ROYAL AIR FORCE YEARBOOK 1981

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ROYAL AIR FORCE YEARBOOK 1981

INTRODUCTION

by the Chief of the Air Staff, Air Chief Marshal Sir Michael Beetham GCB, CBE, DFC, AFC, ADC

WITH the peace we have enjoyed in Europe over the last 36 years it is sometimes easy to forget the need to protect the precious freedoms which we cherish. But there are from time to time ominous reminders of the threat we face and one such has been the Soviet invasion of Afghanistan, the first direct use of Soviet Armed Forces outside Eastern Europe since World War II. The Soviets have made a sustained and massive investment in defence over many years, which has led in turn to a remarkable increase in the size and offensive capabilities of the Soviet Air Force. I commend you to read, therefore, the article on the Warsaw Pact Air Threat in this issue of the Year Book.

To meet that threat we rely on our membership of the NATO Alliance to which nearly all the operational units of the Royal Air Force are assigned. And in order to play our full part in the Alliance we have not been standing still over the last 12 months. An exciting re-equipment programme is now approaching realisation, and over the next few years we will be introducing five new aircraft types into the inventory, along with new weapons and associated equipment. Tornado, the core of the programme, has now entered Royal Air Force service at RAF Cottesmore where the Tri-National Tornado Training Establishment is well under way with its task of training crews from the German and Italian Air Forces as well as our own. Moreover, we have started the "hardening" of our key operational airfields in this country so as to reduce significantly their vulnerability to air attack; we have also awarded the first radar contracts for an improved United Kingdom air defence system.

Meanwhile, front-line, training and support units have all had another busy and productive year, and I believe we are well prepared to take on the many challenges that lie ahead. You will read about the rôle of RAF Germany, RAF Pilot Training, and an account of Air-to-Air Refuelling in this issue; these are but a few examples of our work, and I hope as many of you as possible can find the time to see more of what we do by attending some of the airshows and displays at which the RAF will be represented throughout the year. In particular, I would like to draw your attention to the International Air Tattoo at Greenham Common on 27 and 28 June and the four Battle of Britain "At Home" Days — at RAF St Athan and RAF Abingdon on 12 September, and at RAF Finningley and RAF Leuchars on 19 September.

Michael Beetham

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RAF YEARBOOK 1981

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The air defence element of RAF Germany is provided by two squadrons of McDonnell Douglas Phantom FGR Mk 2s. The long-standard two-tone NATO camouflage colours (above) are now giving way to air superiority grey (bottom of page). The heading photo, previous page, shows a Phantom of No 19 Squadron in company with a Harrier of No 3 Squadron, and (below right) a Harrier is decontaminated in its Hardened Aircraft Shelter (HAS) during a training exercise.

airfield perimeter against anticipated Fifth Column attack, but vulnerable points are protected by support personnel (the "cooks and clerks") who, in war, would discard their pots and pens for rifles and respirators.

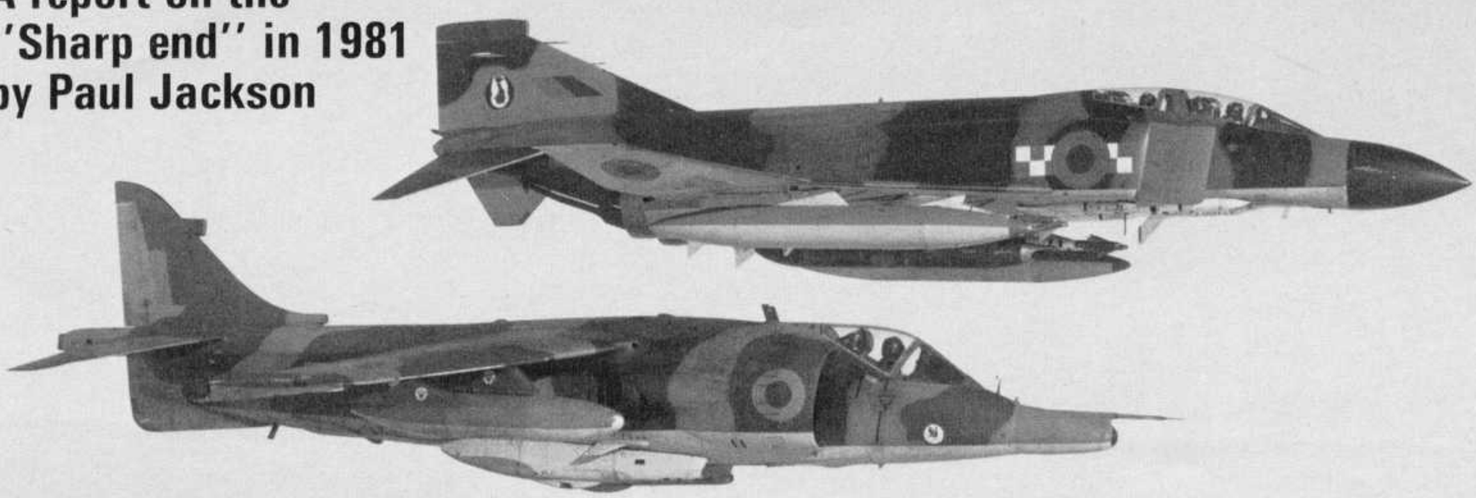
Offensive Operations

The tools of RAF Germany's trade are its aircraft: two squadrons of Buccaneers and four of Jaguars for the strike/attack rôle; one Jaguar and two Harrier squadrons for attack/reconnaissance; two Phantom interceptor squadrons; one Puma helicopter unit for army support; and a communications squadron with Pembrokes. In times of extreme political tension, these would be strengthened by aircraft and personnel from the home-based Harrier and Jaguar Operational Conversion Units (OCUs).

Equally important to the effectiveness of this force are the five squadrons of SAMs, a wing of the RAF Regiment providing ground defence, a maintenance unit and many ancillary services. In the last-mentioned category is the 230-bed RAF hospital at Wegberg, near

ROYAL AIR FORCE GERMANY

A report on the "Sharp end" in 1981 by Paul Jackson



IN PARALLEL with the transformation of Britain's Empire into a Commonwealth and its relinquishment of most overseas protectorates, the RAF's once global presence has shrunk to a mere shadow of its former self. Now, only one major air force element is based outside the UK, joining with the squadrons in Belize, Cyprus and Hong Kong in perpetuating the traditions of an air arm which justified its newly-won independence through efficient defence of British interests over half-a-century earlier.

Royal Air Force Germany today reflects Britain's modern interest in the continued freedom of Western Europe, through its membership of NATO. Together with the UK's other armed services, and those of our allies, it is charged with the daunting task of deterring a formidable and ruthless potential adversary from his oft-avowed intention of forcibly imposing communism on free nations. The axiom, "Those who desire peace should prepare for war" has withstood the test of time, and would make a suitable alternative for RAFG's motto, "Keepers of the peace". As the most finely-honed edge of the RAF's "sharp end", its German-based elements are perpetually at a high state of readiness, their immediate task, in the event of that deterrent failing, being to contain the assault and thereby provide time for the Allied armies fully to deploy. This front-line status is reflected in the continued priority afforded to RAFG despite otherwise stringent curbs on defence spending. For instance, some of its squadrons enjoy an aircraft-to-pilot ratio of 1:1·5, compared to 1:1·2 for home-based units flying similar aircraft types; whilst all-weather protection from low-level air attack is provided by the latest Blindfire-equipped Rapier surface-to-air missiles (SAMs).

Priorities demand, and achieve, enhanced efficiency: RAFG can transition from peace to war in less than one-third of the stipulated NATO reaction time. Readiness is regularly monitored by "Taceval" — a no-notice war exercise (TACtical EVALuation), closely scrutinised by a panel of NATO examiners. Resultant performance assessments are classified, but it is generally accepted throughout the Alliance that RAFG consistently gains the highest honours.

Tactical Air Force

The Command had its genesis in the Tactical Air Force formed within Fighter Command in June 1943 as an aerial spearhead for the coming invasion of occupied Europe. By November of the same year it had been re-titled 2nd TAF and, in July 1945, the name again changed, to become the British Air Force of Occupation. Reverting to 2nd TAF in September 1951, the final re-designation came on 1 January 1959 when RAF Germany was formed, with headquarters at Rheindahlen, near Mönchengladbach.

RAFG now forms part of the 2nd Allied Tactical Air Force (also at Rheindahlen), in company with the Belgian and Netherlands air forces, northern-based units of the West German *Luftwaffe* and elements of the US Air Force Europe. TWOATAF's 60,000-square mile (155 400-km²) area of responsibility extends from Luxembourg to the Danish border, and westward from the Iron Curtain to the North Sea. Together with 4th Allied Tactical Air Force, to the south, it is immediately subordinate to Allied Air Forces Central Europe and, via Allied Forces Central Europe (AFCENT), to the Supreme Headquarters Allied Powers Europe (SHAPE).

In peacetime, only the air defence (manned interceptor and SAM) elements of TWOATAF's five component air arms are controlled by NATO, but at a time of international tension the entire force is placed in the hands of TWOATAF's Commander. The latter position is traditionally occupied by the British officer commanding RAFG.

Four airfields in Germany provide the foundation of the Command's offensive and defensive strength. Hard against the Dutch border, and set in a perfectly flat landscape normally associated with the Netherlands, are Bruggen, Laarbruch and Wildenrath — collectively known as the "Clutch" bases. To the east of the Rhine lies Gütersloh, an airfield once used by the wartime *Luftwaffe* and since modernised for use by present-day jet aircraft. Further east still is Gatow, in the British sector of Berlin, renowned for its rôle in the famous airlift but now possessing only a couple of D.H. Chipmunks for familiarisation flying and serving as the RAF airhead in Berlin for contingency operations.

All operational airfields are prepared for war or, in current jargon, for "when the hooter goes". Buildings and vehicles are camouflaged, and concrete surfaces chemically toned-down so that they blend into their green surroundings. Around the perimeter of the airfield, squadron dispersals comprise a maze of taxiways leading to individual Hardened Aircraft Shelters (HAS — pronounced "haz"), often concealed in woods. For security from air attack, each HAS is at a different angle to its neighbours; an apparently random collection of miniature hangars, all holding one, two or, occasionally, three aircraft.

Within the HAS, groundcrew work to "turn-round" the aircraft after each mission: replenish, re-arm, and (in wartime) repair battle damage. Comforts are few, save for the security of reinforced concrete, and the claustrophobic atmosphere and seeming isolation become infinitely acute when wearing NBC clothing as protection against Nuclear, Biological or Chemical attack. Noise and heat are intense as aircraft start their engines for take-off, and only at the last moment are the finely-balanced steel doors swung open for a mission to be launched. On return, aircraft are speedily pushed or winched back into their hide for the cycle to begin once more.

Barbed wire abounds. Each dispersal, SAM site, fuel- or bomb-dump, and important buildings such as the reinforced concrete operations block, has been turned into a fortified position. Manpower (and womanpower) is insufficient completely to seal the

Mönchengladbach, responsible for the welfare of all British personnel, their wives and families, in the area. Overall, RAFG comprises some 1,200 officers, 9,500 airmen and more than 18,000 dependants.

Most numerous of the aircraft assigned to the Command is the Anglo-French SEPECAT Jaguar GR Mk 1, a hard-hitting single-seat tactical fighter bomber equipped with two internal 30-mm ADEN cannon, and five strongpoints for external weapons and fuel. Two hundred Jaguars, including 35 two-seat T Mk 2 trainers, were delivered to the RAF from 1973 onwards, and these also equip three squadrons and an OCU in the UK.

