lutterworth but their assessment remained that 'the gas turbine was unlikely to be of great importance to the war effort as much development remained to be done'. Fedden believed that his personal priority should remain the mass production of existing piston engines for wartime demands but, surprisingly, he left the company in 1942. Before doing so however he had delegated work on gas turbines to Frank Owner who became

Frank Owner, who had cut his teeth on the unsuccessful Hydra in 1931, became Chief Engineer in 1942, bridging the gap between Sir Roy Fedden's departure and Stanley Hooker's appointment in 1950.

Chief Engineer, following Fedden's departure.

Although Bristol was late in joining the gas turbine world, by November 1941 Owner was a member of the Gas Turbine Collaboration Committee which led, initially, to Bristol's decision to pursue a stocky turboprop design with tandem axial and centrifugal compressors and reverse flow combustion. Neither Rolls-Royce nor de Havilland had adopted the axial compressor for their pioneering work on pure jet engines, both of which had been influenced by Whittle's early choice of centrifugal compressors, whereas Bristol's compressor geometry relied heavily on the RAE's experience on axial designs.

Thus emerged the Theseus which had its first run on test in July 1945 and the following year was awarded its Type Test Certificate, the first turboprop to pass this milestone. To gain representative operating experience, six engines were delivered to the RAF in 1947 for the conversion of two Lincoln bombers by replacing the outboard Merlin piston engines with Theseus turboprops. Seats were installed in the bomb bay for passengers and these two aircraft flew routinely from Lyneham via Malta to Fayid in Egypt, between 1948 and 1950 although the Merlins were not shut down routinely as all the aircraft ancillaries were driven by the inboard engines. This trial gave the Service its first experience of turboprop technology and helped to



The Theseus-Lincoln may well have been 'just another four-engined aircraft' – although it was not normally flown, as here, with its remaining Merlins shut down.

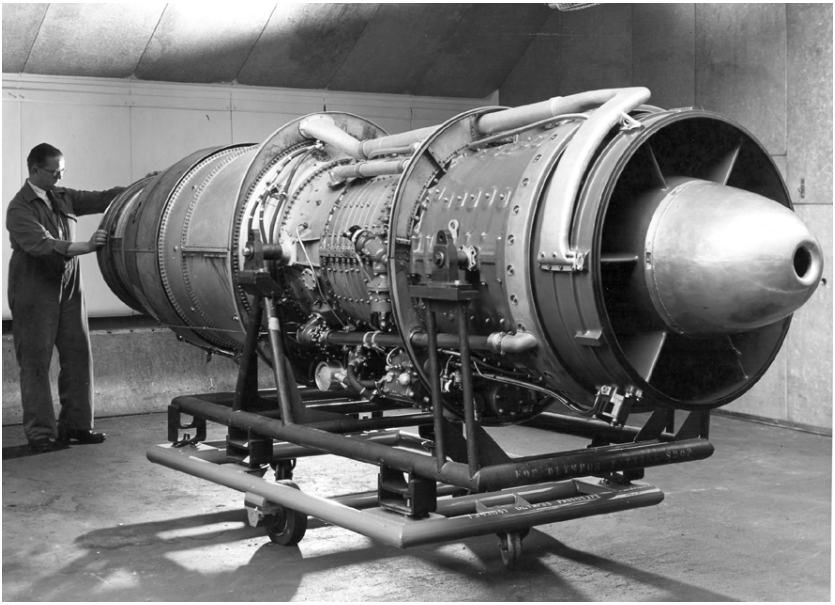
establish its credibility with both air- and ground crew. One of the Lincoln captains is quoted saying 'We look upon the Theseus-Lincoln as just another four-engined aircraft'.

In September 1944, well before the Theseus had made its first flight, work began on a redesigned turboprop, the Proteus, and thus it was unable to benefit from the lessons learned during development of the earlier design. When Stanley Hooker joined Bristol from Rolls-Royce in 1948 he asked Owner how the Proteus was coming along? Owner responded that:

> 'We set out to achieve the most economical turboprop in the world, regardless of weight and bulk; so far we have achieved the weight and bulk!'

Proteus engines were flight tested in December 1950, again in a converted Lincoln, and, despite lengthy development difficulties, they became the powerplants for the Britannia, of which you will hear more later.

In 1946 the Company began the design and development of its first pure jet engine, the BE10 which became the Olympus. It was conceived by Owner, again to be a tandem axial and centrifugal compressor but with straight through combustion. However, at a meeting in Patchway one of Bristol's young engineers, the late Gordon Lewis, persuaded Owner and the Ministry to adopt a twin-



The Bristol BE10 – the Olympus 101.

spool axial compressor. In this configuration the BE10 first ran on test in 1950 at 9,150lbs thrust, exactly as Gordon Lewis had predicted and shortly thereafter it was run to over 10,000lbs, the first turbojet to pass this milestone. It was supposed to be the engine in the Bristol Type 172 bomber which was rejected in favour of the Short SA4 Sperrin and the later V-bombers.

Also in 1946, Owner, as Chief Engineer, presented a paper to the RAeS arguing that there was no future for the conventional interceptor fighter, believing that the pilot would be the limiting factor, and that the company should give priority to bombers and missiles. This view was reinforced in 1950 when Bristol's aircraft designer, Dr Russell, later Sir Archibald of Concorde fame, had stated that manned fighters would be displaced by the surface-to-air missile and, as a result, Bristol concentrated on manned bombers with the Olympus, long range transports with the Proteus and ramjets and expendable turbojets for missiles. That said, by the mid-1950s company policy had changed and Bristol was developing the Orpheus for lightweight fighters and had offered the Olympus, its bomber engine, as the powerplant of

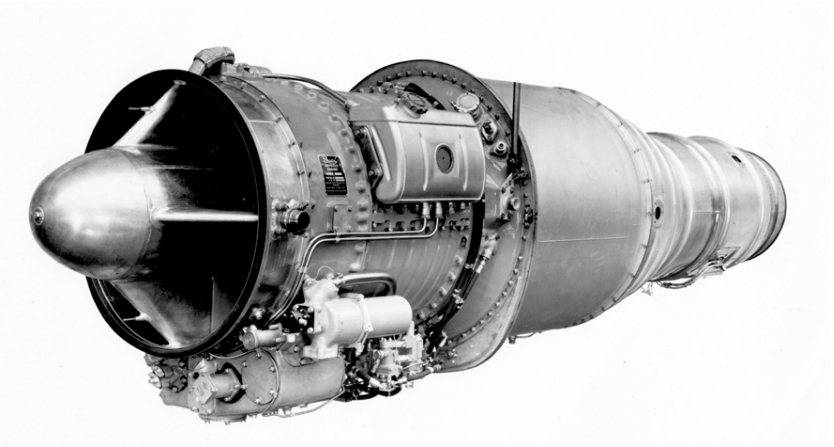
Bloodhound was launched under the power of four Bristol Aerojet Gosling rockets which boosted it to the speed required for its twin Thor ramjets to work..

choice for two advanced fighter projects.

After fierce competition, the Olympus 101 at 11,000lbs thrust was chosen for the Vulcan B1, prototypes of which had flown with Rolls-Royce Avons and Armstrong-Siddeley Sapphires. The Olympus went on to gain world altitude records in a Canberra flying test bed at 63,000 ft in 1953 and 65,000 ft in 1955. Later, after further competition against Rolls-Royce's Conway which was chosen for the Victor B2, the more powerful Olympus 201 was adopted for the Vulcan B2 and proposed for the two advanced fighter projects namely the 'thin wing' Gloster Javelin and Hawker's P1121 both of which were cancelled after the ill-conceived 1957 Defence Review.

Further development led to the Mk 301 for the Skybolt Vulcan B2 and later for the TSR2 at 20,000lbs and 30,000lbs with reheat. This engine was tested in flight from Filton mounted under a converted Vulcan B1 but TSR2's cancellation in April 1965 meant that the Vulcan force retained exclusive use of the Olympus in the RAF until the last operational aircraft was withdrawn in 1984, while the display flight continued operating XH558 until 1993, a Service career spanning 37 years. It was the impetus behind TSR2 which, in 1959, led to the first steps in rationalising the British aerospace industry leaving two principal airframe groups, Hawker Siddeley and the British Aircraft Corporation with two engine groups, namely Rolls-Royce, which had absorbed Napier's engine activities, and Bristol Siddeley which was an amalgamation of Armstrong-Siddeley, Bristol's Engine Division and later Blackburn's and de Havilland's.

Bristol's view, that manned fighter aircraft were approaching their



The Orpheus.

limit, was shared by the RAE who had studied the ramjet as a suitable powerplant for a medium range surface-to-air missile (SAM) in 1945. This work led to trials of a prototype 6-inch diameter ramjet in one of Patchway's test beds and was test flown from Aberporth in 1951. In parallel to the smaller Army Thunderbird and the RN's Seaslug rocket-powered SAMs, Bristol was contracted to pursue the ramjet option, code named RED DUSTER, and this work led to the development of the 16-inch diameter Thor for the Bloodhound SAM. Work began in 1949 and, having suffered combustion problems with the initial design, Bristol exchanged ideas with the Boeing Company in the USA who were developing the Bomarc, a long range SAM also powered by ramjets. The Thor was modified in the light of these discussions and went on to become a successful powerplant in the Bloodhound Mks 1 and 2 with over 2,200 Thor engines delivered to the RAF.

In 1950, with continued Soviet pressure in Germany and with the Korean War underway, a system of 'super priority production' was introduced to ensure that selected new aircraft projects including the Canberra, Swift and Hunter were given urgent status. So work was contracted to the Bristol Engine Division to produce Rolls-Royce Avon 100-series engines for these aircraft and 240 were built at

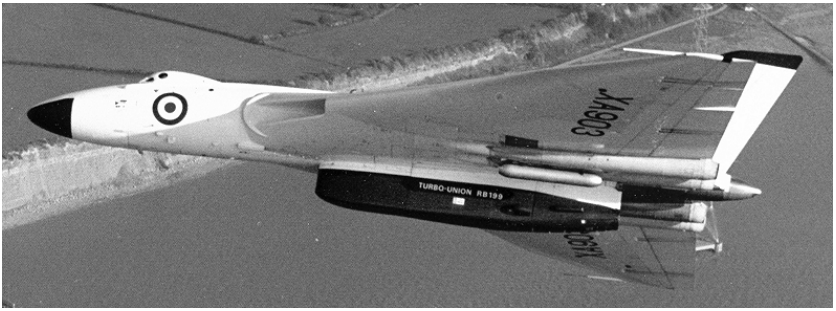
Patchway. Later, Bristol was contracted to overhaul some 650 J47 engines used by the RAF's Sabre squadrons between 1953 and 1957.

In 1953 the Orpheus was conceived by Stanley Hooker as a simple lightweight turbojet and development began, initially as a private venture. It first ran on test in December 1954 and flew in the Folland Gnat prototype in July 1955 before winning the 1956 NATO competition to power a future lightweight fighter. Although the Fiat G91 was the winning airframe, the RAF did not have a requirement for such an aircraft but instead selected the Orpheus for the Gnat two-seater which entered service in 1962 and remained as the RAF's fast jet trainer until its replacement by the Hawk in 1977.

The BE53/2 Pegasus, which will be described in some detail later, emerged after the short-sighted 1957 Defence Review and was conceived by Gordon Lewis as the engine tailored for the P1127, using modules from the Orpheus and Olympus, to create a high bypass ratio turbofan. The project began life as a capability without an agreed concept of operations and the prototype first ran on test in September 1959, achieving just over 9,000lbs thrust, and made its first flight at Dunsfold exactly 50 years ago today. Enhanced for the Kestrel and Harrier, the engine was under-funded throughout its long life, but history will define the Pegasus as a unique and pioneering Bristol achievement.