Bruggen is the base of RAFG's largest wing, comprising four Jaguar units: Nos 14, 17, 20 and 31 Squadrons, all of which are assigned to the low-level, day or night, strike/attack rôle. Principal weapons are the 1,000-lb (454-kg) bomb and the BL755 cluster bomb for counter-air (airfield attack) or anti-armour operations; but, if necessary, nuclear weapons are available. Most of the Bruggen Jaguars have now been fitted with uprated Adour Mk 104 turbofan

Four squadrons of Jaguars make up RAF Germany's tactical strike force, comprising the Wing at Bruggen. A Jaguar of No 20 Squadron is shown (top of page) together with (above left) one of the tactical recce Jaguars of No 2 Squadron at Laarbruch, carrying the ventral camera pod. Laarbruch's two squadrons of Buccaneer S Mk 2Bs are now back in action after being grounded for much of 1980 for structural analysis and repair; an aircraft of No XV Squadron is shown below.

Personnel of No 16 Squadron, RAF Regiment at Wildenrath, reload a Rapier surface-to-air missile fire unit with fresh rounds.

engines to enhance their already impressive performance. In common with most other RAF combat aircraft, they have also acquired grey and green camouflage on their lower, as well as upper, surfaces to reduce detectability when manoeuvering near the ground. Threat-sensors mounted high on the fin advise the pilot when his aircraft is being followed by radar, whilst the tail drag-chute recess is filled with aluminium "chaff", released in a cloud to confuse an uncomfortably-close missile.

A typical wartime mission would involve the four Bruggen squadrons in a combined attack against an enemy target, each unit contributing about half its total of 15 aircraft. Situated literally at all corners of the airfield, each squadron's pilots would receive their individual instructions in the reinforced concrete Pilot Briefing Facility (PBF). The cramped PBF is also the squadron's peacetime home, and is equipped with a filtered air supply for protection from NBC conditions. Outside, however, special clothing would be essential, and in this connection the Wing has recently received the new AR5 respirator. Allowing the pilot immediately to switch to his aircraft oxygen supply without a second's loss of protection in changing masks, the AR5 represents an enormous improvement on its predecessor.

Navigation to the target is simplified by a constantly-updated moving map display in the Jaguar's cockpit, whilst a "head-up" computer presents instrument readings and target-aiming information focussed at infinity on a glass plate in front of the windscreen. Nothing is left to chance, the aircraft's computer making allowance for wind shear and ballistic characteristics when deciding the precise moment for bomb release. For even greater weapon accuracy, use can be made of the Pave Way system — a "clip on" guide unit which transforms any bomb into a "smart" weapon, capable of steering itself down a laser beam reflected from the target. Naturally, a laser source is required and, as no designator is carried by the Jaguar, this must be provided by Allied ground troops or another accompanying aircraft.

Laarbruch's two Buccaneer S Mk 2B squadrons (Nos XV and 16) operate in a rôle similar to the Jaguar, but have the advantage of carrying their own Pave Spike designator on the inner port wing pylon, one aircraft illuminating the target whilst others bomb with Pave Way weapons. Radar and a two-man crew give the Buccaneer a further edge over its compatriot when night- or bad-weather operations are required; and last year this aggressive-looking heavyweight acquired an additional sting, in the form of a single AIM-9B Sidewinder air-to-air missile (AAM) on the starboard outer pylon, for self-defence.

Four 1,000-lb (454-kg) bombs (free-fall or parachute-retarded) are stowed in the rotating bomb bay or, alternatively, the Hunting BL755 cluster-bomb unit (CBU) can be carried. As suggested by its name, the CBU scatters a shower of about 150 "bomblets" over a wide area to saturate targets such as troop concentrations or a column of armoured vehicles. In addition to fuel tanks, Sidewinder and Pave Spike, wing strongpoints may also carry ALQ 101(V)-10 ECM jamming pods to confuse enemy radars and communications.

The two Buccaneer squadrons at Laarbruch are now back to full strength after the entire fleet was grounded with wing fatigue problems from February to August last year. Severe stresses imposed by low-level flying proved too much for even the Buccaneer's robust structure, resulting in the transfer to Germany of some serviceable aircraft from Honington, but Nos XV and 16 Squadrons will discard their present equipment from late 1983 onwards, when the Tornado GR Mk 1 is first deployed to RAFG.

V/STOL at Gütersloh

Whilst the Jaguars and Buccaneers are tasked with close support of the British and Allied armies, Gütersloh's squadrons can claim with justification that they "do it closer". As the nearest RAF airfield to the East/West border, Gütersloh hosts two squadrons of Harrier GR Mk 3s and the recently-arrived Puma HC Mk 1 helicopter squadron, all of which operate in intimate contact with No 1 (British) Corps.

The Harrier's remarkable vertical/short take-off versatility requires little elaboration. Unique among the world's land-based aircraft, it can operate independently of conventional airfields, posing a major headache for enemy forces seeking to eliminate it from the battle. Although a short take-off run is required for it to operate with a full warload, any suitable small clearing near the front line can rapidly become a Harrier base, reducing transit time to the target and increasing sortie rate.

Nos 3 and 4 Squadrons form the RAFG Harrier Wing, which in wartime would operate from about six dispersed sites, each with its own extensive support facilities. No helicopters can at present be spared to transport the Harriers' back-up force so fuel, weapons, accommodation and a multitude of other equipment must be deployed by road. Thrice-yearly practices ensure that the re-positioning process runs smoothly. Principal Harrier weapons are the CBU and two under-fuselage 30-mm ADEN cannon, although No 4 Squadron has a secondary reconnaissance rôle which demands the additional services of four mobile caravans comprising a Reconnaissance Intelligence Centre (RIC). For the latter task, the left-facing 70-mm oblique camera in the Harrier's nose is augmented by an under-fuselage pod containing a fan of five optical cameras: four 70-mm and one 5-in (12,7-cm). The Harrier can carry up to 5,000 lb (2268 kg) of weapons on three fuselage and four under-wing strongpoints, the inboard wing pylons often holding drop-tanks for increased range.

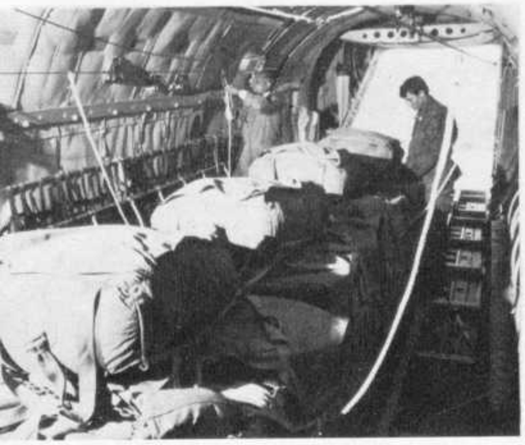
Requests for Harrier support would normally originate with an army commander and pass through the Air Support Operations Centre at Corps HQ, then to the Forward Wing Operations Centre, before being handed-down to a section of aircraft in the field. Here, pilots are briefed by an attached army officer prior to their own flight briefing, while on approach to the target — probably a formation of enemy tanks — an army Forward Air Controller will provide final details from the ground. Harriers have consistently demonstrated their ability to be over target within about 15 minutes of a support request being received. Such would be the pressure of work on the Harrier units that pilots might not leave their aircraft for several sorties. Immediately on taxying back into cover after landing, the aircraft is connected to its control centre by landline to allow re-briefing and flight planning discussions to be conducted without the risk of radio interception.

Newest arrivals in RAFG are the Westland-Aérospatiale Puma HC Mk 1s of No 230 Squadron, which transferred from Odiham, Hants, on 14 October 1980, and became operational on 1 December when the last Wessex HC Mk 2 was withdrawn from the former resident No 18 Squadron. Faster and with a greater load-carrying capability than its predecessor, the Puma has assumed the same rôle of providing tactical transport and battlefield support facilities for the army.

In common with the Harrier force, No 230 Squadron would operate from field sites in times of conflict, maintaining close contact with ground formations requiring its assistance. Similarly, tasks are allocated via the Air Support Operations Centre, where an RAF officer acts as advisor, in a reciprocal rôle to the army major attached to No 230's Headquarters.

Typical Puma loads include 16 fully-armed troops, an underslung Land Rover or field gun, although the helicopter is additionally valuable for evacuation of up to six wounded on stretchers or rapid delivery of urgently-required equipment, and can carry a side-mounted winch or machine-gun.

Helicopter support capability will be enhanced greatly in March 1982 when No 18 Squadron returns to Gütersloh with its new complement of twin-rotor Boeing-Vertol Chinook HC Mk 1s. The Squadron is to be lodged in new accommodation now under construction, and its more powerful Chinooks will be capable of lifting underslung loads up to 28,000 lb (12700 kg); well in excess of



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the Puma's 5,500 lb (2 500 kg). No 230 Squadron will continue to operate with its Pumas from Gütersloh after Chinooks are installed.

Tactical recce

Faced with the massive numerical superiority of Warsaw Pact forces, it is essential that NATO exercises its more limited capabilities with maximum effect. This demands an accurate and up-to-the-minute knowledge of the battlefield in order that the enemy's objectives can be deduced and his weaknesses identified. One of RAFG's units primarily dedicated to obtaining this vital information is No 2 Squadron, whose Jaguar GR Mk 1s operate from Laarbruch. Their equipment comprises a half-ton reconnaissance pod beneath the fuselage, containing a fan of four F95 cameras, capable of taking up to 12 photographs per second for horizon-to-horizon cover; one forward-facing F95 plus a single downwards-looking infra-red linescan camera.

Low cloud and mist have been the bane of aerial photography since the days of the balloon, but IR linescan penetrates murky conditions to give a clear "heat picture" of the ground below. All substances possess unique heat emission characteristics which differentiate them from their surroundings by producing a lighter or darker "colour". Thus IR linescan can identify an aircraft with a lighter fuselage as one with engines running (or recently stopped); and even pick out national insignia on the wings by its different paint signature. A further capability exists in penetrating camouflage-netting to reveal tanks, aircraft or field headquarters beneath — a significant fact of which our own forces are mindful.

When tasked with a mission, No 2 Squadron receives details of target positions, category (one of 17 types), and the precise time at which the aircraft is to be overhead. Pre- or post-strike targets could be a single pinpoint, such as a bridge, a length of road, or a much larger area in which a hostile presence is suspected. No 2 Squadron is not restricted to taking the enemy's picture and can dispense a few CBUs for added effect.

Speed is of the essence. Pilots radio their visual reports of the target while still flying back to base and, after landing, films are rushed by motorcycle to the RIC where they are developed, fixed and dried at the world-record speed of 120 feet per minute. In conjunction with the pilot and attached army officer, interpretation is made from stereo-pairs of negatives spread on a light table and a written Recce Exploitation Report can be signalled to the wartime Joint Operations Centre within an hour of engines-off. Tornadoes will be undertaking RAFG's recce commitments by 1986; but this may be done by a UK-based squadron using Laarbruch only as a forward airfield, rather than permanently installing a unit in Germany.