By 1966 Rolls-Royce had absorbed Bristol Siddeley and in time all military activity became focused on Bristol and responsibility was transferred to Patchway for projects such as the Conway in the VC10, military Avons, Adour, Tyne in the Belfast and Spey in the Nimrod, Phantom and Buccaneer. Design authority for the Viper, which was an Armstrong-Siddeley product, came down from Coventry much earlier. It was the engine in the Jet Provost and Strikemaster throughout their lives and it served also as a booster powerplant on the later Shackleton MR3s. Bristol's initial job, however, was to develop civil versions of the engine for the DH125 family which became the Dominie T1 for the RAF in 1965.

In 1968, the first draft of AST 392 was issued for a Multi Role Combat Aircraft (MRCA) to meet the requirement for a low altitude, high speed, all weather strike/attack aircraft, albeit with a range much reduced from the cancelled TSR2. The primary mission called for an engine which would operate economically in these demanding



As with advanced derivatives of the Olympus intended for Concorde and TSR2, the Conway and the Spey, a Vulcan was used, as here, to flight test the RB199 that would power the Tornado.

conditions. After it had been decided that the aircraft should have two engines, a competition was conducted in 1970 between Pratt and Whitney and a European consortium led by Rolls-Royce, later referred to as Turbo-Union, which included MTU and Fiat. Turbo-Union's design was selected and a contract placed to develop the RB199 turbofan for the MRCA. The brochure which emerged from the feasibility study described an aircraft with an empty weight of 22,000lbs and the engines were sized accordingly. Rolls-Royce was responsible for the combustion system and high pressure turbine and the engine was designed to achieve 9,000lbs dry and 16,000lbs in reheat with a relatively high bypass ratio of 1:1. It was flight tested at Filton, again under a Vulcan, and the first MRCA flight took place from Manching in Germany in 1974. After intensive engine development the Tornado GR1 entered service with the TTTE at Cottesmore in 1980 by which time the aircraft empty weight had grown to 30,000lbs (a 35% increase) so throughout its life the RB199 has had to work particularly hard. A total of 640 engines was delivered and it will power the GR4 for the foreseeable future although only a small number of F3s remain in the front line.

The development of the RB199 was lengthy, difficult and expensive and the civil business in Derby had faced similar problems with the RB211 for the TriStar. In 1980 Rolls-Royce was owned by the government, having been effectively nationalised in 1971, so in 1982 it was to the mutual advantage of the company and the MoD that a comprehensive programme of engine technology demonstration,

The EJ200 in an early Typhoon.

embracing both civil and military interests, was funded jointly by MoD(PE), the DTI and the Company. Included in this were three military engines; XG15 as the basis for future Pegasus development, XG20 for the RB199 and XG40 for the future agile fighter. The last forty production Pegasus engines for the RAF were based on XG15 technology and are designated Mk 107, achieving 23,800lbs thrust, some two and a half times that of the prototype within the same carcase size. The technology that evolved from the XG40 gave Rolls-Royce a head start in the four-nation Eurojet consortium that was formed with ITP in Spain, MTU and Fiat to develop the EJ200 engine for Typhoon. This successful project was a great improvement over that for the RB199, and the technology demonstrator programme as a whole was praised by the National Audit Office. Following its successful development, production of EJ200 hot end modules began at Patchway in 2001 and engines for the RAF aircraft and Saudi export variants are assembled here.

All of Bristol's helicopter turboshafts were inherited from de Havilland at Leavesden in 1992, via Bristol Siddeley and Rolls-Royce Small Engines Division. These engines include the various marks of Gnome in the RAF's Whirlwind HC10, Wessex HC2 and Sea King

The STOVL Lockheed Martin X-35B, that is scheduled to become the F-35B which the RAF/RN had been expected to acquire, although the UK will now buy a reduced number of the carrier-capable F-35C instead. (Lockheed Martin)

HAR3. More recently, another successful collaboration with Turbomeca is the RTM-322 in the Merlin HC3. It was flown in a Sikorsky S70 Blackhawk modified by Rolls-Royce as a flying test bed and was developed from the RTM321 technology demonstrator also funded by the MoD.

From the 1970s Rolls-Royce had continued to study several advanced STOVL concepts for use in a next generation fighter which could replace the unique capability of the Harrier. Although the MoD had no formal requirement, largely because of its pursuit of suitable partners in the EFA project, none of whom were persuaded by the merits of STOVL, there was an understanding that it was important to stay abreast of emerging technology and limited government funding was made available to the company. In time the US created a programme, known as JAST (Joint Advanced Strike Technology) to study a new fighter/attack aircraft which would replace the USAF's A-10 and F-16, the USMC's Harrier and the USN's F/A-18. Three American companies competed on paper and two were contracted to develop prototypes of a Joint Strike Fighter, both to build one example each of their STOVL and conventional designs. Boeing and Lockheed built the X-32 and X-35 respectively and both STOVL designs used Rolls-Royce technology with Lockheed's X-35 winning the competition after flight demonstrations in 2001; but this is where today's history comes to a close.

THE LAST OF THE LINE – THE RAF BRITANNIA

Sqn Ldr David Berry

David Berry gained his Private Pilots' Licence at 17 via an ATC Flying Scholarship. He subsequently joined the RAF and served for forty years, accumulating some 10,000 flying hours as a fighter pilot, QFI and in the transport world, much of the latter associated with the Britannia. He has written a number of aviation books, including two about the Britannia.

My brief is to speak on the Bristol Britannia in Royal Air Force service. I have to keep this in mind and not wander into a general history of the Britannia – especially as there must be many here with a greater knowledge of that subject.

My qualification for giving this presentation is also a potted history of the military Britannia. Having served for ten years in the RAF, I joined the Britannia fleet at RAF Lyneham, as a co-pilot, in 1962. This was three years after the delivery of the first aircraft in 1959. I progressed through the ranks – from co-pilot to captain to training captain and examiner – at Lyneham and later Brize Norton. With a three-year break this amounted to ten years on the aircraft, brought to an end with the selling off of the fleet in 1975 as a result of the 1970s' Defence cuts.

This was not the end of my association with the Britannia as the Aircraft and Armament Experimental Establishment at Boscombe Down had a Britannia, used as its 'bus and lorry' for overseas trials. It was my good fortune to fly this aircraft for three years before it too was sold. As I was the person to deliver it to the new owners, this qualified me as the last RAF pilot to fly the Britannia! In my grand total of thirteen Britannia years, I accumulated 5,000 hours.

Many of you will have knowledge of the rather erratic history of the development of the Britannia. For my book, *The Whispering Giant in Uniform*,[1] I was privileged to receive the help of Sir Archibald Russell in the form of a handwritten, fourteen-page account. One

[1] Berry, D; *The Whispering Giant in Uniform* (Keyham Books, Startley, Wilts; 1996).

amusing insight was the fact that the original specification for a 36-passenger aircraft was based on the seating capacity of a standard airport bus!

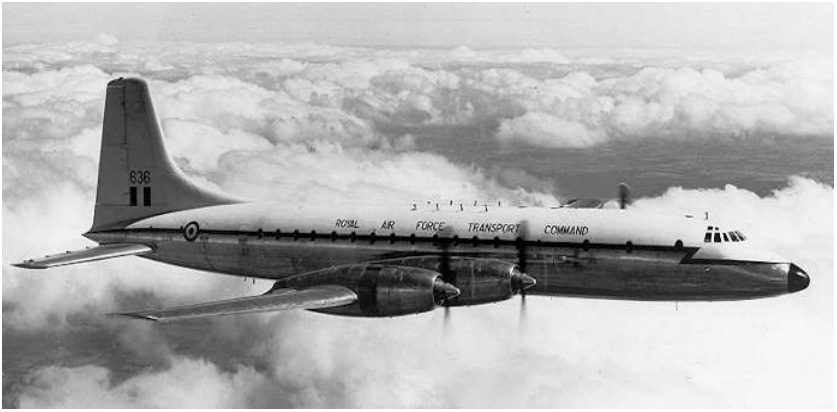
To put a precise date on the beginning of the Royal Air Force Britannia is difficult. Partly to support production development, the Ministry of Supply took an early interest in the aircraft. To justify this, it was anticipated that eventually these aircraft would be leased to civil operators for air trooping. From June 1955, the Ministry of Supply issued 'Development Progress Reports on Civil Aircraft' that featured the Britannia. From samples of these reports, one can gain an impression of the agonising struggle involved in producing an aircraft on time, up to specification and last, but by no means least in the case of the Britannia, with a full Certificate of Airworthiness.

If a conception date has to be determined for the totally military Britannia then it might be seen as July 1956 when the Chiefs of Staff set up the Bingley Committee. Its remit was to make recommendations on the inter-Service requirements for a future air transport force. In mid-1957, the resources available for a major peacetime emergency were:

20 × Hastings
10 × Beverleys
5 × Comet 2s
11 × Valettas
30 × Shackletons and
29 × civil aircraft diverted from routine trooping.

The Committee worked on a requirement for a future strategic transport fleet based on reinforcing the Far East in seven days. Each Service contributed its requirements. Calculations complete, it was discovered that sixty-four Britannias would be needed! The same question was then asked that we, as individuals, apply to our own budgets – 'What can we afford?' The answer was a tidy number of twenty. But the RAF Britannia fleet ended up with an untidy twenty-three aircraft with the three Ministry of Supply aircraft being absorbed. These aircraft were not up to the full military specification of the twenty aircraft – in particular, they did not have a strengthened freight floor.

How did this new Strategic Transport Force compare with the old?



A Britannia – surely one of the most of graceful of RAF aeroplanes.

At the time of Suez, assuming a 75% serviceability, 2,400 passengers *or* 375 tons of freight could be airlifted. The comparable 1962 figures were 5,600 passengers *and* 1,000 tons of freight.

Filton, and under licence Short Brothers, Belfast, set to work and the first Britannia was delivered to Lyneham in March 1959. Within two years the fleet was complete.

The first test of the RAF Britannia's capabilities came in 1961 – it could have ended in disaster. It was the *first* Iraq War – the war that never was. Iraq claimed that Kuwait belonged to them and started moving forces towards the border. 'Operation VANTAGE' was launched to move troops, armoured cars and a Hunter squadron to secure the airfield.

That airfield was Kuwait New, which had minimal published aeronautical information, blowing sand and temperatures in the 40s. Assuming that the aircraft found the airfield – it is alleged that one landed in the desert and took off again – there was the problem of unloading. The Britannia was designed as an airliner where the freight and passengers being ten feet from the ground was not a handicap, but it was a constant problem for a military transport aircraft.

Another problem was ground electrical power. If there was none then the aircraft's engines had to be started from the internal batteries. This was a skilful operation, involving getting everything ready before throwing the battery switch. As the starter button was pressed it was 'fingers crossed' that the first engine would start before the batteries

went flat!

This leads to another area of contrast with civil operations. The latter are conducted in a peaceful environment, but there could be hostility to military supply flights. For this reason we were never permitted to fly across Egypt and had to stay within Libyan and Sudanese airspace – leading to Egypt's south west boundary being labelled 'Nasser's Corner'.

It has been said that the reinforcement of the Far East was used as a possible scenario for the Britannia – but what if the 'less than friendly' Middle East countries opposed this? There were contingency plans, which were exercised. One was known as the Cable Route where the route ostensibly followed that of the undersea cable to the Far East. From the UK it stayed out over the Atlantic as far as Ascension and then headed east across Africa, staging through Angola and Rhodesia and overflying Mozambique, before island hopping across the Indian Ocean to Perth via Mauritius and Cocos.

Another exercise was 'Travelling Causeway', which went westwards to Singapore using United States Air Force bases in Greenland and Alaska before crossing the Pacific via Midway and Guam. The 'Causeway' title arose from the fact that the first aircraft positioned the all important ground power units, slip crews and servicing personnel to provide the stepping stones for the main flow of aircraft.