Air Defences

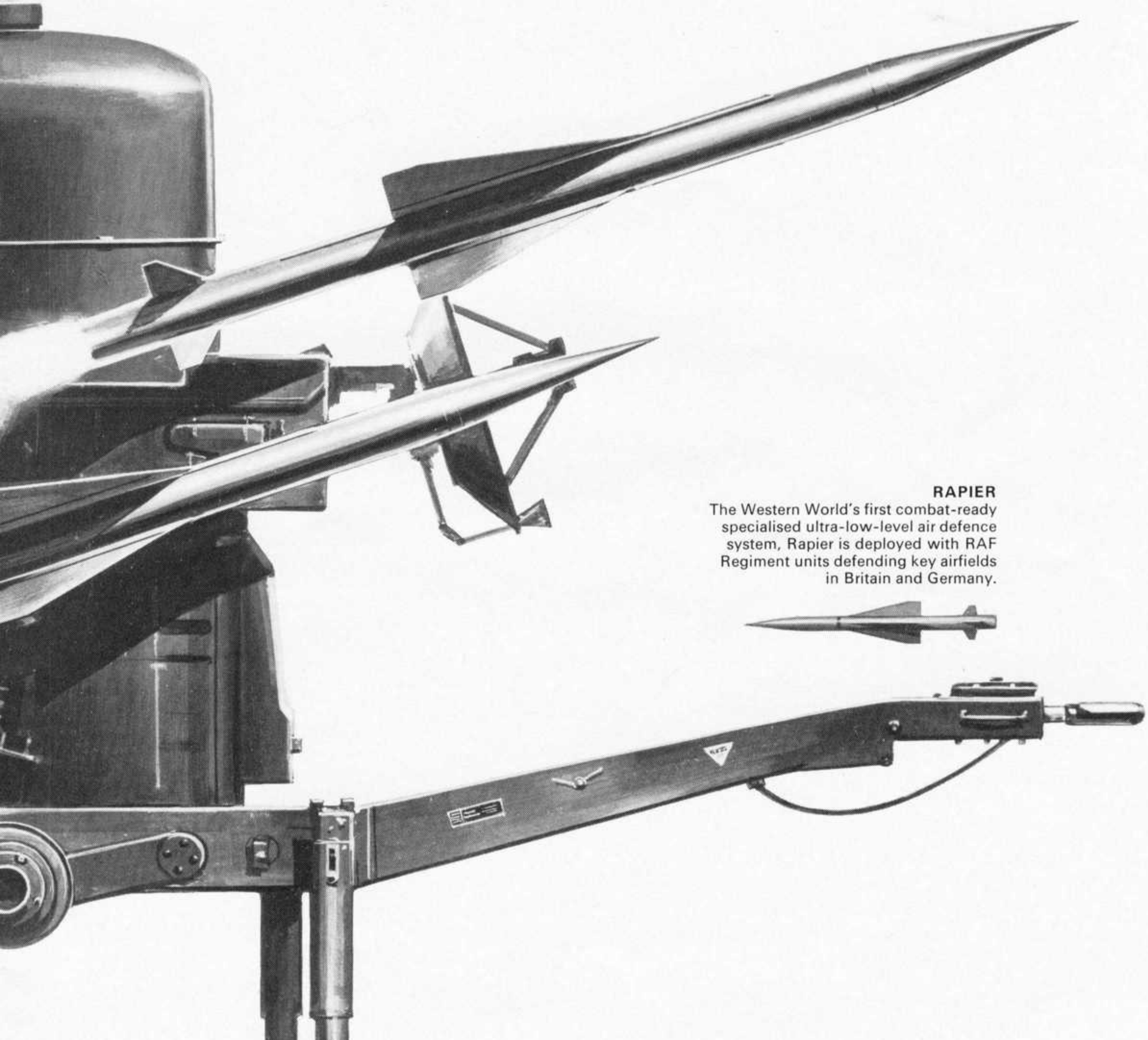
The strike/attack and reconnaissance squadrons of RAFG would be of no value if their airfields were rendered inoperative. Therefore, great importance is attached to defence from enemy air attack and repair of runway damage by detachments of the Royal Engineers. NATO's Nike and Hawk SAM belts further to the east are the first line of defence. If he successfully evades these, an incoming enemy pilot would then have to contend with two Phantom squadrons and, finally, a ring of short-range SAMs surrounding each airfield.

An intimidating aircraft when viewed from any angle, the McDonnell Douglas Phantom FGR Mk 2 serves with Nos 19 and 92 Squadrons at Wildenrath in the air defence rôle, about half the aircraft being in the new overall light grey combat camouflage that is being progressively applied at the time of major overhauls. A formidable array of eight AAMs is carried by each aircraft: four radar-guided AIM-7E-3 Sparrows, and four infra-red, heat-seeking, AIM-9G Sidewinders.

Sky Flash — an improved, medium-range, British adaptation of the

RAF Germany's squadron of Wessex helicopters, No 18, was withdrawn to the UK during 1980 to re-equip on the Boeing-Vertol Chinook HC Mk 1 (above right). Meanwhile, No 230 Squadron has taken its place in Germany, based at Gütersloh, with Westland/Aérospatiale Puma HC Mk 1s (below).

British Aerospace is proud of a continuous contribution to the strength of the Royal Air Force which dates back to the earliest days of military air power and which is today more varied and more vital than ever before. Tornado and Rapier are only two of an unequalled range of aircraft and missile systems which will be the cornerstone of RAF strength for many years to come. Among others are the Hawk jet trainer, Harrier VSTOL combat aircraft, Jaguar tactical strike aircraft, AEW Nimrod airborne early-warning system, VC10 flight refuelling tankers, Sky Flash radar-guided, all-weather, air-to-air missiles, and a variety of electronic, avionic and advanced-technology products.



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The Western World's first combat-ready specialised ultra-low-level air defence system, Rapier is deployed with RAF Regiment units defending key airfields in Britain and Germany.

unequalled in its range of aerospace programmes

Sparrow — entered service with RAFG from January 1981 whilst the NATO Sidewinder production programme will see introduction of the latest AIM-9L version in the near future. Both the AIM-7E and AIM-9G will be retained for optional use after the new missiles have been delivered, as will the podded SUU-23 Vulcan six-barrel gun beneath the fuselage. Phantoms regularly practice air combat with F-15 Eagles of the US Air Force and attend missile firing camp in Anglesey each year. In future, it is hoped to make increased use of the new Air Combat Manoeuvering Installation off the Sardinian coast for realistic air defence exercises.

Under the unaltered terms of the post-war German peace treaty, the RAF and USAF are responsible for the integrity of West German airspace, and maintenance of free access to West Berlin via the three air corridors (France also shares responsibility for access to Berlin, but no longer contributes aircraft for "policing" duties). Only in the event of war would the *Luftwaffe*'s two interceptor wings become "operational" in this context.

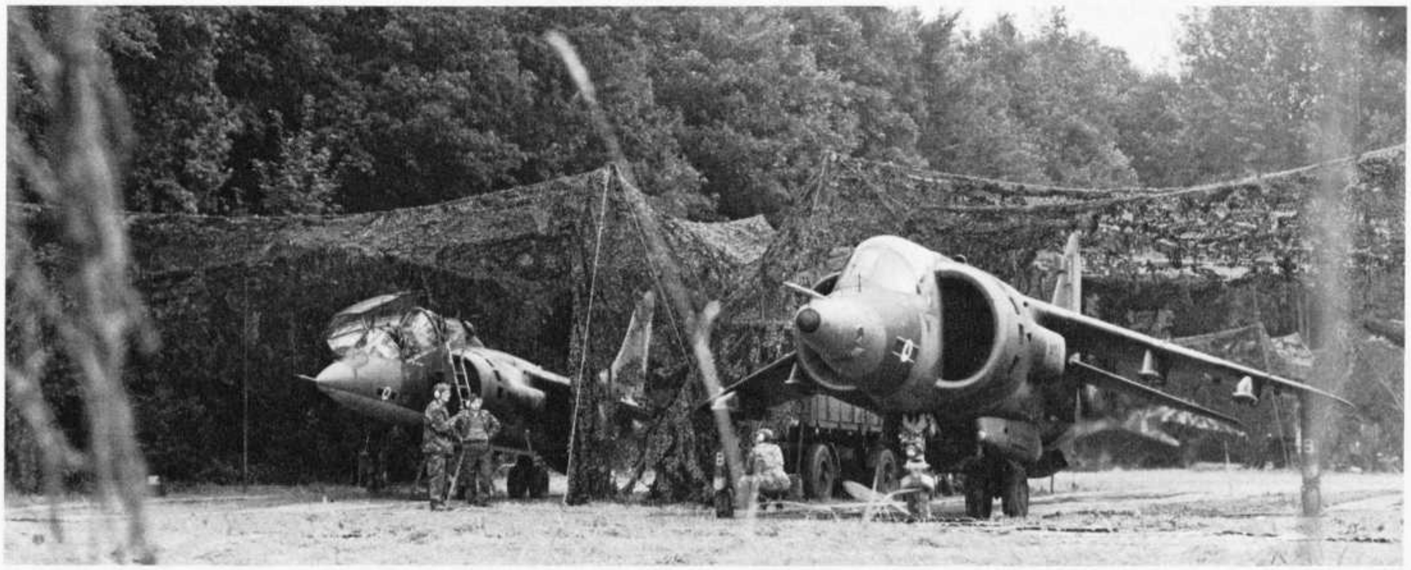
Running parallel to the East German border, but well within the Federal Republic's territory, is the Air Defence Identification Zone, in which only authorised flying is permitted. Investigation of unknown aircraft within the ADIZ is the responsibility of Wildenrath's Battle Flight — one Phantom from each of the two squadrons — and the Eagles of the 32nd Tactical Fighter Squadron, USAF, at Soesterberg across the Dutch border. Located in two perpetually-manned HASs by the runway edge, the Battle Flight can be airborne in less than five minutes but invariably their "customer" proves to be no more than an off-course civil aircraft from the West. Occasionally he is shot — with a camera — as evidence for the civil proceedings which will inevitably follow, these often resulting in a stiff fine and loss of licence.

Air-refuelling capability would be a distinct advantage for the Phantom, as well as other RAFG aircraft, but lack of facilities has meant that pilots are unable regularly to practise aerial hook-ups; and, indeed, the Buccaneer's refuelling probes have been removed. Training in AR is being re-considered this year, however, following agreement with the USAF to supply KC-135A tanker aircraft in wartime. These would have a refuelling hose and basket attached to their flying boom for compatibility with RAF methods.

Each of the four RAFG bases is defended by a squadron of Rapier short-range SAMs, whilst the "Clutch" airfields share the Bloodhound Mk 2s of No 25 Squadron: "A" Flight at Bruggen; "B" Flight, Wildenrath; and "C" Flight, Laarbruch. The Bloodhound was originally produced as a medium/high-level defence system but was deployed to RAFG in the low-altitude rôle during 1970. A Bloodhound Flight comprises two Type 86 radars (on 17-ft/5,2-m towers for increased range) each linked to eight missiles, the whole system being under centralised control from Bruggen. If any aircraft approaches the airfield low and fast from certain directions during war, it is automatically assumed hostile and treated accordingly. With the advent of Blindfire-equipped Rapiers, the Bloodhound is judged

(Above) Groundcrews arm the gun pods on a Harrier and (below) unload the cameras from the pod of a Tac-R Jaguar.

(Above right) Sidewinders being loaded on a Phantom, the standard armament of which includes Sparrows as well as Sidewinder AAMs. (Below) One of the seven Pembrokes that remain in service with No 60 Squadron at Wildenrath for communications and light transport duty.



A Harrier GR Mk 3 (right) and a T Mk 4 of No 3 Squadron share a hide at one of the several dispersed field sites used regularly by the close-support V/STOL aircraft of the two squadrons at Gütersloh.

no longer essential to the defence of the Command and will be withdrawn to bases in the British Isles in the near future.

Rapier SAMs are operated by four squadrons of the RAF Regiment comprising No 4 Wing, headquartered at Wildenrath. No 16 Squadron defends its home base, whilst No 26 Squadron is at Laarbruch, No 37 Squadron at Bruggen and No 63 Squadron at Gütersloh. A Squadron comprises eight detachments (four to a Flight), each of one launcher and a Marconi DM181 "Blindfire" radar. Detachments would be deployed to sites outside the airfield perimeter during hostilities.

Such is the accuracy of Rapier that it is described as a "Hittile" rather than a missile; and this capability has been further enhanced by delivery of Blindfire units over the last two years. The re-equipment programme was completed at Easter 1981 with No 63 Squadron, enabling No 4 Wing to provide 24-hour defence in all weathers — a significant advance over the daylight/fair weather operations possible before Blindfire.

The RAF Regiment also features prominently in the external ground defence of airfields, and of Harrier detachments in the field. No 33 Wing, RAF Regiment, at Gütersloh normally comprises only No 1 Squadron (lodged at Laarbruch), but would be reinforced in wartime by two further squadrons from the UK. Regiment equipment includes 81 mm mortars, 84 mm Carl Gustav anti-tank weapons and machine guns, to be augmented in autumn 1981 by Scorpion and Spartan armoured vehicles which will replace the Land Rovers used hitherto.