So far I have given two examples of RAF Britannia activities: 'Operations' – the real thing, and 'Exercises' – practising contingency plans for 'the real thing'. The third major activity was Supply and Trooping flights. The Britannia was operating in the days when we still had major garrisons around the world – notably in Singapore, Hong Kong, Aden, Cyprus, Malta, Gibraltar and the Persian Gulf. These all had to be supplied with personnel and freight – some of it by air. In fact, one aircraft a day departed Lyneham for Singapore. This aircraft was known as the Changi Slip, after the Singapore terminal at RAF Changi, adjacent to the notorious jail, and the crews 'slipped' to keep the aircraft moving.

The route changed over the years, but initially the Lyneham crew would fly the aircraft to El Adem in Libya for a two-hour refuel and flight planning stop and then carry on to Aden. There they would hand over to a fresh crew who would complete the journey to Singapore via

Weather like this, all too common in tropical latitudes at the Britannia's operating height, involved a significant risk of icing.

the RAF's Indian Ocean island base at Gan in the Maldives. In 30 hours, the load reached its destination. After an eight-hour unload and reload, it was ready for the journey in reverse.

These double legs were quite demanding for the crew especially as it was more than likely that they were not starting at the beginning of the day after a normal night's sleep. Throw in a bit of unserviceability and it could be a long day. There were limits on our crew duty time. It is difficult to believe now that it was 19 hours.

Much of this route was conducted in the weather turmoil of the Intercontinental Tropical Convergence Zone – thick layer cloud and embedded towering cumulonimbus – which leads to thoughts of engine icing! Many of you will be aware that the Britannia's Proteus engines did not encounter icing problems until it was completing its route proving flights for BOAC. It was discovered that the reverse flow configuration of the Proteus lent itself, in certain conditions of air temperature and moisture content, to ice forming at the bends and this ice could break off and pass into the engine with disastrous consequences. This imposed a two-year delay on the aircraft's entering airline service whilst a remedy was found.

The first solution, and the one installed in the civil Britannias, went by the name of 'B-Skin Jets'. This involved gas jets playing on the vulnerable bends. The version adopted for the RAF's Britannias was 'Cowl Heat' – areas of the engine cowling being heated internally. With both systems it was absolutely imperative that a drill was closely followed – if it wasn't it was rather like the well-known 'Carb Heat'

problem – making ice rather than being protected from it. The drill for Cowl Heat is permanently lodged in my brain – as is the recollection of sitting on the edge of my seat, in the dark, with a torch shining on the windscreen to detect the first signs of precipitation.

The effects of incorrect operation – or lack of it – could not be taken lightly. The chunks of ice breaking off would cause 'engine bumping' and possible turbine damage. The next stage could be the extinguishing of the engine flame, resulting in an 'automatic relight'. This would disconcert the passengers, particularly in the dark, as it produced a long flame from the engine exhaust. The ultimate in 'frighteners' was for the automatic relight not to work and the crew having to carry out a 'rapid relight drill' – but not *too* rapidly, as it wouldn't work.

Perhaps, after this doom and gloom on the Proteus, a little light heartedness is called for. Did engine manufacturers employ the services of a classics scholar? Olympus, Orpheus, Pegasus – and our Proteus. The scholar obviously knew of the devious airflow in the engine, so chose the name of a Greek sea god capable of taking on many shapes.

There is a story about the 'B-Skin Jets'. During the design stage of the Proteus it was decided to label the various areas of the interior of the cowling, starting with 'One Skin', 'Two Skin', etc. Possible embarrassment was predicted when number four was reached, so the letters were adopted instead.

Having considered the activities associated with Operations, Exercises, and Supply and Trooping flights, a fourth task for the Britannia was Aeromedical and Mercy Flights. Fortunately, the aircraft was never required to fulfil this role to the full capacity listed in Pilots Notes, a 'maximum of 53 stretchers with provision for two iron lungs.' Strange, now, to see the words 'iron lungs'. Nevertheless, the Britannia did carry out a considerable number of life-saving evacuations to the UK. Some of them highlighted the predilection of soldiers to dive into empty swimming pools.

In the context of 'Mercy Flights' the Britannia rendered assistance in the wake of a number of typhoons, earthquakes and similar natural disasters.. There were also several instances of British Nationals being evacuated from sticky political situations.

The penultimate activity for the Britannia was VIP and 'Showing

The only serious accident involving an RAF Britannia occurred on 12 October 1967 when XL638 overran Khormaksar's runway.

the Flag' flights. The Britannia was an impressive looking aeroplane which was enjoyed by many a VIP and it seemed that every new Commander-in-Chief of an overseas command had to have his Britannia trip to say 'Hello' – and another one to say farewell! There was royalty, typically attending the many African nations' independence celebrations of that time. Sadly, there was only one occasion when we flew Her Majesty the Queen – and that was only to Amsterdam and return. 'Showing the Flag' involved air displays and the like. Another activity in this category would be the support of, say, V-Bombers on an overseas detachment.

Finally we have 'Training'. As is the way with a non-profit organisation, no expense is spared in certain areas. Our aircraft were over-serviced and under-used by commercial standards – and the aircrew were over-trained. One could say that all this did have a benefit – not a single life was lost during our flying operations. I wish I could say that we didn't even suffer a major accident – but there was one.

It was a dark and sticky night at RAF Khormaksar in Aden. The crew had flown in from Cyprus. Part of the story is that the Britannia was incredibly difficult to land smoothly. One would have a good run – and then, 'Thump'. Khormaksar had an incredibly smooth runway – and in this instance the captain made an incredibly smooth landing. Old and bold pilots say that the landing isn't over until you shut down the engines in dispersal. How true in this case. At touchdown the crew

cheered their congratulations.

The standard calls to slow the aircraft then followed. ‘Superfine’, a switch to put the propellers into a very fine pitch which ensured sufficient rpm on the ground to keep the alternators on-line – it also has a braking effect. The next call was ‘Brake Dwell’. This was the first step in retracting the throttles for reverse power. There was an indent in the throttle mechanism where one ‘dwelt’ to check for four green lights which confirmed that the propellers really were in reverse pitch. This was essential, as any further retraction of the throttles actually increased the engine power.

The inexperienced flight engineer could not get the green lights and he kept on trying going back beyond the indent – which meant bursts of forward thrust. The relaxed, unprepared crew found themselves gracefully sliding off the end of the runway into muddy waters. The aircraft was recoverable but, sadly, it was the high pressure time of the military evacuation of Aden and the tall fin of the aircraft technically constituted a take-off obstacle – so the Army had to blow it up.

A few words about crewing – if one sits on the flight deck of a Britannia – and there is still the opportunity to do so with the preservation of an RAF one at Kemble – then you might be puzzled by the layout. Perfectly normally, there are the captain and co-pilot’s seats. Then, in the middle, back from them, is a third seat. This was for the flight engineer. But it was usual for aircraft of that era to have a dedicated station for the engineer, with his own set of engine instruments and controls. However, the original concept had envisaged that the Britannia would be operated by just the two pilots – ahead of its time? But it was discovered that they needed pilots with contortionist’s bodies and arms six feet long – so the flight engineer’s seat was an afterthought.

Our engineers were incredibly knowledgeable. The Britannia bridged a gap; it was very much more sophisticated than its predecessors but it did not have the automatic diagnostics or system redundancies of later aircraft. So, it still depended on a detailed understanding of systems to ‘manually’ sort out problems in flight.

A fourth person on the flight deck was the navigator. This was not yet the era of inertial navigation or GPS and many of the routes we flew were quite challenging. Finding, for instance, the two-mile long

island of Gan at the southern tip of the Maldives after five or six hours over the sea. We did have a Doppler radar which was quite sophisticated for its day but the navigator still used a sextant to take sightings on stars and the sun for some of his position information.

The fifth crew member represented a foot kept in the past – a signaller. Again, because of the routes flown, long-range communications were primitive compared with today. HF radios and the Morse key were the tools. Half way through the Britannia's career, however, single-sideband radios came on the scene. These permitted all communications to be carried out by voice. The pilots could do that themselves, of course, so the signallers became redundant.

There was at least one more crew member; there could be more than one, an air quartermaster to look after the back end. Because so many of our routes were non-standard one-offs, the AQM's duties were considerably more than those of airline cabin staff. At a remote airfield, for instance, loading and unloading and seeing that the aircraft was in trim could be their responsibility, but they did also take pride in seeing that the crew, during the flight, were well fed and watered.

So much for the crew, what of the aircraft itself? Many people ask me what the Britannia was like to fly? My answer would be, 'It rewarded effort!' The controls were on the heavy side and with all the rods and gear boxes in the system there was some lost motion. Some of you will be aware that the aircraft had power assisted controls – well an aerodynamic version. The control column was not connected to the control surfaces themselves; it was actually connected to control tabs on the edges of those surfaces. The pilot moved the control column which moved the tab up or down into the airflow and this moved the control surface. This system only became operative when there was airflow. So, when the controls were unlocked for take-off it could happen that one elevator would flop up and the other one down. There has been many an anxious call from the pilots of other aircraft to Air Traffic Control advising of the 'problem'. I have already mentioned the fact that the Britannia was not an aircraft you could guarantee to land smoothly and I think that the free floating controls came into this.

Away from the actual handling of the aircraft, it was quite a challenge to manage efficiently. The major factor here was the risk of

engine icing. If, in cloud, the indicated outside air temperature was between plus two and plus twelve degrees then Cowl Heat had to be switched on. If that temperature was plus two to plus six then you had to slow down first to 200 knots and check the temperature again. If it was still within the range, then Cowl Heat went on.

There could be a 'Double Whammy' here. Cowl Heat absorbed engine power and you would be flying at a slower speed. All this could add up to a fuel problem on a long leg. Unfortunately, the temperatures at the Britannia's normal operating height, in the tropics, of around 20,000 feet are – plus two to plus twelve. All of this concentrated the minds of crews at the meteorological briefing and the subsequent pre-flight planning. Choosing the height at which to fly was a kind of aeronautical brain teaser. Flying at the optimum height for fuel flow, airspeed and range could have the temperature right in the critical bracket. At a lower height, the temperature would be alright but the fuel flow too high. Flying as high as possible might bring the temperature below plus two but the airspeed might be unacceptably low to cover the distance with the fuel available. It was certainly a juggling act for crews.

Strangely, it was a number of years into the life of the aircraft before a system evolved which largely overcame the problem. This was known as the 'Low/High Technique'. Initially the aircraft was flown low, typically 12,000 feet, with temperature well above the dreaded band. Good progress would be made but at the cost of high fuel consumption. After two or three hours, with the weight now reduced by the amount of fuel burnt, the aircraft was climbed and was comfortably able to achieve a flight level, at a good airspeed with low fuel flows, where the temperature was below plus two. It worked, although initially it took a lot of nerve as the fuel tank contents seemed to sink so rapidly. Remember, on the legs into and out of Gan, this was taking place over a predominantly ocean route.

But, with all that, we loved our Britannia. With the pattern of life we led, a tremendous camaraderie was created. We didn't fly fixed crews. The 'constituted crew' had been a tradition in large aircraft since their earliest days. It was considered a good idea that the same people flew together; they would mould into a team. This was tried in the early Britannia days and abandoned. That 'team' could become very sloppy and non-standard. It was also difficult to administer. For

A Britannia crew could be complete strangers, teamed together for only as long as it took to complete the current task.

instance, the whole crew had to take leave at the same time – and their wives have babies. There was also the inevitability of some people 'not getting on' and, the extreme case of this, an individual whom nobody 'got on with'. If he was a captain, that could be very difficult.

The true tale is told (I was there) of an attempt to reintroduce the constituted crew system on 99 Squadron. A large piece of paper was pinned on the board with the captains' names along the top. Crew members were invited to put their names below the name of the captain with whom they wished to fly. The list had to be taken down after a few days when captains X, Y and Z had no names below theirs.