Support Organisation

Although RAFG is first and foremost a fighting formation, it requires a large support organisation to maintain its efficiency. Needs range from school teachers for servicemen's children to air supply and transport, in which the Army is also an appreciative customer. The sole Command flying unit not assigned to NATO is No 60 Squadron at Wildenrath which operates seven Pembroke C 1s, including three with VIP interiors, for communications and light transport work. No 60's oldest Pembroke was built in 1953 but a complete re-spar programme has left all aircraft fit for many more years of service.

Apart from the regular weekly spares-flight to Northolt, Pembroke operations are on a short-notice basis, and an aircraft is always available within six hours for unplanned missions — often medical evacuation of a child for specialist attention in London, or sick personnel into nearby Wegberg hospital. The squadron staff is also responsible for servicing the many aircraft which visit their airfield.

Wildenrath's traffic includes a large number of passenger and freight flights, among which are Britannia Airway's Boeing 737s transferring servicemen and their families between the UK and the Continent. The RAF Freight Distribution Centre handles an average of 750 tons (762 tonnes) each month brought in by Hercules and VC-10s. The Air Movement Squadron at Gütersloh undertakes similar work, dealing with some 100 aircraft, 11,000 passengers and 410 short tons of freight and baggage each month. Apart from trooping and families' flights, Gütersloh is the gateway for deployments to Northern Ireland and the Army training ground at Suffield, Canada, and also handles Territorial Army troops on annual exercise and German-based units travelling for overseas training (Harriers to Decimomannu, Sardinia; RAF and Army Rapiers to Benbecula).

Almost all RAFG formations look to No 431 Maintenance Unit for supply or repair of their equipment. The majority of the MU occupies a 38-acre site at Bruggen. Whereas MUs in Britain concentrate on a particular aspect of the support task, No 431 is required to combine their many functions within one organisation, whether it be refurbishing married quarters' furniture or repairing a £5 million aircraft after an accident. No 431 MU's Aircraft Engineering Squadron attends to any aircraft or engine repair and modification which is beyond the operating unit's capability. Its Mechanical Engineering Squadron handles all RAFG's vehicles and oxygen/nitrogen stocks, whilst the Supply Squadron stores and distributes weapons and other equipment.

Rapid repair of battle-damaged aircraft (BDR) is a rôle which No 431 MU has pioneered with notable success. Personnel from all the Command's airfields receive instruction in the technique, and other NATO countries have also learned from the masterpieces of "make-do and mend" performed by the Aircraft Engineering Squadron. In 12-24 hours, BDR will repair to war standards damage which would take three to four months to rectify in peacetime, thus providing a tremendous boost to offensive capability. Metal patches hastily riveted over holes and severed control-rods patched with a wooden dowelling rod may not appear in the manufacturer's service manual; but if the aircraft can be made good enough to fly again then it is one more to strike back at the enemy.

Of RAFG's total dedication and high level of professionalism there can be no shadow of doubt. Its aircraft and personnel are ready to undertake their wartime rôles at a few moments' notice, with either conventional or nuclear weapons, and its airfields are fortified against air and ground attack; but this state of preparedness cannot be sustained without continued diversion to the defence budget of scarce financial resources, despite the present economic problems. But why bother? In certain circles it has become fashionable to decry Britain's European commitment and argue that all mankind will live in joy and happiness for evermore if NATO (and only NATO) discards nuclear weapons, and much of its conventional forces besides. The motives of those advocating this dubious proposition are not difficult to deduce.

Others, who affirm that RAF Germany and the rest of NATO must remain well-equipped and watchful, have no more powerful supportive voice than that of the Soviet leadership itself. Let President Leonid Brezhnev have the final word, from a policy speech to Warsaw Pact leaders assembled in Prague: "Trust us comrades, for by 1985 we will have achieved most of our objectives in Western Europe. We will have consolidated our position, improved our economy, and a decisive shift in the correlation of forces will be such that by 1985 we will be able to exert our will wherever we need to".

Royal Air Force Germany, and its allies, are our first line of defence against this prophecy of a Soviet-dominated Britain becoming fact. □

Lightning

The RAF's oldest interceptor, still far from being obsolete, described by Roy Braybrook

THE EARLY post-war years were difficult times to be designing high performance aircraft, with the "sound barrier" still very much a threat to further progress. True, it was known that shock waves produced a sudden increase in drag as the speed of sound was approached, and that the shock waves led to flow separations on the aircraft, causing buffeting and loss of control. In high-speed dives of propeller-driven fighters (notably the Spitfire) these frightening phenomena had been encountered many times.

German wind tunnel research had proved that wave drag could be reduced by using thinner aerofoils and by sweeping back the wing. However, manufacturing technology had not advanced to the stage that really thin wings could be built: the production techniques that made possible the 3·3 per cent (thickness/chord ratio) wing of the Lockheed F-104 were still years away. Conversely, it was known from German research that aircraft with sweptback wings tended to pitch-up at high angles of attack due to the outboard drift of boundary layer air encouraging tip stall, while forward-swept wings required great torsional strength to control the tendency for them to twist as they bent under load.

The *Luftwaffe* had flown a variety of swept-wing aircraft by 1945, but there was still not the comprehensive experience with a wide variety of configurations that a designer needed to proceed with confidence. To make matters worse, the only powerplants known to provide high thrust at supersonic speeds were rockets, which had had a disastrous record for accidents. Furthermore, aircraft designers had had no experience of working with high temperature materials, and no experience of powered flying controls. In summary, the challenge of transonic and supersonic flight represented a combination of unknowns that was enough to put off all but the boldest of designers, now that the war was over.

In Britain, the view was taken (not only by the government, but by many established designers) that in the circumstances the most sensible course of action was the gradual, step-by-step development of fighters, rather than any attempt at a quantum leap in performance, which would clearly risk the life of the pilot and would have no immediate practical application. The Miles M.52 supersonic research project was therefore cancelled in 1946, with the prototype only half built. On the other hand, in America the longer-term benefits of having supersonic flight experience with a manned vehicle were felt to outweigh the risks involved. Thus, on 14 October 1947 Captain Charles E ("Chuck") Yeager was dropped from a Boeing B-29 in the rocket-powered Bell X-1, and reached a speed of M=1·06 in level flight. It had been a brute-force experiment, in that the X-1 had a straight wing of 10 per cent thickness/chord ratio, but at least America had proved that the speed of sound was not the impenetrable barrier for human pilots that some had preferred to believe. It may be added that, with improvements, the X-1 series went on to higher speeds, finally reaching Mach=2·42 at 70,000 ft (21 335 m) in December 1953. The programme produced a great deal of useful data, but the X-1 was not the basis for a practical fighter aircraft.

On the British side of the picture, 1947 was clearly a bad year for those in military aviation. In those days it was popular to explain away America's lead in bombers and transport aircraft by saying that the UK had been too busy building war-winning fighters and pioneering the gas turbine engine, but it now appeared that the US was stealing the lead in high-speed research. The Ministry of Supply was therefore obliged to change its stance on supersonic trials, and consider following its testing of rocket-propelled models with manned aircraft that would provide design data for a supersonic interceptor.

In 1947 Britain's traditional fighter manufacturers were all busy developing conventional subsonic aircraft. Hawker Aircraft was manufacturing piston-engined Sea Furies, developing the straight-wing, jet-engined Sea Hawk as a successor, and thinking about swept-wing variants of the Sea Hawk. Supermarine was still building Spitfires to October 1947, and at that stage had flown only two prototypes of the jet-engined, tail-dragger Attacker, which used the wing of the Spiteful. Gloster and de Havilland were occupied in steadily improving the Meteor and Vampire, the RAF's first generation of jet fighters.

However, the war had brought several newcomers into the fighter business. One of these was English Electric, which had re-entered aviation at the time of the pre-war build-up in 1938, and had spent the war years manufacturing aircraft designed and developed by other concerns. The Aviation Division of EEC was centred on Preston, and in 1947 the Chief Engineer of that division was W E W ("Teddy") Petter.

Although a designer of considerable talent, Petter's creations might be regarded as a succession of "one-off" projects in the sense that (although they were produced in quantity), they did not form the normal coherent series, each new aircraft developed from the last. Thus, his Westland Lysander army co-operation STOL aircraft was followed by the Whirlwind (F.37/35) twin-engined fighter-bomber, the English Electric Canberra (B.3/45), the RAF's first jet bomber, and (after the Lightning), the Folland Gnat lightweight subsonic fighter, which provided the basis for the more numerous two-seat advanced trainer.

This unusual approach to designing, ie, of finding any gap in the current spectrum of military aircraft and designing something to fill it, clearly had both advantages and disadvantages. On the one hand it freed Petter from the restrictions imposed by blinkered conventional thinking, but on the other hand it must have denied him some of the detailed know-how and the service contacts that come from having spent a whole career in one narrow field. However, it is arguable that the benefits of the Petter-type approach outweigh the disadvantages when making a major advance, and past experience has little relevance.

Preliminary design

In May 1947 English Electric won a contract to study the design of an M=1·5 experimental research aircraft to meet specification ER.103. The contract was awarded five months after the first powered flight of the Bell X-1 on 9 December 1946, and five months before it broke through the sound barrier. Arising out of these studies, a revised specification (F.23/49) was produced and issued to the company. Once again, it was for a research aircraft (notwithstanding the F prefix), but it was now seen as a 7*g* research aircraft with guns and a sighting system "to investigate the practicality of supersonic speed for military aircraft". This was the specification around which English Electric designed the P.1, from which the P.1B was developed in the mid-1950s, this aircraft in turn forming the basis for the Lightning fighter which entered service at the end of that decade.

For most of their service life to date, the RAF's Lightnings were flown in a natural metal finish, camouflage having been a more recent addition. Shown below is a Lightning F Mk 3 as serving with No 56 Squadron at RAF Wattisham in 1965, featuring the pre-war red-and-white checkerboard on the fin and rudder, plus red trim along the fuselage spine and wing leading edge. The arrowhead on the nose incorporates the squadron's "Phoenix-arising" badge. Note the Firestreak missiles and ventral fuel tank.

(Below) In the last few years of the Lightning's service in RAF Germany, an olive green finish was adopted for all upper surfaces, as shown on this F Mk 2A of No 92 Squadron, based at Gütersloh in 1975. The squadron badge on the fin comprises a cobra and a sprig of maple. Note the Firestreak missiles and combined ventral gun pack and tank.

(Below) The two remaining Lightning squadrons in Strike Command, based at RAF Binbrook, Lincs, fly the F Mk 6 version, armed with Red Top missiles and ventral gun pod/fuel tank. Standard green/grey camouflage has been adopted, with grey undersides. The tail marking incorporates the well-known maple leaf of No 5 Squadron.

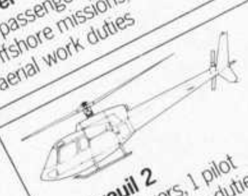
(Below) Sharing RAF Binbrook with the two operational units, Nos 5 and 11 Squadrons, is the Lightning Training Flight, with a lion emblem on the fin. The illustration shows a T Mk 5, the side-by-side two-seat version of the Lightning, with ventral tank but no guns. Red Tops are carried and the T Mk 5 is fully combat-compatible.

SUPER PUMA, DAUPHIN 2N, ECUREUIL 2
A RANGE WHICH KEEPS ITS PROMISES

With every passing day Aérospatiale's three new twin-engined helicopters, presented at the 1979 Paris Air Show, prove just how superior they are from the comfort, safety, operational efficiency and cost-effectiveness standpoints. These attributes coupled with a high level of performance stem from Aérospatiale's mastering the use of new technologies (composite material rotors, original manufacturing techniques, modular dynamic elements, employing of new materials, etc.).
The sizeable number of orders already entered bears witness to the fact that Aérospatiale's three new twin-engined helicopters more than meet operators' expectations.

Super Puma
21 passengers, 2 pilots
Offshore missions,
aerial work duties

Dauphin 2N
13 passengers, 1 pilot
Offshore and
corporate missions



Écureuil 2
5 passengers, 1 pilot
Business liaison duties,
close offshore work
Parapublic tasks

Société Nationale Industrielle
aerospatiale
DIVISION HELICOPTERES 2-20, av. Marcel Cachin - 93126 La Courneuve Cedex - France

Mc ALPINE HELICOPTERS Ltd
Swallowfield Way HAYES
Middlesex U831SP

Thus, today's Lightning (which appears set to remain in RAF service until the late-1980s) had its formal origin in 1947, although Petter began sketching possible supersonic configurations late in 1946. It might well be said that no-one would design an aircraft of that shape today, but in the circumstances this would hardly amount to criticism of Petter's talent, bearing in mind the very limited aerodynamic data available to designers of the period and the severe constraints under which he set out to produce a research vehicle which (unlike the X-1) would have direct military development potential.

The most important of these constraints was the lack of a suitable powerplant. The RAF knew too much of wartime *Luftwaffe* accidents to visualise the rocket motor as a desirable peacetime engine (although the service was to toy with the idea fairly seriously in the late-1950s). In 1947 the best engines in immediate prospect in the UK were the Armstrong Siddeley Sapphire and Rolls-Royce Avon, both axial-flow engines with low frontal areas in comparison with the centrifugal-flow engines then powering Meteors and Vampires, but unreheated. In consequence, their thrust varied little with forward speed. The ideal was a powerplant giving thrust that increased steeply beyond M=1 to match the drag rise; but the afterburner needed to produce such a characteristic was still years away.

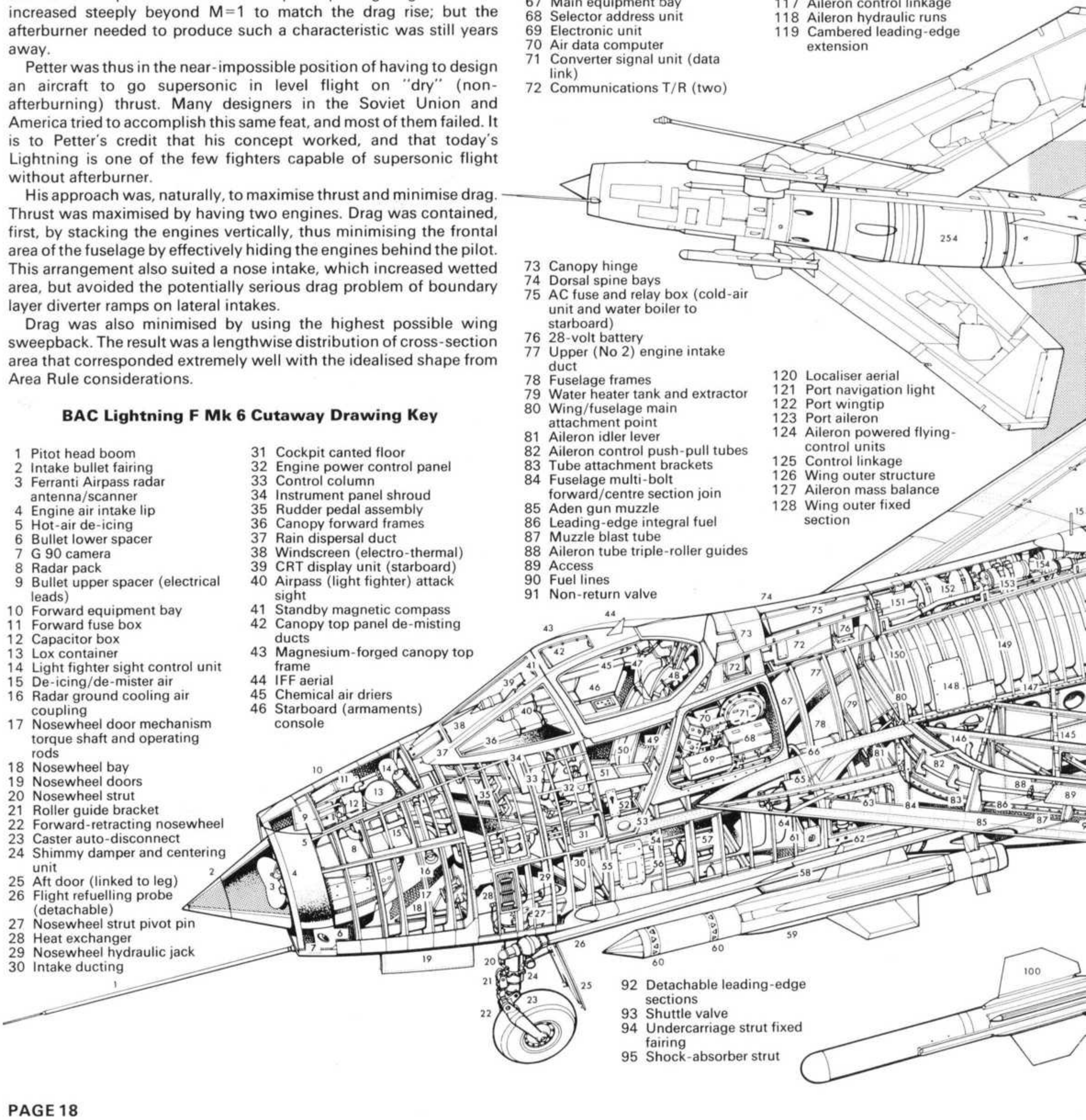
Petter was thus in the near-impossible position of having to design an aircraft to go supersonic in level flight on "dry" (non-afterburning) thrust. Many designers in the Soviet Union and America tried to accomplish this same feat, and most of them failed. It is to Petter's credit that his concept worked, and that today's Lightning is one of the few fighters capable of supersonic flight without afterburner.

His approach was, naturally, to maximise thrust and minimise drag. Thrust was maximised by having two engines. Drag was contained, first, by stacking the engines vertically, thus minimising the frontal area of the fuselage by effectively hiding the engines behind the pilot. This arrangement also suited a nose intake, which increased wetted area, but avoided the potentially serious drag problem of boundary layer diverter ramps on lateral intakes.

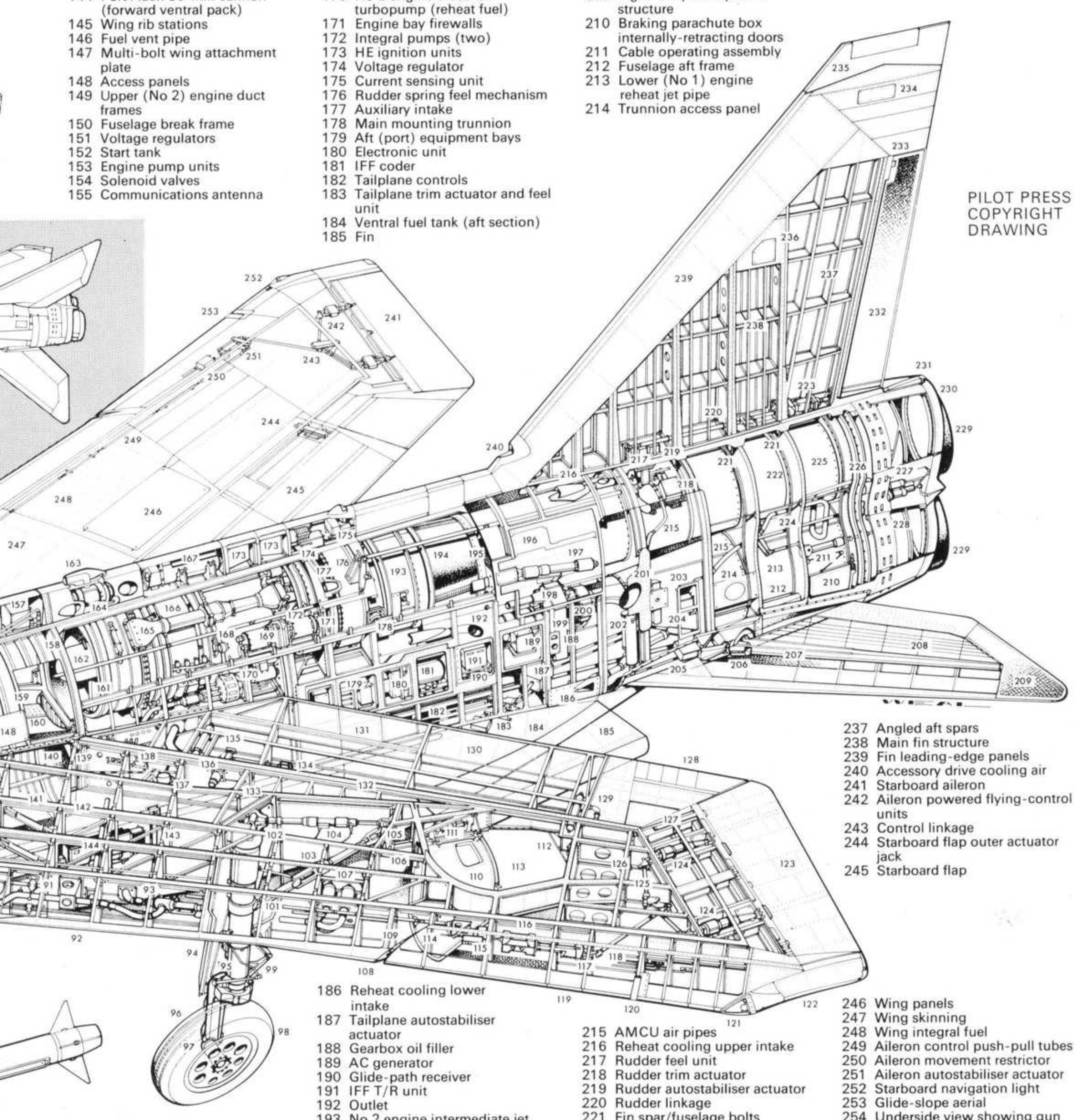
Drag was also minimised by using the highest possible wing sweepback. The result was a lengthwise distribution of cross-section area that corresponded extremely well with the idealised shape from Area Rule considerations.