So, the system was for each aircrew trade section (pilots, navigators, engineers, signallers and air quartermasters) to allocate individuals for each flight. This meant that you could set off on a trip, that could last for anything up to three weeks, with a fresh group of

Fork lift trucks and aeroplanes do not make an ideal combination and great care has to be exercised to avoid damaging the latter.

people – and end up with a new set of friends.

I will conclude with just one example of Britannia life. In 1965, Prime Minister Ian Smith led Rhodesia's unilateral declaration of independence. A fairer deal was sought for the Africans and the British government took their case to the United Nations. This received general support and there followed the freezing of Rhodesian assets in the UK, blocking of their exports and an oil embargo. Landlocked Zambia was badly affected by all this and one form of relief was an agreement to supply the country with oil. With no sea port and very poor road communications, other than north up through Rhodesia, the only way of achieving this was by air. The detachment to accomplish this became known as 'The Oil Lift'.

Six Britannias and twelve crews formed the air side. Fifty technicians and air movements staff made up the balance. There were to be two delivery airfields in Zambia, Lusaka and Ndola. Each of the six aircraft flew two sorties per day carrying fifty-six barrels, alternating between Lusaka and Ndola. In ten months, three and a half million gallons of fuel was carried into Zambia.

With its door sill over ten feet from the ground, loading freight on a Britannia always presented a challenge and this was certainly so when the load was to be fifty-six barrels. The only practical way was two at a time by fork lift. But one of the 'Laws of Air Transport' is that if a fork lift is frequently manoeuvred close to an aircraft then, sooner or later, one of the forks will pierce the skin.

A technique was developed to reduce the inevitability of this. The forklift was pre-positioned below the freight door. It would lower its forks to the ground and two drums were rolled on. With the forks now

tilted back, they would be raised to the sill; there, with a gentle tip, they would be rolled into the aircraft. The empty forks would then be lowered for the process to be repeated. For unloading, the procedure was reversed. This method meant that the location of the fork lift remained unchanged and the risk of an accident was almost entirely eliminated. When unloading, a tilt as the barrels reached the ground was used to give them some impetus which was seized upon by the local labour to keep them rolling to the lorry at the perimeter.

As the aircraft taxied in, the air quartermaster would be unchaining. With all this, remarkable turn round times were accomplished; twenty minutes from landing to take-off was the record. The Oil Lift was a considerable RAF Britannia achievement.

The sad news of 1974 was the Defence cuts proposed by the then Labour government. They confirmed the UK's closer involvement with NATO and a reduction in its global commitments. Many reinforcement forces would not be required. All this spelt out a cutback of the air transport force. The final reduction was subsequently declared as 50%, which would include the Britannia fleet.

In January 1976 the last Britannia was flown to Kemble for disposal and 99 and 511 Squadrons were disbanded. The aircraft were quickly purchased by civilian operators – by civilian commercial standards they were relatively young in flying hours. There then followed a number of years of use, with many of the airframes being cannibalised to keep others going. The final example was ex-RAF Britannia, XM496, which was still flying in Zaire in 1997. With the insurrection there, it was decided to cease operating the aircraft. It was known that there were enthusiasts in the UK who would preserve it and it was flown into Kemble in October 1997. Its landing there ended the very last flight of a Britannia – and those are my last words on the Whispering Giant in Uniform.

BRISTOL COLD WAR PROJECTS

Tony Buttler

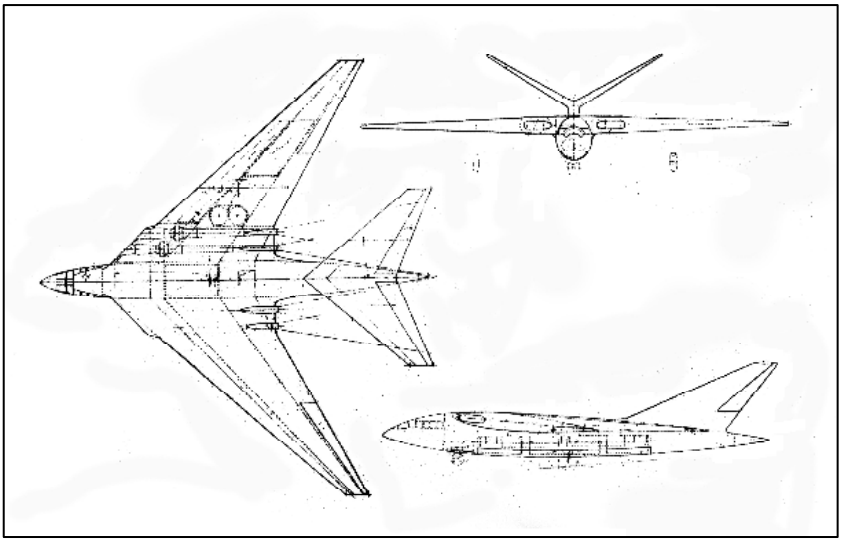
Tony Buttler joined High Duty Alloys in Redditch in 1974 as a metallurgist and spent almost twenty years testing aluminium and titanium airframe and engine components for all of the world's major aircraft. While with HDA he became increasingly interested in the design and development of aircraft and in 1993 he left the company to take a Masters Degree in Archives and Library Studies at Loughborough. He has been a freelance aviation historian and writer since 1995 and, aside from numerous magazine articles, his sixteenth major book has recently been published.

I must start by saying what a great pleasure and a privilege it is to be asked to contribute to today's proceedings.

So far we have looked at real aeroplanes, designs which were successfully turned into hardware, but design teams are, and always have been, working on new projects and ideas. In the 1950s some manufacturers still tended to specialise in a specific category of aircraft. For example if you look at the project lists for Hawker up to the start of the P.1127/Harrier programme you will find a very high percentage relating to fighters, while Avro concentrated on much larger aircraft like bombers and transports. Bristol, however, seems to have had a go at most things and we have already seen piston-engined fighters and bombers, helicopters, airliners and missiles. I would like to talk about some proposals that the company made against Air Staff and Ministry requirements from the end of the war until the late 1950s, on categories of aircraft that were never actually built by Bristol – jet fighters and bombers. I will then finish with a research aeroplane that was built and flown during the 1960s, the Type 188.

Bristol Type 172 Long Range Bomber

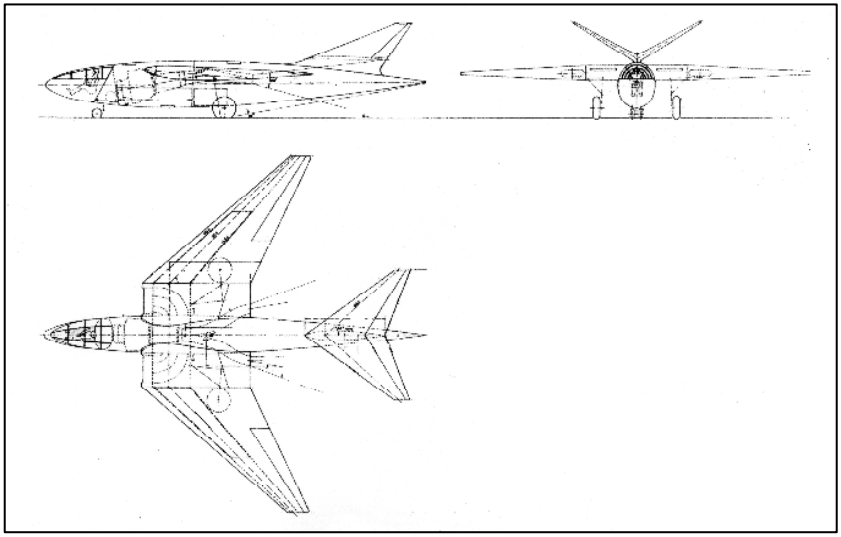
On 16 February 1945 Short Brothers at Rochester was asked by the Air Ministry to design a jet bomber with a 5,000 mile range. The resulting project was eventually scaled down to become the Sperrin, but the idea of a long range bomber had been established and in due



The Type 172 bomber project as at 31 October 1946.

course several other companies provided studies for such a type. Bristol's Type 172 was one of those considered by the Ministry and there were at least two versions of it. The drawings of the first were dated May 1946. It had swept wings, a swept 'butterfly' tail and was to be powered by four Bristol BE10 engines, which at that stage had not yet been named Olympus. All-up-weight was 166,000 lb and with a 10,000 lb bomb load the Type 172 was expected to achieve the 5,000 miles range requirement. Top speed was estimated to be 600 mph at 40,000 ft.

By late October 1946 the 172 had been redesigned with a high wing but it still had the V-tail. Six 6,000 lb conventional bombs could be carried for an all-up-weight of nearly 172,000 lb. By now the Air Staff had produced a fairly detailed outline for the long range bomber under Operational Requirement OR230 and it would have to attack targets deep into enemy territory. The Air Staff wanted very much to procure a long range bomber, but by December 1946 studies were indicating that its all-up-weight with a full load of fuel might reach as much as 200,000 lb. Clearly, such a type would be very expensive and the financial considerations meant that perhaps only one or two squadrons could be equipped with the aircraft. Other studies showed



The Type 174, a 4/10ths scale model which was to have validated the basic design of the Type 172 bomber.

that the majority of enemy targets could still be reached by an aeroplane having around 75% of the original range, so alternative requirements were prepared for an advanced medium range bomber which eventually produced the V-bombers. Consequently, the Bristol Type 172 was never ordered and, despite what some published sources have stated, the project was *not* proposed against Specification B.35/46 and Operational Requirement OR229 which produced the Avro Vulcan, Handley Page Victor and Vickers Valiant. In fact Bristol did not tender a design to B.35/46.

An important feature of the Type 172 was its swept wings and scale flying models were required to provide experience with this configuration (the advanced wing shapes of the Vulcan and Victor were of course assessed by scale model aircraft in the same way). Bristol's model proposals began with the Type 174 and then moved on to the Type 176.

Bristol Type 174 and 176 Scale Model Test Aircraft

Two four-tenths Type 174 scale flying models were ordered in 1948 to Specification E.8/47. These were given the serials VX317 and VX323 and each aircraft was to be powered by a Rolls-Royce Nene.

A model of the Type 176 swept-wing research project of 1948.

The layout retained the swept V-tail and Bristol began working on the Type 174's design in 1947. The effort reached the stage of loft plates and tooling and a shop was allocated to construct the airframes. However, it was found that the wing/body junction shape and the powerplant installation for the 174 were unsatisfactory and so the project was replaced by the smaller, and very different, Type 176.

The three-tenths Type 176 scale model, to be powered by one of the first production 6,500 lb Rolls-Royce Avons, was planned against Specification E.8/47 Issue II of May 1948 and it was to have a limiting Mach number of 0·92. However, any thoughts of building a long range bomber had long passed and Bristol was now looking at the 176 more as a pure research aircraft. The project's Chief Designer was Barry Laight (who later went on to achieve success at Blackburn with the Buccaneer) and some years ago he told me that the 176's purpose was essentially to provide Bristol with practical flight experience of swept wings. The Type 176 had a bicycle undercarriage plus a nose intake which was then split to pass along either side of the single-seat cockpit. In many respects the design looks somewhat Russian in appearance, exhibiting a number of features seen in several contemporary Soviet fighter designs. The Type 176 Mock-Up Conference was held in October 1948 but the project was finally

The prototype Type 182R BLUE RAPIER – it never flew.

cancelled in 1949 to release funds for other work.