BAC Lightning F Mk 6 Cutaway Drawing Key

1 Pitot head boom
2 Intake bullet fairing
3 Ferranti Airpass radar antenna/scanner
4 Engine air intake lip
5 Hot-air de-icing
6 Bullet lower spacer
7 G 90 camera
8 Radar pack
9 Bullet upper spacer (electrical leads)
10 Forward equipment bay
11 Forward fuse box
12 Capacitor box
13 Lox container
14 Light fighter sight control unit
15 De-icing/de-mister air
16 Radar ground cooling air coupling
17 Nosewheel door mechanism torque shaft and operating rods
18 Nosewheel bay
19 Nosewheel doors
20 Nosewheel strut
21 Roller guide bracket
22 Forward-retracting nosewheel
23 Caster auto-disconnect
24 Shimmy damper and centering unit
25 Aft door (linked to leg)
26 Flight refuelling probe (detachable)
27 Nosewheel strut pivot pin
28 Heat exchanger
29 Nosewheel hydraulic jack
30 Intake ducting
31 Cockpit canted floor
32 Engine power control panel
33 Control column
34 Instrument panel shroud
35 Rudder pedal assembly
36 Canopy forward frames
37 Rain dispersal duct
38 Windscreen (electro-thermal)
39 CRT display unit (starboard)
40 Airpass (light fighter) attack sight
41 Standby magnetic compass
42 Canopy top panel de-misting ducts
43 Magnesium-forged canopy top frame
44 IFF aerial
45 Chemical air driers
46 Starboard (armaments) console
47 Ejection seat face-blind/firing-handle
48 Air-conditioning duct
49 Rear pressure bulkhead
50 Martin-Baker ejection seat
51 Port instrument panels
52 Cockpit ladder attachment
53 Cockpit emergency ram-air intake
54 Lower (No 1) engine intake duct frames
55 Firestreak weapons pack
56 Launch sequence units
57 Control units
58 Port missile pylon
59 Firestreak missile
60 Fuse "windows"
61 Armament safety break panel
62 Aileron accumulator pressure gauges
63 Accumulator group bay
64 Plessey LTSA starter in lower (No 1) engine nose cone
65 Lower (No 1) engine intake
66 Wingroot inboard fairing
67 Main equipment bay
68 Selector address unit
69 Electronic unit
70 Air data computer
71 Converter signal unit (data link)
72 Communications T/R (two)
73 Canopy hinge
74 Dorsal spine bays
75 AC fuse and relay box (cold-air unit and water boiler to starboard)
76 28-volt battery
77 Upper (No 2) engine intake duct
78 Fuselage frames
79 Water heater tank and extractor
80 Wing/fuselage main attachment point
81 Aileron idler lever
82 Aileron control push-pull tubes
83 Tube attachment brackets
84 Fuselage multi-bolt forward/centre section join
85 Aden gun muzzle
86 Leading-edge integral fuel
87 Muzzle blast tube
88 Aileron tube triple-roller guides
89 Access
90 Fuel lines
91 Non-return valve
92 Detachable leading-edge sections
93 Shuttle valve
94 Undercarriage strut fixed fairing
95 Shock-absorber strut
96 Port mainwheel
97 Brake unit
98 Tubeless tyre
99 Torque links
100 Red Top missile
101 Aft fairing flap
102 Undercarriage pivot
103 Radius rod (inward-breaking)
104 Undercarriage retraction jack
105 Door jack sequence valve
106 Door master locking mechanism
107 Collector tank and booster pumps (two)
108 Aerodynamic leading-edge slot
109 Tank pressurising intake/vent (in slot)
110 Mainwheel door
111 Undercarriage jack sequence valve
112 Door latch linkage
113 Port mainwheel well
114 Aileron control push-pull tubes
115 Aileron movement restrictor
116 Aileron autostabiliser actuator
117 Aileron control linkage
118 Aileron hydraulic runs
119 Cambered leading-edge extension
120 Localiser aerial
121 Port navigation light
122 Port wingtip
123 Port aileron
124 Aileron powered flying-control units
125 Control linkage
126 Wing outer structure
127 Aileron mass balance
128 Wing outer fixed section

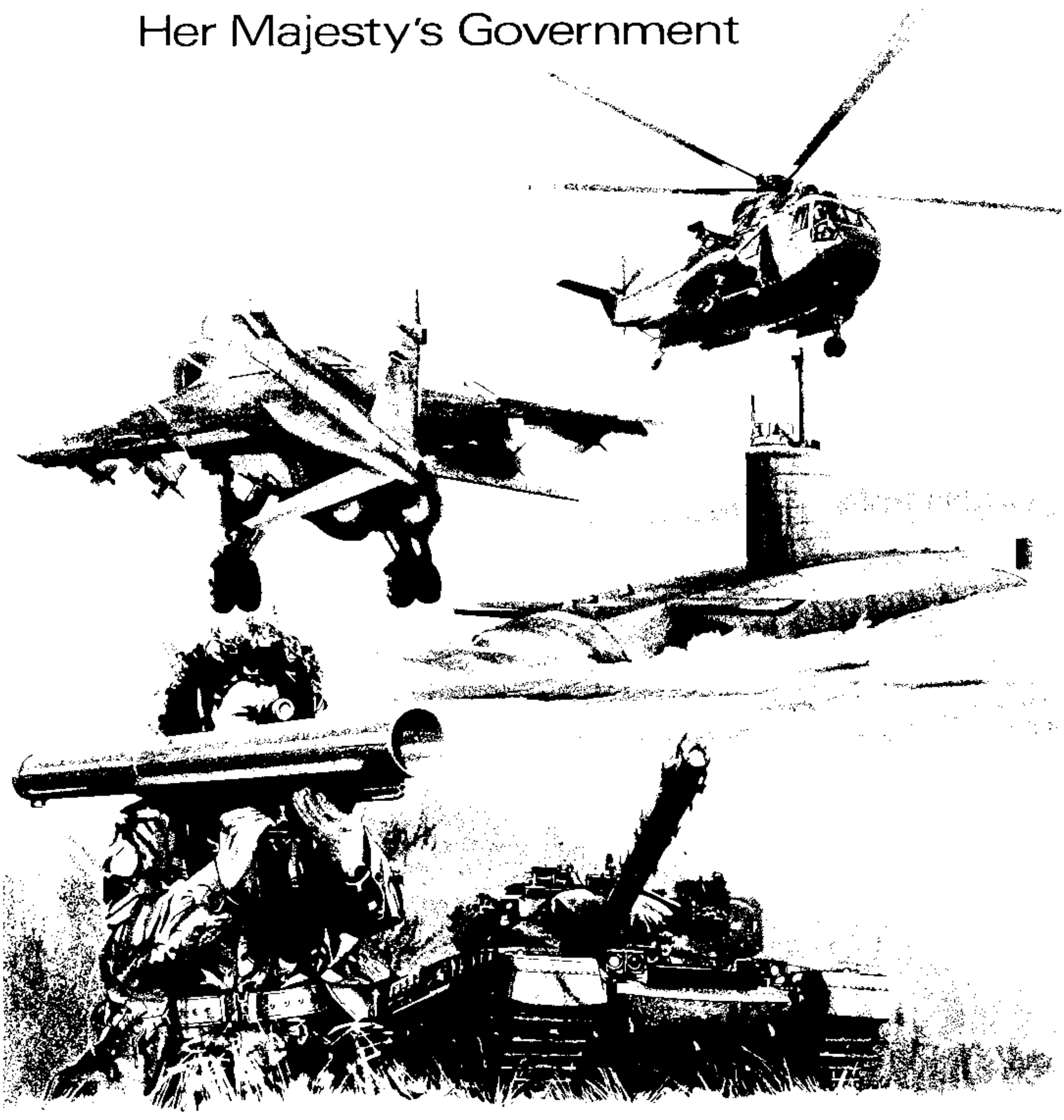


129 Flap outer actuator jack
130 Flap sections
131 Flap integral tank
132 Angled aft spar
133 Undercarriage attachment
134 Refuelling/defuelling valve
135 Flap inner actuator jack
136 Three-way cock (manual)
137 DC transfer pump
138 Gate valves
139 Wing/fuselage rear main attachment point
140 Lower (No 1) engine intermediate jet pipe forward face
141 Wing inboard structure
142 Wing integral fuel
143 Intermediate spar booms (T-section)
144 Port Aden 30-mm cannon (forward ventral pack)
145 Wing rib stations
146 Fuel vent pipe
147 Multi-bolt wing attachment plate
148 Access panels
149 Upper (No 2) engine duct frames
150 Fuselage break frame
151 Voltage regulators
152 Start tank
153 Engine pump units
154 Solenoid valves
155 Communications antenna
156 Starter control unit
157 HF igniter units
158 Fuselage frame
159 Main wing box upper skin
160 Forged centre rib (multi-bolt attachment)
161 Starter exhaust
162 Upper (No 2) engine nose cone
163 Generator cooling ram-air intake
164 Stand-by generator
165 Anti-icing bleed air
166 Upper (No 2) Avon 301 turbojet engine and reheat units
167 Airpass recorder unit
168 Engine front mounting point
169 Engine accessories
170 No 2 engine bleed-air turbopump (reheat fuel)
171 Engine bay firewalls
172 Integral pumps (two)
173 HE ignition units
174 Voltage regulator
175 Current sensing unit
176 Rudder spring feel mechanism
177 Auxiliary intake
178 Main mounting trunnion
179 Aft (port) equipment bays
180 Electronic unit
181 IFF coder
182 Tailplane controls
183 Tailplane trim actuator and feel unit
184 Ventral fuel tank (aft section)
185 Fin
186 Reheat cooling lower intake
187 Tailplane autostabiliser actuator
188 Gearbox oil filler
189 AC generator
190 Glide-path receiver
191 IFF T/R unit
192 Outlet
193 No 2 engine intermediate jet pipe
194 Refrasil heat shrouds
195 Stress-bearing upper (No 2) engine hatch
196 Port airbrake
197 Airbrake hydraulic actuator jack
198 DC generator
199 Main-accessory-drive unit
200 Airbrake lower frame
201 Turbine exhaust (from 199)
202 Tailplane accumulator and nitrogen bottle
203 Reheat "hotshot" igniter box
204 Tailplane drive triangular unit
205 Tailplane powered flying-control unit
206 Tailplane spigot
207 Pivot spar
208 All-moving tailplane
209 Light-alloy honeycomb structure
210 Braking parachute box internally-retracting doors
211 Cable operating assembly
212 Fuselage aft frame
213 Lower (No 1) engine reheat jet pipe
214 Trunnion access panel
215 AMCU air pipes
216 Reheat cooling upper intake
217 Rudder feel unit
218 Rudder trim actuator
219 Rudder autostabiliser actuator
220 Rudder linkage
221 Fin spar/fuselage bolts
222 Fuselage frame formers
223 Rudder powered flying-control unit
224 Reheat jet pipe mounting rail
225 Upper (No 2) engine reheat jet pipe
226 Rear rollers
227 Air-driven nozzle actuator
228 Jet pipe trunnion access panel
229 Variable propelling nozzles
230 Streamer cable around rear lip (spring-clipped)
231 Parachute streaming anchor and jettison unit
232 Rudder light-alloy honeycomb structure
233 Flutter damper
234 Communications antenna
235 Dielectric tip
236 Compass unit



PILOT PRESS COPYRIGHT DRAWING

237 Angled aft spars
238 Main fin structure
239 Fin leading-edge panels
240 Accessory drive cooling air
241 Starboard aileron
242 Aileron powered flying-control units
243 Control linkage
244 Starboard flap outer actuator jack
245 Starboard flap
246 Wing panels
247 Wing skinning
248 Wing integral fuel
249 Aileron control push-pull tubes
250 Aileron movement restrictor
251 Aileron autostabiliser actuator
252 Starboard navigation light
253 Glide-slope aerial
254 Underside view showing gun ports and Red Top missiles



This approach worked, but the basic measures adopted were desperate ones. By the same token that imitation is the sincerest form of flattery, the fact that a novel idea is *not* copied is presumably an indication of its limited value. The vertical stacking of engines has never been copied in a fighter, because of obvious safety servicing and maintenance considerations. The 60-deg sweep of the wing is only rivalled by the Sukhoi Su-7 (*Fitter A*) and its derivatives, basically because of the severe weight penalty associated with extreme sweep angles on the wing spars. The P.1 wing planform used to be described as a "notched delta", ie, a delta in which the part that carries less lift has been cut away. This is all very well aerodynamically, but it rules out the use of lightweight straight-through spars. In relation to their areas, the wing weights for the Lightning and Su-7 are probably over twice the values for average supersonic fighters.

The basic aircraft shape advocated by Petter was thus (of necessity) chosen purely to minimise wave drag, rather than representing the normal compromise between aerodynamic, structural, and maintenance considerations. In view of the fact that powerful afterburning engines shortly became available, this emphasis on wave drag may be regarded with hindsight as excessive. However, by that time the handling characteristics of the aircraft had been found to be excellent, and the motivation to start again from scratch was accordingly reduced. On the credit side, this low wave drag did result in an aircraft that out-accelerates the F-4 Phantom transonically, which is no mean feat.

High sweepback permitted a relatively deep wing, despite a thickness/chord ratio of only 5 per cent. This provided a very useful fuel volume, and led Petter to keep the fuselage free of fuel, since the RAF wanted a short-range, fast-climbing interceptor. One innovation in terms of wing planform was the tip cut-off normal to the longitudinal axis, which was a result of English Electric's desire to minimise the sweep of the aileron hinge line. It also placed the aileron on the torsional axis of the wing, and thus virtually eliminated wing twist due to lateral control movements.