Bristol Type 182 Flying Bomb

In September 1945 the Air Staff issued a request for an unmanned expendable bomber which offered greater range than a conventional aircraft – memories of the German V-1 flying bombs were still fresh in the mind. However, it was not until September 1950 that the research effort could provide assurance that the concept was viable. Using radio control from the UK, there was a potential for a 400 nm range and, in the event that an enemy might occupy the Channel coast, the weapon could help protect the UK from short range air attack by attacking enemy airfields, missile sites, troop concentrations, bridges, radars, etc. Specification UB.109T was issued for this Short Range Expendable Bomber and in April 1951 Bristol and Vickers submitted designs. The required war load was a cluster of ten 500 lb bombs and the aircraft's speed was to be 500 knots (576 mph) at 45,000 ft. The 'firing' rate would be sixty bombers per hour using a slotted tube catapult for each launch, and it was envisaged that many thousands of them would be manufactured for launching in barrages. In early 1952 Vickers and Bristol were both asked to proceed with their projects which were now codenamed RED RAPIER and BLUE RAPIER respectively.

The Bristol Type 182 BLUE RAPIER was to be built in moulded Durestos, an asbestos fibre with a phenol and formaldehyde resin, which was the same material employed in making Bristol's aircraft drop tanks. The fixed wing had an identical shape to the Folland Gnat and production aircraft (to be powered by a 3,750 lb Bristol BE19) would have no undercarriage. However, retrievable prototypes called

Type 182Rs were to be built in light alloy and fitted with a de Havilland Venom undercarriage and an Armstrong Siddeley Viper engine and it was intended that these would be test flown at Woomera in Australia. The Type 182's top speed was estimated to be 576 mph at 41,000 ft but the Bristol project, and Vickers' RED RAPIER, were cancelled in 1954, one of the reasons being the contemporary electronics industry's inability to provide a guidance system with the necessary reliability and accuracy.

Bristol Type 186 Low-Level Bomber

A Low Altitude Bomber was first considered by the Air Staff in June 1951, and from 1952 until 1954 the Air Ministry and Ministry of Supply considered procuring such a type to complement the V-Force. A low altitude bomber would not suffer from the V-bomber's anticipated future vulnerability at altitude and it would also force the Soviet Union to increase its defences substantially. Specification B.126T and Operational Requirement OR314 were approved in May 1952, the aim being to attack distant targets at low-level. With an anticipated range of up to 2,500 nm, the aircraft was expected to cruise at, at least, Mach 0·8, with 80% of the outbound sortie being flown at 500 ft or less. The aircraft was to be provided with a dedicated air-to-surface missile with which to deliver its attack.

By the end of December 1952 Bristol had proposed the Type 186. This had a V-tail and two 11,000 lb Olympus engines mounted on struts above and to the side of the rear fuselage. The single streamlined 10,000 lb weapon was housed in a recess on the upper fuselage above the wing roots and for release it would be raised on a support until its folded wings became clear of the parent aircraft. These would then unfold, the propulsion unit would start up, the support would extend further to push the missile into the airstream and it would then be released. The Type 186's take-off weight of 97,000 lb was far less than its gross weight of 180,000 lb (of which 128,000 lb was fuel), so to provide maximum range an in-flight refuelling operation would be essential directly after take-off. The 186's cruise speed would be Mach 0·85 (which at 1,000 ft was 645 mph) and its maximum speed at height over Mach 0·9.

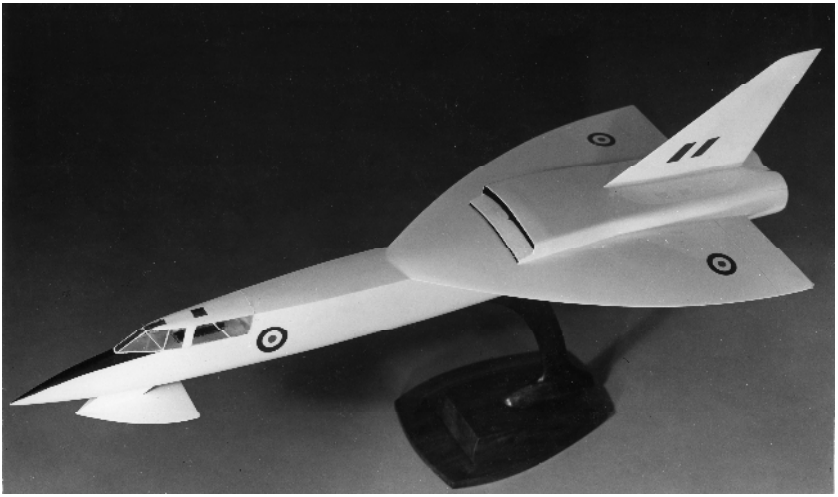
In many respects this project was an information gathering exercise that focused attention on the problems associated with sustained high-

A model of the Type 186. The weapon, normally semi-recessed into the upper surface of the fuselage, is seen here extended, with its wings deployed, as it would have appeared immediately prior to ignition and launch.

speed low-level flight. Crew airsickness and the huge stresses exerted on the airframe by turbulence were two fields of general research; finding an accurate navigation and terrain clearance system was another. In addition, to meet the range requirement the aircraft had to carry a phenomenal quantity of fuel. The competing design studies, from four companies, were all essentially flying fuel tanks, none of which could take off with a full fuel load. In September 1954 the Low Altitude Bomber was cancelled because of its intractable problems. The required high speeds at low altitude had raised serious structural issues, the associated weapon was complicated and expensive, and entirely new navigation techniques and equipment were required.

Bristol Type 204 Bomber – the Canberra replacement

Some years ago this Society held a seminar, here in Bristol, which reviewed the history of the British Aircraft Corporation's TSR2, a programme which began as a replacement for the English Electric



The innovative Type 204, Bristol's answer to GOR339.

Canberra bomber (*TSR.2 with Hindsight*, RAF Historical Society 1998). However, that splendid event did not look too closely at the alternative design studies that industry produced in response to GOR339, the General Operational Requirement of 1957 that had started things off. Bristol's offering was the extraordinary Type 204.

The Type 204's Gothic wing was expected to provide a low response to the inevitable 'bumpiness' that would be encountered at low level while meeting the stringent take off and landing limits required by GOR339 without using direct lift or very high blown flaps. It would also provide good subsonic and supersonic flight characteristics. Recent aerodynamic studies had indicated that the Gothic's flow pattern would be more stable than that of a conventional narrow delta, especially at high incidence, and that it would create less induced drag. There was also a Gothic foreplane, mounted on a pylon under the nose, a still unique arrangement which has not yet featured on any other known projects proposed in the UK, America or the Soviet Union. It was intended to serve as the primary longitudinal control and act as a trimmer for the main wing's full-span single-slotted trailing edge flaps/ailerons. An unusual 'letter box' double-shock wedge intake for the pair of Olympus 22s was placed above the wing. In the end the Type 204 was rejected in favour of the

submissions made by Vickers and English Electric which became, after the companies had been merged (together with Bristol) to create the British Aircraft Corporation, the TSR2.

Bristol Type 175MR Anti-Submarine Patrol Aircraft

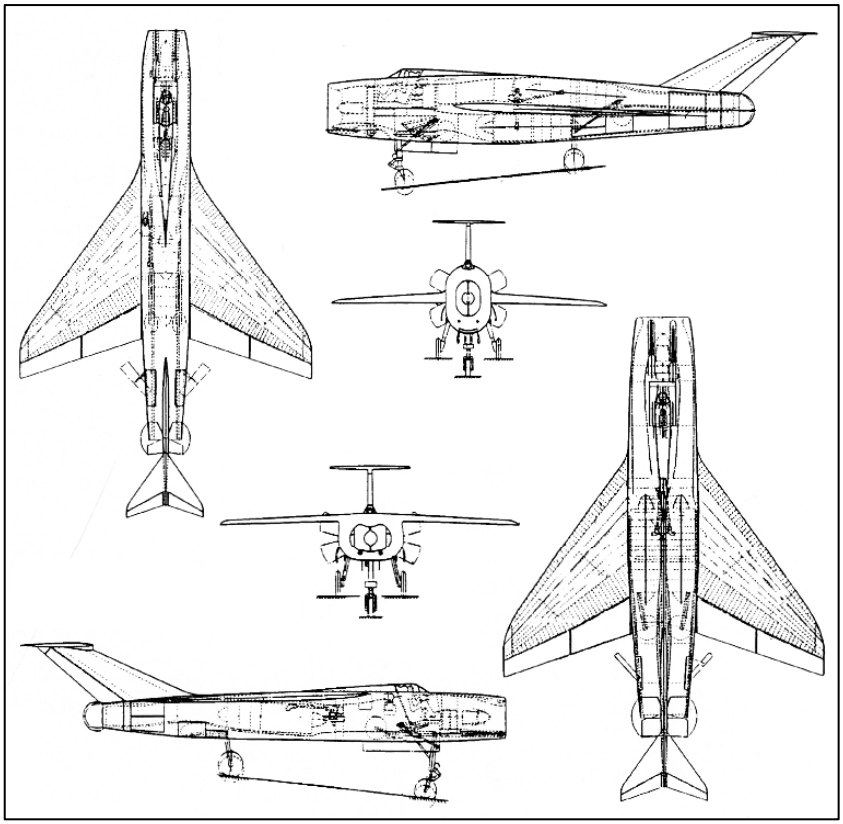
Along with the jet bomber studies there were two anti-submarine proposals. The first, the Type 175MR of April 1953, resulted from several proposed developments of the Britannia. Its forward fuselage was reminiscent of the wartime Short Stirling, with Wright R3350-32W radial engines taking the place of the Britannia's Proteus turboprops. A substantial bomb bay could hold a mix of anti-submarine weapons while rocket projectiles and missiles could be carried under the outer wings. The Bristol Type 189 was a similar project which would have been powered by four of Napier's rather complicated, but very economical, turbo-compound Nomad diesels.

Bristol Type 206 Anti-Submarine Patrol Aircraft

The Type 206 of May 1958 was submitted to a NATO competition between European aircraft manufacturers for a maritime patrol aircraft to replace the Lockheed Neptune in European air forces. The winning proposal was the project from Breguet which became the Atlantic. The 206 was to be powered by two Rolls-Royce Tyne turboprops and, along with 6,000 lb of anti-submarine weapons stored in the fuselage bay, could carry a Bullpup air-to-surface missile under each wing.

Bristol Type 177 Jet Fighter

The second important area of military aircraft design at Bristol during this period was the jet (and rocket) fighter. The first effort was the Type 177 but it is uncertain just how much design work was done on this project, since a major proposal brochure does not appear to have been submitted to the Ministry. It was to have been a supersonic fighter and three versions were drawn, the 177A and 177B of November 1948, and the later 177C. The 177A had two Bristol BE10s placed one above the other and, with its large nose orifice was, again, a little reminiscent of contemporary Russian practice. The wing was swept 56° and two 30mm cannon were placed below the intake. The Type 177B was similar but had the BE10s mounted side-by-side. The Type 177C of February 1949 was very different; it had only one engine, side intakes, a 65° swept wing, a solid nose and a bicycle

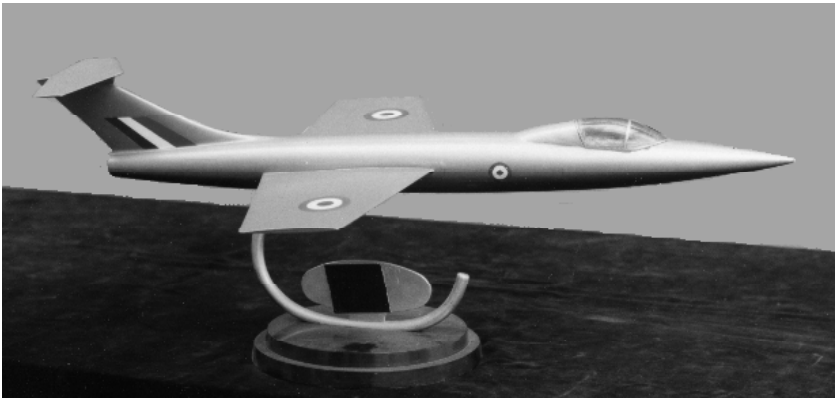


Two rather clumsy looking fighter projects; top, the Type 177A and bottom, the Type 177B.

undercarriage. Some published sources have indicated that the Type 177 projects were designed to Specification F.3/48, which covered the Hawker Hunter, but this is not indicated on any of the drawings and there are no Ministry documents for F.3/48 showing any references to Bristol. However, the dates of the specification (October 1948) and the 177 drawings do match very well.

Bristol Type 178 Rocket Fighter

In 1952 Specification F.124T and Operational Requirement OR301 were raised for a highly supersonic rocket-powered interceptor to deal with incoming high flying enemy aircraft. This fighter was to have an



Schemed to a 1952 specification, the straight-winged version of Bristol's Type 178 was strikingly similar to the contemporary Lockheed F-104 which flew for the first time in 1954.

outstanding rate of climb offering sea level to 60,000 ft in two and a half minutes. Nine designs were submitted by industry including two variants of Bristol's Type 178, straight- and swept-wing versions of the same aircraft powered by an 8,000 lb thrust Armstrong Siddeley Screamer rocket motor. Forty-eight rocket projectiles were to be carried in twin retractable batteries in the lower fuselage. Take-off was to be made from a trolley and the fighter would land on a bicycle undercarriage. The competition was won by the Avro 720 and the Saunders-Roe P.154 projects, but Avro's aircraft was cancelled before its first flight, although Saro's was completed and flown experimentally as the SR.53. Because its thin wings were of interest to the Air Staff some consideration was given to ordering an example of straight-wing Type 178 as a research aeroplane, but this was not pursued.

Bristol Type 183 Swing Wing and Type 184 Delta Wing Fighters

Many features of modern aircraft design were first considered during the 1950s, including the introduction of swing wings. Variable geometry wing research was raised by Specification ER.110T of February 1951 for a supersonic fighter and several submissions were made, representing a variety of concepts for swing wings (although none of the recognised 'fighter companies' took part). Bristol's

Type 183 proposal was powered by a pair of 9,760 lb thrust Armstrong Siddeley Sapphires and had two 30mm cannon in the nose. A single-seater, the 183 was expected to be capable of Mach 1·39 at 45,000 ft. Take off would be achieved using a catapult, with landing on a mat. However, Bristol also suggested that a tailless delta winged aircraft would actually provide better altitude performance so a parallel study was made as the Type 184. The ER.110 competition was an early attempt to find a swing wing aeroplane and, like the low altitude bomber project, it did a lot of the spade work that would provide the foundations on which the programmes of the 1960s were built.

Bristol Type 188 Mach 2 Research Aircraft

The only supersonic military project from Bristol to complete a flight test programme was the Type 188. In June 1952 RAE Farnborough recommended that flight at Mach 2 should be investigated and a design competition for a research aeroplane followed against Specification ER.134T. Bristol's Type 188 proposal, with a long slim fuselage and two Rolls-Royce Avons, in equally slender wing nacelles was declared the winner. The objective was not simply to achieve Mach 2 but to sustain this speed for ten minutes in order to assess the effects of kinetic heating (the build up of heat due to air friction). A critical aspect of the design, therefore, was that it featured a stainless steel structure to cope with this extreme environment. Two prototypes (XF923 and XF926) were ordered in early 1954 with three more following in May 1955. The second batch was intended to support the Avro 730 Mach 3 jet bomber programme, but when the 730 was cancelled in 1957, the additional Type 188s went with it.

The Avons would have been fine at speeds up to Mach 2·1, but by March 1954 the required maximum had risen to Mach 2·5 which meant that this engine was no longer suitable. Other power units were considered and having wing nacelles facilitated the redesign of intakes and exhaust nozzles dictated by a change of engine without requiring a major rebuild. It was finally decided that the 188s should be powered by a pair of de Havilland Gyron Juniors giving 10,000 lbs of dry thrust and 14,000 lbs with reheat.

The use of stainless steel within the structure was not without its

XF926, the supersonic Type 188, with its Hunter chase plane.

problems as was the search for an alloy that could tolerate the speed or, more specifically, the temperatures that would be encountered while retaining the ability to be manufactured in the form of sheets. The eventual choice was the Rex 448 alloy but this required a substantial development programme to establish a new puddle-welding process for joining sections of material together. It took two years to refine this process and to develop the skills needed to ensure that the required standards of surface flatness, finish and tolerance would be met. Consequently, the programme fell well behind schedule but the resulting surface finish on the two airframes was one of the smoothest yet seen and their structure was capable of handling the heat generated when flying at Mach 1·2 at sea level and in excess of Mach 2·5 above 35,000 ft.

XF923 flew for the first time from Filton on 14 April 1962 piloted by Bristol's Chief Test Pilot, Godfrey Auty. The aviation press reckoned the 188 was a 'hot' ship and the noise provided by the aircraft at the Farnborough Show in September did much to confirm this. However, XF923 was never intended to fly supersonically. On 15 November it was grounded for resonance testing and then withdrawn from flying. Its best speed had been Mach 0·86 and the aircraft subsequently went into store at Filton. In the meantime Gyron Junior ground running had revealed some problems and the modifications required to cure them reduced the engine's potential performance. In truth the engines were not fully developed, and it was found that they burnt fuel much faster than had been predicted, which meant that the aircraft was unable to fly for a sustained period at high speeds.

Nevertheless, on 29 April 1963 the 'supersonic' airframe, XF926, made its maiden flight. Ten supersonic sorties had been flown by early June with Mach 1·63 recorded at over 40,000 ft. Mach 1·83 was reached in July and on Flight 47 in mid-November XF926 reached Mach 1·88 at 36,000 ft, which proved to be the aircraft's best. The Type 188's last flight was made on 16 January 1964 and both airframes subsequently went to the Proof and Experimental Establishment at Shoeburyness to serve as gunnery targets. Fortunately, XF926 survived and it can be seen today at Cosford.

It is worth noting that in March 1955 the company drew the Type 188N single-seat fighter development of the aircraft with an AI Mk.20 radar in the nose and air-to-air missiles under the wings. The Bristol 188 is usually considered to be a failure, but in fact its design, development and testing broke a lot of new ground and much was learnt from the programme. Significant progress was made in materials development and in welding techniques, and real-time telemetry, for recording and assessing data as it happened, was used for the first time. The aircraft's Achilles' heel was the underdeveloped powerplant.

One must mention the BAC 221 – the first Fairey Delta II prototype, WG774, which was rebuilt at Filton and flown in May 1964 to perform high speed research for the Concorde. But this happened after Bristol had become part of BAC and the project takes us into civilian territory. However, it confirms, again, that the design team at Filton was capable of tackling many different types of aeroplane. We have seen that some of Bristol's aircraft were of the highest class and indeed civilian types like the Bristol Freighter were also very successful. But had events gone differently, we might have been talking today about Bristol's successful jet fighter and jet bomber programmes. The Bristol design team certainly offered plenty of variety in its proposals for new aircraft.

Note. This paper was prepared using original Bristol Aircraft Company documents, brochures and drawings drawn from Duncan Greenman's Bristol AiRchive and from papers held in the AIR and AVIA Files at the National Archives at Kew.

FIFTY YEARS OF THE PEGASUS IN FIFTEEN MINUTES
or, three-and-a-half years a minute.

Andrew Dow

Andrew Dow joined Bristol Siddeley as a Commercial Apprentice in 1962 and he subsequently filled a variety of posts in Bristol, Coventry and Millville, NJ until 1975 when he was appointed Commercial Manager, Pegasus, and remained responsible for the engine (and an increasing number of other military products in the US) until 1991. After leaving Rolls-Royce he became Head of the National Railway Museum, before spending 1994-99 working on 'Pegasus – The Heart of the Harrier' (Pen & Sword, 2009).

Late last year, in our ignorance of coming events, we celebrated the fiftieth anniversary of the first test bed run of the BE53/2 engine which, soon after its first flight, was named Pegasus. That first flight, in the Hawker P.1127, was fifty years ago this very day. The Pegasus was then, is now, and ever more shall be, a remarkable engine. It was not conceived in a flash of inspiration, but by a succession of applications of knowledge and experience from two enquiring and imaginative minds, starting with Michel Wibault's dissatisfactions with the inherent limitations of the helicopter, in the course of which he invented vectored thrust, followed by Gordon Lewis' appreciation of the enormous potential of the axial compressor and the flexibility of the two-spool engine.

Both men went through four discrete stages in their inventive processes, and the result was an engine that challenged the Wright brothers' established means of getting into the air and achieving flying speed. All they had in common, I believe, was the use of bicycle chains, the one to drive propellers, the other to drive nozzles.

As an item of engineering, the Pegasus was a great leap forward, as well as a great leap upward. In the mid 1950s the first fan engine had a bypass ratio of a mere 0·3:1. The Pegasus as first designed had a ratio of 1·75:1, nearly six times greater. Indeed, it was the first engine to which the expression 'big fan' could be applied. The fan was

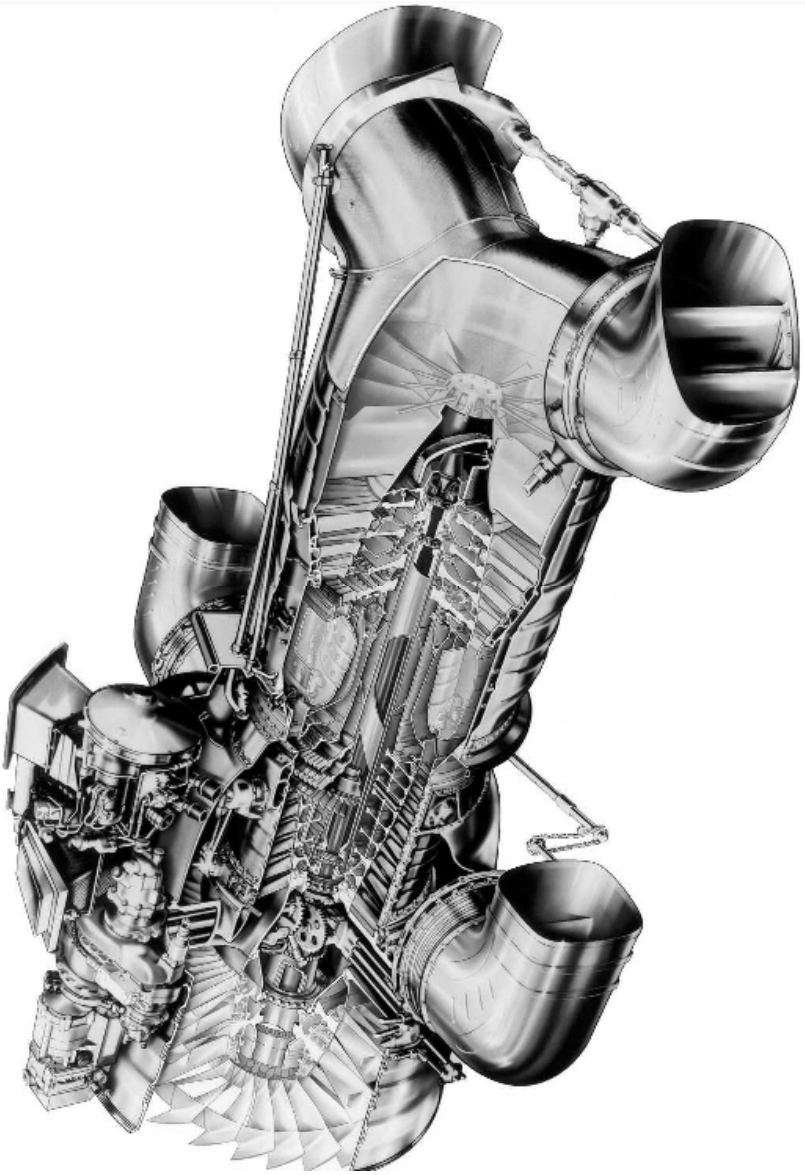
supported by a bearing at the back, rather than the front, and it thus set the pattern for all big commercial fan engines ever since. The success of the Pegasus formula led to further work by Bristol Siddeley on engines of ever greater bypass ratio, and resulted in the purchase of the company by Rolls-Royce, the financial demands of which contributed to its downfall five years later. You will have to read the history of the Pegasus to understand why I make this extraordinary statement, but you will find that it is so.