Looking at German and American wind tunnel data, the company concluded that pitch-up (at that time the big risk associated with swept-back wings) could be avoided by placing the tailplane below the wing plane. The aerodynamicists at RAE Farnborough opposed this arrangement, arguing for a high-set tailplane and reduced wing sweep. The question was settled by building the Short SB.5, a subsonic test aircraft with provision for a variety of wing sweep angles and tailplane settings. Flight tests with the SB.5 bore out the English Electric approach. It is said that the principal value of the SB.5 programme was in demonstrating the effectiveness of leading edge notches (an idea first developed in US wind tunnels) for controlling flow separations towards the wingtips.

In concluding this section on the preliminary design, it is probably fair to comment that the aircraft that resulted combined some of the best and the worst features of the traditional British fighter. It has an outstanding climb rate and acceleration, and it handles superbly ("just like a big Hunter"), but it has very little fuel capacity in comparison with American fighters. In fact, internal fuel initially represented only approximately 17 per cent of the clean take-off weight, whereas in US Navy fighters (to take the opposite extreme) this fuel fraction is normally closer to 30 per cent. British fighters have always been characterised by short radius and endurance, and the Lightning is no exception.

The design did, however, break with convention in lacking the operational flexibility that many of its predecessors provided. The combination of a high sweep angle and a wing-mounted main undercarriage made it extremely difficult to find suitable underwing locations for pylons, and forced its designers to desperate measures in giving the aircraft more fuel and provisions for bombs and rocket pods. It also broke with tradition in lacking the aesthetic appeal that characterised the British fighter up to and including the Hunter. The Lightning has all the aesthetic appeal of a milk bottle!

Early days

To revert to the early history of the project, in 1949 English Electric was awarded a contract for one structural test specimen and two Sapphire-engined research aircraft to meet specification F.23/49, these aircraft being known as the P.1 and P.1A. In the following year Petter left English Electric to join Folland Aircraft, his place being taken by the former head of the stress office, F W "Freddie" Page (now Sir Frederick Page, chairman of the Aircraft Group of British Aerospace). Another important event in 1950 was the first operation of English Electric's transonic wind tunnel, a very advanced facility for its day. In the course of the P.1/Lightning programme, some 51 models were tested, and over 4,600 runs made in various wind tunnels.

Sartorial elegance for the Lightning pilot, including flying helmet, visor, oxygen mask, anti-g suit and flying overalls, with map stowage, displayed alongside a Lightning F Mk 6. The size of the interceptor is emphasised by the access ladder to the cockpit; also visible is the long probe for flight refuelling, extending from the port wing leading edge.

The first aircraft (WG760) was generally similar to today's Lightning, but it had a simple pitot intake of egg-shaped cross section, a delta fin with rounded tip, and an uncranked wing leading edge. To minimise wave drag, the top of the hood was virtually flush with the upper line of the fuselage, which had the disadvantage of restricting rear view. The P.1 made its first flight on 4 August 1954 from Boscombe Down, piloted by the company's chief test pilot, Wg Cdr R P "Bea" Beamont. Although each Sapphire gave only 7,500 lb (3 400 kg), of thrust it went marginally supersonic in level flight on its third flight, on 11 August.

The P.1A (WG763) was similar, but had two 30-mm Aden cannon and American-style toe-brakes. It first flew on 18 July 1955, and in September of that year made the type's debut at Farnborough. These two aircraft were used in a wide variety of tests, including the use of a fixed-nozzle reheat system on the P.1. This gave a 10-20 per cent thrust boost when the afterburner was operating, but cut the dry thrust by half, eliminating the possibility of returning to base and landing on one engine, should the other have failed.

It was found that the aircraft were somewhat short of supersonic directional stability, a problem that was to plague the series for many years, leading to three stages of fin area increase. Nonetheless, supersonic gunfiring was carried out, and the flight boundary was gradually extended to M=1·52. These first two aircraft were also used to test a number of features that were subsequently applied to the Lightning, including a ventral fuel tank and a wing with a cranked leading edge and extended tip chord. Both the P.1 and P.1A are now at RAF Henlow.

While the flight testing of these two research aircraft was still in progress, English Electric was working on the detail design of the P.1B, which could form the basis for an operational fighter. A contract for three P.1Bs was signed in 1954, this improved design having 200-series Avons with four-stage reheat, a raised canopy to improve rear view, and provision for a Ferranti AI-23 radar to be housed in a conical centre-body in a round intake, and for two de Havilland Blue Jay (Firestreak) infra-red homing missiles on fuselage pylons. Various armament options were considered, but in the end it was agreed that two 30-mm guns would be placed in the upper front fuselage, and that the lower armament pack would take the Blue Jay pylons and accessories, or two additional cannon, or two retractable packs each containing 24 two-inch (5-cm) rockets. While the three P.1Bs were being constructed, English Electric received an order for 20 pre-series aircraft to test the various aspects of what was to become an "integrated weapons system". This was followed in November 1956 by an order for 20 production aircraft, including a non-flying fatigue specimen.

However, this contract, which marked the start of what became the Lightning programme, was not simply the outcome of successful flight trials with the P.1 and P.1A. Up to that point the RAF had been planning on a heavy interceptor (OR.329), which would carry two large radar-homing missiles, originally designated Red Dean and later Red Hebe. This requirement brought responses from approximately a dozen companies, including Armstrong Whitworth, Fairey, Gloster, Hawker, Saunders Roe, and Supermarine. The Hawker P.1103 was one of the lightest aircraft proposed, being built around a single de Havilland Gyron with a dry thrust of approximately 20,000 lb (9 070 kg) and an afterburning thrust of 30,000 lb (13 605 kg). However, the winner was reportedly a Fairey project powered by two massive RB.128 engines and weighing almost as much as the long-penetration strike aircraft (eg, TSR.2, Hawker P.1129) designed a few years later to meet OR.339.

The fact that the OR.329 aircraft was never developed can be ascribed to two principal factors: the staggering costs predicted for such a heavy fighter, and the growing realisation that in the future the main threat to Britain would come from ballistic missiles rather than bombers. Instead of this large, all-weather interceptor, the RAF was given a fighter derived from the P.1 research aircraft, weighing roughly half as much, and armed with lightweight, clear-weather IR-homing missiles.

The maiden flight of the first prototype P.1B (XA847) took place on 4 April 1957. Powered by two 200-series Avons giving 14,430 lb (6 545 kg) of thrust with afterburning and 11,250 lb (5 105 kg) dry, it reached M=1·2 without reheat on its first flight and gradually expanded the flight boundaries until on 25 November 1958 it attained M=2·0 in level flight at 41,000 ft (12 500 m), albeit with some intake buzz. This aircraft, which might be regarded as the first real prototype of the Lightning, is now an exhibit in the RAF Museum at Hendon.

By 1957 the programme was sufficiently advanced in terms of flight tests and design development that it survived the cuts announced in the Defence White Paper presented to Parliament by the then Minister of Defence, Duncan Sandys, on the day of the first flight of the P.1B. The White Paper said that, since a proportion of attacking bombers would always get through with their megaton weapons, the emphasis must be on deterring war, with the rôle of the manned fighter limited to defending bomber airfields, a rôle that would later be taken over by ground-to-air missiles. In view of the progress already made with such weapons, the government concluded that the RAF was "unlikely to have a requirement for fighter aircraft of types more advanced than the supersonic P.1", and accordingly stopped work on such projects.

Thus reprieved, English Electric continued with the manufacture of the 20 pre-series P.1Bs, the first of which (XG307) took to the air on 3 April 1958. The airframes exhibited no major changes, although a taller fin was fitted from the fourth aircraft (XG310). Since the original P.1, the main changes had been in the powerplant area (including the intakes and nozzles), but the airbrakes had been revised and moved forward of the fin, and the leading edge root flap (covered by an English Electric patent) had been deleted. In addition, the trailing edge flaps had been used to provide additional fuel volume (a desperate measure by any standards), a dorsal spine had been added to give easy access to control runs and other equipment, and the intake bullet support strut had been used to house the nosewheel, thus eliminating the need to rotate the wheel to the horizontal as it retracted.

Throughout 1958 there was serious interest in the idea of fitting a Napier Double-Scorpion rocket pack (as fitted to a Canberra to create a new world altitude record in August 1957), using the ventral shape developed earlier as an auxiliary fuel tank. However, this scheme to combat the highest of high-flying intruders did not proceed, presumably because of the Lightning's excellent ceiling and the snap-up capability of Blue Jay and its developments.

The name Lightning F Mk 1 for the initial 20 production aircraft was announced in October 1958, and on 29 October 1959 the first of this batch (XM134) made its maiden flight. In December 1959 three of the pre-series P.1Bs were delivered to the RAF's Air Fighting Development Squadron (AFDS) at Coltishall. However, deliveries of the Lightning F 1 did not begin until the end of June 1960, and the first squadron (No 74 Sqn at Coltishall) was not declared operational until the following year. Also in 1960, English Electric's aviation interests were combined with Bristol Aircraft, Vickers Armstrong (Aircraft) and Hunting Aircraft to form the British Aircraft Corporation (BAC).

(Left) Afterburners lit, a Lightning T Mk 5 of No 5 Squadron takes off from RAF Akrotiri during the Armament Practice Camp for the Lightning Wing pilots, held in Cyprus each year. (Right) Lightning F Mk 6.

(Above) A Lightning F Mk 6 of No 5 Squadron and (below right) a similar aircraft from No 11 Squadron, both photographed during the 1980 APC in Cyprus; the annual Armament Practice Camp gives pilots from the Lightning Wing at Binbrook the opportunity to gain ACE (Allied Command Europe) qualifications.

The Lightning F 1 was followed by the F 1A, of which 28 were built. It differed mainly in having provision for a detachable flight refuelling probe under the port wing, improved windscreen rain dispersal, and UHF as standard (whereas it had been fitted only retrospectively on the Mk 1). The first F 1A (XM169) flew on 16 August 1960. This maiden flight was, in fact, preceded by that of XM966, the first production T 4 (the two-seat trainer equivalent of the F 1A), on 15 July 1960, the first of two prototype two-seaters (XL628) having flown in the previous year under the company designation P.11.

The F 1A was issued to No 56 Sqn in late 1960 and to No 111 Sqn early the following year, these units forming the Wattisham wing. At that stage Lightning conversion training (most pilots coming from Hunters) was the responsibility of the Central Fighter Establishment, of which AFDS was a part. It was not until 1962 that a Lightning Conversion Squadron was formed at Middleton St George, as the T 4 (of which 21 were built) became available in numbers. In 1963 this unit became No 226 OCU, using T 4s and later some F 1s (ex-74 Sqn) for weapon training.

The next single-seat Lightning was the F 2, which had fully variable reheat for its Avon 210s in place of the earlier four-stage system. It also had liquid oxygen (LOX) and an automatic flight control system. The first production aircraft (XN723) made its maiden flight on 11 July 1961 and was delivered to AFDS at Binbrook in November 1962. The F 2s were issued to No 19 Sqn from late in 1962 and to No 92 Sqn from early 1963. These units together formed the Leconfield wing, which was declared operational in the summer of 1963. The two squadrons did a considerable amount of ground attack training in four cannon configuration, as preparation for the wing's move late in 1965 to RAF Germany, where in due course it became the Gütersloh wing.

Some 44 Lightnings were built as F 2s, and of these 31 were later modified to F 2A standard, with cranked and cambered wing leading edges and a large angular vertical tail. In place of the earlier 250-Imp gal (1 136-l) jettisonable ventral tank, the F 2A could be equipped with a non-jettisonable tank of 610-Imp gal (2 773-l) capacity, which, in conjunction with the wing modifications, provided a major increase in ferry range. The F 2A entered service in 1968.