The Pegasus is a short engine, with narrow-chord blades, clean burning, and thus, visual stealth. It has phenomenal acceleration, excellent and fine response to the throttle, so vital for in-flight refuelling as well as putting down on the deck in a sea state that has all the others grounded. It has an affinity for confined spaces, such as clearings in woods, helicopter pads, and the buildings of St Pancras and Manhattan, as proven within a few weeks of entering RAF service in 1969, in the Transatlantic Air Race. What a splendid statement of faith in the Pegasus that was!

The Pegasus started life at 9,000 lbs thrust, entered RAF service with 19,000 lbs, and now, from the same size engine carcase, produces 23,800 lbs. Electrical power take-off has increased proportionately more, from 8Kv to 30Kv. It had a life, in vertical and hovering flight, of a mere fifteen minutes, and now has a full overhaul life of 1,000 hours. In the course of its development it has always been on the high end of temperatures and the sharp end of technology.

Cooled turbine blades, a digital fuel system, investment cast blades, 360 degree electro-chemical machining, the overhung big fan, wire laced blades, examination by borescope, and single crystal blades, each one a notable advance in its day, have all been part of the Pegasus story as power, reliability and life have all gone up, and as weight, fuel consumption and parts usage have been kept down. The engine has been expected to ingest turbulent and distorted air, exhaust gas – its own or from other engines – missile exhaust, rain, hail, rivets and their mandrels, birds from Lapwings to Tropical Vultures and, if legend is to be believed, the odd snake and rabbit.

Many pilots credit the Pegasus with saving their lives. Such is the flexibility it offers, the aircraft, whether by landing on a helicopter platform on a ship, or in a sandstorm, or on a road, can survive. In any other aircraft the pilot would be giving thanks to Martin Baker instead



of Bristol.

But the Pegasus is so much more than all of this. It came along at a time when air forces had been dependent on runways for nearly fifty years, and had expensively committed most of them to concrete. It arrived when many of the world's navies had replaced the battleship with the carrier, and were now hooked upon catapults and arrester wires and large defensive fleets. Along comes this little aeroplane with its big Pegasus, saying cockily and, to some, unacceptably, 'I don't need any of that'

It is not often that an engine causes all that much trouble, or makes all that progress in doing so. The first Pegasus, a nine cylinder radial of 1,000 horsepower widely used by the Royal Air Force, was, as we have heard, the first to fly man over Everest, seized long distance and height records, brought comfortable flights to the Empire in the big flying boats, drove a pusher propeller in the Walrus, devastated the Italian fleet at Taranto, facilitated the sinking of the Bismarck, and played a significant role in the 1,000 bomber raids over Germany.

The turbine Pegasus was no less familiar to controversy. It was created in response to NATO's realisation that long concrete runways were highly visible and vulnerable, and allowed refinement of NATO's new policy in its operational flexibility. Thanks to Gordon Lewis' concept of the four rotating nozzles, directing the entire thrust of the engine through the centre of gravity of the airframe, Hawker pilots were able to develop four means of getting into the air (Vertical, Rolling Vertical, Short and Conventional), and as many for landing. That is, three more than the other guys. This was not the only source of extraordinary operational flexibility of a kind that not even the STOVL version of the JSF will have, but it was also the reason why the Harrier and the Sea Harrier were able to go to the Falklands, and the reason why Tornadoes, Jaguars, Phantoms and Buccaneers could not.

These types, as one American observer wrote, were 'irrelevant'. There were no runways for them to use, and the Royal Navy had neither catapults nor wires. They did, however, have far simpler take-off and landing equipment, in the form of four nozzles on each engine. Interoperability with the US and French navies was not an issue back then.

From time to time, we hear of, or experience, inter-service rivalry.

The Pegasus was good at stirring up that too. As you all know, the US Navy has its own army, and that army has an air force. Because the mission of the Marines involves opposed landings without any guarantee of landing fields as they advance, they had for years been reliant upon the Navy's carriers for operational bases until the CB's had got ashore to build a runway. At the same time the Navy was getting rid of its big gun battleships with which to provide artillery support. These reasons, and others, were why the Harrier fitted in so very well with Marine Corps thinking.

Those who seized upon it looked well ahead, and almost simultaneously conceived a successor, the AV-16 powered by the Pegasus 15, to be co-produced by Bristol with Pratt & Whitney. This was typical of the Marines, thinking as far outside the box as Michel Wibault and Gordon Lewis had done so brilliantly fifteen years earlier. The cost of substantial engine development was to be the death of the Pegasus 15, the AV-16, and, for a moment, the Marine Corps' vertical ambitions. It was unfortunate that at the time the RAF had no requirement for such an aircraft, and the MoD was busy defining the Sea Harrier.

The eventual answer, as you all know, was the development of the AV-8B, in which engine development was expressly forbidden. That doesn't mean that we didn't do any, but it did mean that once the AV-8B Harrier II had proven itself as an even more remarkable airframe than the Harrier I, and when in the 1980s engine development was the only route to enhanced Harrier types, such as the radar version, Bristol had to find a way of developing it without embarrassing the Marines into admitting that they were sponsoring the forbidden.

Although the MoD had supported a demonstrator engine to show that more thrust could be made available, funding for a production engine from MoD was not forthcoming for some time. The commercial, political, and marketing periphery of the essential engineering of the Pegasus had therefore to be as imaginative as the engineering itself. That is part of its story, and for those fortunate enough to be involved with it, part of its remarkable character.

Throughout its development, the engineering of the Pegasus has not been merely a question of turning up the wick and changing materials to deal with the higher temperatures. Because of its need to

respect the airframe's centre of gravity, thrust development has concentrated as much on the fan as the hot end. Often this has been within the constraint of retaining fan diameter, because although some variants, such as the Pegasus 15 have looked at a larger diameter as a means of getting more air – greater mass flow – through the engine, in fact the diameter of production engines has stayed the same, much to the relief of the airframers. As a result, the air passing through the intake is now at about Mach 0.98, or as fast as it can possibly be.

There have been several relatively recent studies for increasing pressure ratio, by getting more work out of an enhanced hp compressor, but none has been carried through. The most recent, by the way, were part of a 'Plan B' style effort, in case the STOVL version of the JSF did not happen for some reason.

Bless the Pegasus! Like its cousin the Olympus, it has a name, not a mere number; it has flirted with collaboration, but was never a collaborative engine, and that was a source of pleasure. That may sound self-indulgent, but we saw enough of the problems on collaboration on other Bristol engines to know that going solo was a very practical matter. The Pegasus is Bristol through and through; its engineers have so often demonstrated the virtues of teamwork with airframers, rather that the vices of not-invented-here attitudes; its management has always kept the faith with the ideas, opportunities and advantages of V/STOL. Its customers, whether decision-makers on the ground or in the air, have similarly been faithful and true.

This is not merely a statement of admiration and self-congratulation. It is a recognition that the Pegasus, and all that it represents, is a classic, and will unquestionably go down in history as such. Its contributions to the arts and sciences of aeronautical engineering and achievement in the air, do not only concern vertical flight, but also fundamental engine design, manufacturing technology, survival, faith, and guts. With few exceptions, its accounts were printed in black ink, not red.

Fifty years on, these things are our cause for celebration. This shared experience of triumph and turmoil, disappointment and elation, and above all a sense of doing something very *worthy*, bind us together. It may be that the supersonic fraternity coined the expression 'V/STOL Penalty', in an attempt to say that vertical flight is in some way less than manly, but it is a fact that there is a very real

'Supersonic Penalty', whether on land or at sea.

This was demonstrated as long ago as 1976, when AV-8As operated from USS *Franklin D Roosevelt*. Their operations not only demonstrated the flexibility of V/STOL, as offered by the Pegasus, but also the many limitations of C/TOL. Not least of these was the way that the Harriers got up and at 'em so quickly that the best use of the supersonics of the conventional aircraft was to catch up with the Harriers. After this demonstration, Harriers have never since been to sea on a big CV carrier. Harriers were never allowed to share decks and hangars with Tomcats and Hornets. But in the air they took on Tomcats in simulated combat, and the Marines, using the nozzles of the Pegasus to perform unnatural acts in the air, bested the Tomcat too often for the Navy's comfort.

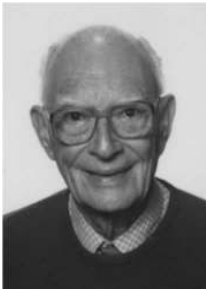
Bristol proved V/STOL to be practical and practicable, and until this week we thought it was here to stay, with a seamless and orderly progression from Harrier to JSF. Now, V/STOL, meaning operation away from runways, is not as indispensable as we had thought.

It is ironic that in 1965, an incoming government hell-bent on budget cuts, declared the need for a Defence Review, and a few weeks later cancelled several projects, including the P.1154. It was declared that to preserve design teams and British technology, the RAF would receive a V/STOL aeroplane, to be called the Harrier. Now, forty-five years later, the Harrier has itself been culled by a Defence Review, although it is difficult to see where the preservation of design teams and British technology come into it.

Last year the Works in which the Pegasus was designed and built were razed to the ground. Just seventeen days ago, that brilliant engineer and good friend, Gordon Lewis, was called to a higher place. Now we are told that the Harrier and its Pegasus engine are to go. Yes, we all knew that one day this would have to come, and we have much to be thankful for in the achievements over the years. But the unsatisfactory and premature manner of its going is not a cause for celebration. Some of the engines in the fleet have yet to reach the end of their first 1,000 hour life.

I hope that you will forgive me for ending on a low note. Right now it is difficult to be as objective as you have every right to expect. But I thank you for letting me muse briefly on the finest hours of the Pegasus, and to provide a reminder of the Bristol men who created it.

In Memoriam – GORDON LEWIS



Perhaps, just over two weeks since we lost our great friend Gordon Lewis, I may add a few words about him. I first met him over forty years ago, and recently, while I was researching for the book on the Pegasus I interviewed him, on tape, eight times. We also had numerous telephone conversations, and these all served to tell me much about him. Quite apart from his work on the Wibault proposal that became the Pegasus, I discovered his seminal involvement with the Olympus, which unlike some engines of its day worked well from its first test bed run, largely because of the discipline that Gordon brought to the design. Then there was his pioneering work with transonic compressors, well ahead of the Americans, for example, and his work on a new design of hp compressor for the JT9D. The fact that he was asked to design one speaks volumes for the respect that the Americans had for him. There were other great works of course, but his modesty has probably hidden many advances that he made in the form and function of the turbine engine. I hope that one day soon a full reckoning of his inventiveness can be assembled into a permanent record.

He never stopped thinking about invention and design: the dates of his patents are spread over forty years, and only last year did he have a meeting with other like-minded men about the inventive process. Even more recently he had been involved in a study of compressor design, and lessons to be learned from success and failure.

There was no side to him: he was honest and straight with everyone. He was always kind and welcoming, and our long conversations, accompanied by lunch with him and Marjorie in their home, or supper at a local restaurant, were always a delight. He had a somewhat anarchic sense of humour (anarchic, that is, if one came from Derby), and, as one former colleague pointed out, he had a great capacity for lateral thinking. It was an immense privilege to know him as well as I did.

Gordon Lewis was a giant in the world of the gas turbine. History will recognise him as one of the great men of British Aviation.

Andrew Dow

AFTERNOON DISCUSSION PERIOD

Patrick Hassell: Jeff Jefford and Graham Pitchfork have explained, very clearly, how unfortunate one would have been to have been Blenheim aircrew in 1940. Clearly the aeroplane had been outperformed by later single-engined monoplane fighters. I wonder whether the problem would have been just as bad for the Germans if, for instance He 111s, a near contemporary of the Blenheim, had been faced with the same sort of fighter opposition.

Jefford: Well, I guess so. Yes. The fact is that aeroplanes, of that era, were out of date almost as soon as they arrived. The Blenheim could show a clean pair of heels to any RAF fighter when it first entered service but by the time that the war began, only two years later, it was already past its sell-by date. But we had more than a thousand of them – and that is what we had to go to war with. That happens with every generation of aeroplanes. The Fairey Battle was a similar case, a significant advance over the Hind, but already out of date by 1940. The Ju 87 was another – as a single-engined bomber it was, arguably a German Battle and it established a frighteningly formidable reputation until it came up against determined fighter opposition when it was found that it couldn't really cope, any more than the Battle could. 'Last year's' aeroplanes could survive, for a while, in a relatively benign environment, as in North Africa, where Blenheims could just about cope with Fiat biplanes in 1940, but not Bf 109s in 1941. The Germans were obliged to persevere with the He 111 and they stood little chance against a Spitfire, and even less a Tempest.

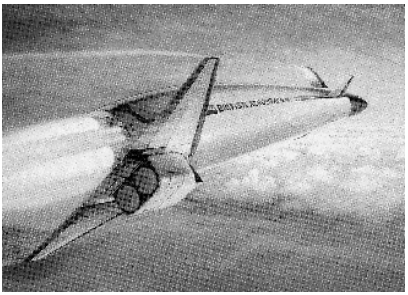
Pitchfork: I would add that the Germans never really tried to operate their early Dorniers, Heinkels and Ju 88s in the way that the RAF used its Blenheims – in daylight. They tended to fly them in large packages with a heavy fighter escort. It is sometimes overlooked that, on 14 August 1940, at the height of the Battle of Britain, the *Luftwaffe* based in Norway and Denmark mounted an attack on the north east of the UK. The unescorted bombers were badly mauled by Spitfires and, because they could not be provided with fighter cover over the range involved, they never came back again in daylight. I have little doubt that, had the Do 17s and He 111s been obliged to operate in 1940, in

penny packets like the Blenheims of No 2 Gp in 1941, they would have suffered the same fate.

Maurice Budds: Do you consider the Eurofighter to be a realistic replacement for the Harrier?

Squire: Perhaps I could have a go at that one. Typhoon is a quite different aeroplane. It was designed as an advanced air defence fighter for the Cold War. It is now in service with an initial air-to-ground capability and that facility will be further enhanced with the delivery of the Batch 3 aircraft so that the Typhoon will eventually become our most advanced air-to-ground aircraft while retaining its original air-to-air capability. Clearly, however, it will never have the operational flexibility that was conferred by the Harrier's unique STOVL performance. So – yes – in terms of its radius of action, the weapons that it can carry and accuracy with which it can deliver them, the Typhoon will be an excellent aeroplane – but it will never have the ability to operate from confined spaces or from a maritime platform.

Terrence Harper: Can anyone tell me what happened to HOTOL?[1]



Andrew Dow: I think a lack of money – and probably, lack of a demand. Interestingly, the engine was developed by a former Bristol engineer. I recall hearing an exchange between him and Gordon Lewis on one occasion; he was telling him that his engine would run absolutely beautifully,

[1] HOTOL – Horizontal Take Off and Landing – was an unmanned reusable spaceplane project conceived in the early 1980s, as a potential alternative to the US space shuttle programme, and publicly funded as a BAe design study from 1986. The power plant, designed by Alan Bond, was a hybrid 'air-breathing rocket' which was acquired by Rolls-Royce to become the RB545. Escalating cost, aerodynamic and structural problems, increasing complexity (and the competition represented by the Ariane satellite launcher) led the government to withdraw its support in 1988 and shortly afterwards Rolls abandoned the engine. Alan Bond subsequently formed Reaction Engines Ltd which, among other very advanced engineering projects, still works on HOTOL's successor, the Skylon spaceplane and its SABRE (Synergistic Air-Breathing Rocket Engine) power plant. **Ed**

but that he had no idea how to start it! (*Laughter*) In short, HOTOL was only a design concept, and it was never fully developed.

Neil Thomas: For Sir George. The point was made that, even in the early days, aviation was pretty expensive. How was research and development funded? Was it privately financed, through the company, or was it supported by the government?

Sir George White: I think that, in the very early days, the money came out of my grandfather's pocket. He was certainly a great philanthropist and number of well known contemporaries of his are on record as saying that he put up vast sums of money for the development of aeroplanes – with absolutely no hope of seeing a return – not, at least, in the short-term.

Sir Peter Squire: That 'seeing a return' issue is still with us today of course. Government funding of R&D has reduced significantly over the years, which leaves it up to industry to do it – but where is the commercial incentive to invest their own money, unless they can be guaranteed an eventual contract. It's a problem.

Jefford: I think that that was also true in the 1920s and '30s. Relatively few aeroplanes were produced purely for R&D work, but most of those that were were built against Air Ministry contracts. Beyond that, most aeroplanes were built to meet specifications published by the Air Ministry. An example of each of two or three of the competing designs might be ordered, and paid for, with a view to selecting one for a production contract. But many other aeroplanes were designed to meet the same requirements but built purely as private ventures in the hope that they just might produce a winner or, at least, something interesting enough for the government to purchase the prototype. So a great deal of incremental development work was actually funded by company money on a speculative basis. In effect, it was gambling.

CHAIRMAN'S CLOSING REMARKS

Air Chief Marshal Sir Peter Squire

Our aim today was to record the relationship between the Royal Air Force and Bristol's aerospace industry over the 100 years that aviation development and production has been conducted here – and I think that we can claim to have done that pretty well.

In closing I will highlight just one or two points – in no particular order. I, for instance, had not, until today, really appreciated the scale of the production effort here at Filton. Neither was I aware of the scope of the various training schemes operated by Bristols, or of the number of sites that that involved – extending as far east as Brooklands. At times, this represented a substantial proportion of the company's effort and it is interesting to reflect on the degree of reliance that the Service was prepared to place on industry providing the early stages of aircrew training.

We have also seen something of the tension that exists within the procurement process – and not just today. As we have heard, it also existed between the wars with respect to which of industry's many projects would, and which would not, attract a much-needed production contract – and thus sustain jobs. We have also had an insight into the scale of the investment that was made. I am not thinking in financial terms so much as the human investment, the intellectual effort involved in the design and development of airframes and engines and, of course, the cost in lives of those who eventually operated the aeroplanes that Bristols built.

Finally, we have to come to terms with the fact that, until relatively recently, there was on this site an enormous development and production facility which is now but a shadow of what it once was. That would, I am sure, have been of real concern to Sir George White and his successors who led the company as Chairmen, Engineers and Designers. Why has it happened? Mainly, I think, as was intimated during the afternoon, because projects are no longer carried out by a single company. Today they are usually collaborative undertakings – like Tornado and Typhoon – and, in view of the limited production runs, there just isn't as much work to go round as there used to be.

So – those were my personal key points, but I am sure that you will all have focused on issues of your own. It only remains for me to

thank, on your behalf, all of the presenters for the time and effort that they have clearly devoted to producing such an enjoyable day.

One of the original civil-registered fleet of Tiger Moths operated by the second pre-war Bristol-run school, No 10 ERFTS at Yatesbury. (Yatesbury Association) *There is some uncertainty about the colours worn by Bristol's Tiger Moths. Bill Morgan's original notes referred to their being in the 'BAC house colours of silver and black'. With his concurrence, your Editor has changed this to read 'black and yellow', on page 39, reflecting an article in a 1936 edition of* Flight *which, being contemporary, seems (to me) to be the more likely to be accurate. The waters are muddied, however, by noted author A J Jackson who says 'black and orange' (*British Civil Aircraft 1919-59, Vol I, *Putnam, 1959, p323) while Stuart McKay, Secretary of the de Havilland Moth Club, says that they had a 'purple fuselage and custard yellow wings' (*Tiger Moth*, Midland, 1999, p2). 'tis a puzzlement.* **Ed**

POSTSCRIPT

Since the Society met at the BAWA in October 2010 it has been announced that Bristol's historic airfield at Filton is to be closed on 31 December 2012.

ROYAL AIR FORCE HISTORICAL SOCIETY

The Royal Air Force has been in existence for more than ninety years; the study of its history is deepening, and continues to be the subject of published works of consequence. Fresh attention is being given to the strategic assumptions under which military air power was first created and which largely determined policy and operations in both World Wars, the inter-war period, and in the era of Cold War tension. Material dealing with post-war history is gradually becoming available under the 30-year rule. These studies are important to academic historians and to the present and future members of the RAF.

The RAF Historical Society was formed in 1986 to provide a focus for interest in the history of the RAF. It does so by providing a setting for lectures and seminars in which those interested in the history of the Service have the opportunity to meet those who participated in the evolution and implementation of policy. The Society believes that these events make an important contribution to the permanent record.

The Society normally holds three lectures or seminars a year in London, with occasional events in other parts of the country. Transcripts of lectures and seminars are published in the Journal of the RAF Historical Society, which is distributed free of charge to members. Individual membership is open to all with an interest in RAF history, whether or not they were in the Service. Although the Society has the approval of the Air Force Board, it is entirely self-financing.

Membership of the Society costs £18 per annum and further details may be obtained from the Membership Secretary, Dr Jack Dunham, Silverhill House, Coombe, Wotton-under-Edge, Gloucestershire. GLI2 7ND. (Tel 01453-843362)

THE TWO AIR FORCES AWARD

In 1996 the Royal Air Force Historical Society established, in collaboration with its American sister organisation, the Air Force Historical Foundation, the *Two Air Forces Award*, which was to be presented annually on each side of the Atlantic in recognition of outstanding academic work by a serving officer or airman. The RAF winners have been:

1996	Sqn Ldr P C Emmett PhD MSc BSc CEng MIEE
1997	Wg Cdr M P Brzezicki MPhil MIL
1998	Wg Cdr P J Daybell MBE MA BA
1999	Sqn Ldr S P Harpum MSc BSc MILT
2000	Sqn Ldr A W Riches MA
2001	Sqn Ldr C H Goss MA
2002	Sqn Ldr S I Richards BSc
2003	Wg Cdr T M Webster MB BS MRCGP MRAeS
2004	Sqn Ldr S Gardner MA MPhil
2005	Wg Cdr S D Ellard MSc BSc CEng MRAeS MBCS
2007	Wg Cdr H Smyth DFC RAF
2008	Wg Cdr B J Hunt MSc MBIFM MinstAM
2009	Gp Capt A J Byford MA MA
2010	Lt Col A M Roe YORKS

THE AIR LEAGUE GOLD MEDAL

On 11 February 1998 the Air League presented the Royal Air Force Historical Society with a Gold Medal in recognition of the Society's achievements in recording aspects of the evolution of British air power and thus realising one of the aims of the League. The Executive Committee decided that the medal should be awarded periodically to a nominal holder (it actually resides at the Royal Air Force Club, where it is on display) who was to be an individual who had made a particularly significant contribution to the conduct of the Society's affairs. Holders to date have been:

Air Marshal Sir Frederick Sowrey KCB CBE AFC
Air Commodore H A Probert MBE MA

SECRETARY
Gp Capt K J Dearman
1 Park Close
Middleton Stoney
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OX25 4AS
Tel: 01869 343327

MEMBERSHIP SECRETARY
(who also deals with sales of publications)
Dr J Dunham
Silverhill House
Coombe
Wotton-under-Edge
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