However, the F 2A was still essentially an early-model Lightning with some of the long-range modifications of the later marks. Chronologically speaking, the next single-seater after the F 2 was the F 3, which combined the performance advantages provided by the

Avon 301-series engines with the weapons system improvements provided by an upgraded AI-23B fire control system and the Red Top (originally Blue Jay Mk 4) collision course IR missiles. The two cannon which had hitherto been standard fit in the upper nose were deleted and the extended, cambered leading edge was fitted.

The Avon 301 gave a dry thrust of 12,690 lb (5 755 kg) and 16,360 lb (7 420 kg) with afterburning, making the Lightning a genuine M=2·0 aircraft over a sizeable altitude band. To cope with directional stability demands at these high speeds, the F 3 was fitted with a larger fin. It also had OR.946 instrumentation, with Mk 2 master reference gyro. Provision was made for two jettisonable overwing tanks, again a somewhat desperate measure, but one that (with flight refuelling) made possible reinforcement flights to Malaysia, whereas previous

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Tornado training at Cottesmore

THE TRIPLE-T ESTABLISHMENT

THIS YEAR has seen the start at RAF Cottesmore of the training of British, German and Italian pilots and navigators for operational units to be equipped with the interdictor/strike (IDS) version of the Panavia Tornado. A massive tripartite operation, it will provide economically and quickly aircrews for four major NATO services (the Royal Air Force, Germany's *Luftwaffe* and *Marineflieger*, and the *Aeronautica Militare Italiano*), all trained to a mutually-agreed syllabus and to a common standard. At its peak, which is expected to take two years to attain, the system will produce approximately 135 trained aircrews per year, which is (for example) almost twice the capacity of the RAF Jaguar OCU and over four times the current output of the Buccaneer OCU.

In its time, RAF Cottesmore has seen many changes. Construction of the airfield in South Leicestershire began in 1935, and three years later Fairey Battles started to arrive, to be replaced by Handley Page Hampdens at the outbreak of war in 1939. In the following year the station became a bomber OCU, although some of its aircraft did take part in the early Thousand Bomber Raids, on Cologne, Essen and Bremen. In 1943 Cottesmore was handed over to the USAAF IXth Troop Carrier Group, whose Dakotas and gliders played an important rôle in the initial D-Day assaults and subsequent airborne operations; it was handed back to the RAF in 1945, then becoming a Lancaster OCU (No 1667 Heavy Conversion Unit).

In the early post-war years, RAF Cottesmore was used for flying training, with Harvards, Prentices and Balliols, but in 1954 it once again became a bomber base, when two Canberra squadrons were stationed there. Four years later it received two Victor squadrons, and in 1964 these were replaced by three Vulcan squadrons. The V-bombers moved to Cyprus in 1969, and Cottesmore became once again a Canberra base and OCU, although it also received a mixed squadron of Varsities and Argosy transports. These aircraft moved out in 1976, and the station was placed on a care-and-maintenance basis until 1978, when RAF Cottesmore was re-opened to prepare for its new rôle as a Tornado training unit; with the inauguration of the first TTTE course early in 1981, it is now once again an active part of No 1 Group of Strike Command.

The station commander at RAF Cottesmore is Gp Capt M G Simmons AFC, whose flying experience was gained mainly on Canberras and Buccaneers, and who in 1979 took the Tornado ground school course at Manching in West Germany as a preliminary to converting to the Tornado on the first TTTE course. Gp Capt Simmons is responsible for both the Tri-national Tornado Training Establishment (TTTE) and for the Tornado Ground Servicing School (TGSS), the latter being purely an RAF Support Command establishment with a primarily engineering rôle.

At its peak, TTTE will include some 1,900 servicemen and 140 civilians. It consists of the Tornado OCU (TOCU), which is tri-national in both its instructional staff and its students, plus an Engineering Wing and an Administrative Wing. These last two units are basically RAF-manned, although the Engineering Wing does include a small German team. The costs of TTTE are being borne 42·5 per cent by Germany, 40 per cent by Britain, and 17·5 per cent by Italy.

The officer commanding TOCU has the title of Chief Instructor, and will be either British or German. At the present time the appointment is held by Wg Cdr Robert P O'Brien, who has approximately 2,900 flying hours, mainly on Buccaneers. He is responsible for four tri-nationally manned flying training squadrons and an associated ground school.

Of the flying units, "A" Squadron is commanded by a German, this post being currently held by *Korvettenkapitän* J Rosch of the *Marineflieger*; "B" Squadron is commanded by an RAF officer, currently Sqn Ldr N Ball, and "C" Squadron is commanded by an Italian officer, currently *Tenente Colonello* C Pollice. The Standards Squadron is to be commanded either by a German or British officer, this appointment alternating in nationality with that of the Chief Instructor, to whom the head of the Standards Squadron is deputy. At present the Standards Squadron is commanded by *Major* Hartmut Jung, who has approximately 2,000 hours of flying experience on the F-104G Starfighter in the *Luftwaffe*. This squadron is responsible for advanced training, instrument rating checks and special tasks, which include training the instructors and providing courses for senior officers and refresher training.

The Chief Ground Instructor is *Luftwaffe Oberstleutnant* Jorg D Flik. Ground facilities at Cottesmore include four principal types of training aid: the Basic Flight Simulator (BFS), which enables both pilot and navigator to become familiar with the basic flying characteristics and to practice emergencies, the Full Mission Simulator (FMS), which takes both crew members through a complete operational mission, the Nav-Attack Systems Trainer, which — unlike the BFS and FMS — is a fixed-base training aid for the navigator only, and the Basic Avionics Procedures Trainer (BAPT), which is a simple ground school aid.

In preparation for the start of student training at Cottesmore, five courses, each of five pilots and five navigators, were run during 1980 by Messerschmitt-Bölkow-Blohm (MBB) under the designation Service Instructor Aircrew Training (SIAT), the first course beginning on 5 May and the last ending on 28 November. However, most of the officers attending SIAT went solely for the ground school syllabus, which was conducted at several locations in the Munich area, and only nine pilots and six navigators did the 13-hour flying syllabus at Manching. These aircrew formed the nucleus of the staff in the four TOCU squadrons, which began training students and other instructors for TTTE on 5 January 1981. When TTTE reaches its peak, "A", "B" and "C" Squadrons will each have 11 pilots and four navigators on their staff, and the Standards Squadron will have one less in either category.

During the early days of Tornado aircrew training, all students are required to have multi-tour backgrounds including experience on fast jets, although it is anticipated that eventually they will be taken straight from flying training. In the case of navigators, RAF students are currently coming from Buccaneer and F-4 Phantom units and later will come from Vulcans, while their German counterparts *(Kampfbeobachter)* come from the F-4F and RF-4E. However, Italy's *AMI* currently has no navigators with experience of fast jets, hence it may be necessary to provide prior training in the back seats of TF-104s. The Italian navigator-instructor slots are therefore being filled initially by British and German staff.

The training syllabus was devised by the multi-national Tornado Aircrew Design Team and subsequently endorsed by the Tornado Steering Committee; it consists of four weeks of ground school and nine weeks of flying. The function of TOCU differs from that of a normal RAF OCU in that it excludes weapon training, which is to be handled on a national basis: in the case of the RAF the Tornado Weapon Conversion Unit will be at Honington, currently a Buccaneer base. At Cottesmore the student will thus spend 35 hours on conversion to type, aircraft handling, formation flying and basic tactics, prior to 30 hours at a separate weapons unit.

All instruction will take place in English, which is the official language of TTTE, as it is for the Tornado's prime contractor, Panavia. This is not the problem in training that it might appear at first sight, since all German military pilots receive their flying training in America, and since Italian pilots routinely use English in radio communications. There is thus no requirement for instructor and student to have the same nationality.

There are minor national differences between Tornadoes, primarily in regard to radios, IFF, navaids and approach aids. However, in each category the controls have the same location in the cockpit, hence it is purely a matter of learning to use the particular equipment. Despite the best efforts of the respective OR Branches, there is a considerable degree of unanimity among the practising aviators at Cottesmore on the preferred equipment: British radios and German IFF, for example.

The average pilot could go solo on Tornado after six/eight hours of dual instruction, but under the TOCU syllabus the time is rather greater, since formation flying is done before the first solo flight (as is standard practice in the German services). The student pilot does some simulator work, then three "transition" flights, two formation flying sorties, a simulator check, two instrument flights, a further simulator check, and a "transition" check-ride before going solo. From this point he "crews up" with a student navigator, and for most sorties they then continue their training as a team, although a few are still flown with instructors.

Training begins

The formal courses began at TTTE on 5 January 1981, with only three crews (ie, three pilots and three navigators) on each of the first three main courses. Some 13 weeks later the first courses graduated. In the case of RAF officers, these early graduates went either to the WCU at Honington or remained at Cottesmore to take the 15-hour CTI (Competent-To-Instruct) course, in order to build up the teaching staff at TOCU. The number of students per course is increasing steadily (although there will be some seasonal variation to allow for the effect of weather on flying rate), toward a peak of 10 crews on each course. The three main squadrons operating 13-week courses will then theoretically be capable of producing 160 crews per year, although practical considerations are expected to reduce this figure to the region of 135.

The first RAF trainee destined for an operational squadron is student No 63, taking course No 10, which starts on 21 September 1981 and leads to graduation in January 1982. On present plans, this student will become the CO for the first RAF Tornado squadron, No 617 ("Dambusters") Squadron at Scampton, which will relinquish its Vulcans and will relocate at Honington to work up on the Tornado.

The German Navy will have a Tornado unit operational on approximately the same timescale as the RAF, although the *Marineflieger* students take longer to pass through Cottesmore, since the service insists that they all take the additional 15-hr CTI course to qualify them as instructors. The first German Navy student graduates

The Tripartite Tornado Training Establishment at RAF Cottesmore began work in earnest at the beginning of 1981, with the first courses devoted to "instructing the instructors" who will subsequently enlarge the training staff at Cottesmore itself or assume responsibilities at other establishments such as the weapons training units at RAF Honington, Jever in Germany or Decamomanu in Sardinia. Meanwhile, the fleet of Tornadoes at the TTTE (below) is steadily growing towards its planned total of 48 aircraft.

Initial aircraft serving at the TTTE came from the British and German assembly lines, both being represented in the three-aircraft formation seen above and below right. Six Italian-assembled aircraft will eventually join the 23 German and 19 British Tornadoes at Cottesmore, these totals including a substantial number of the dual-control version as well as strike versions.

from Cottesmore in October 1981, and will then go to Jever, where weapon training is to be conducted. The first German Navy student for an operational wing (MFG1) will leave Cottesmore in April 1982, having started training in November 1981.

The first two Tornadoes were delivered to TTTE on 1 July 1980, these being respectively the second production British IDS and trainer aircraft, with construction numbers BS002 and BT002 and RAF designations Tornado GR Mk 1 and GR Mk 1 (T) respectively. These were followed by British and German trainers BT004 and GT005 on 2 September, and a further German trainer, GT004, on 3 September. Aside from these construction numbers, each aircraft has a serial number from its respective service, and a TOCU fleet number on the fin, fleet numbers below 50 being allocated to trainer aircraft and from 50 upward to IDS aircraft. For example GT005 bears the *Luftwaffe* code 43+05 on the front fuselage, the aircraft serial 4005 and fleet number G-24 on the fin. Likewise, BS002 has serial ZA322 on the rear fuselage and fleet number B-50.

When the first formal course began in January, TOCU had 15 Tornadoes on strength. At its peak the unit will have a total of 48, of which 23 will be provided by Germany, 19 by Britain, and six by Italy. All servicing and maintenance is provided by RAF groundcrews. Sorties will peak at 60 per day, of which approximately half will be flown at low level, to a minimum of 250 ft (76 m) above the ground. The Tornado is much quieter than most existing high performance military aircraft (and notably the Phantom), but the low-level flights will in any case be dispersed throughout the UK low-flying areas to minimise their impact on local environments.

Aircraft characteristics

At the time this report was written, TOCU had not received external tanks for its Tornadoes, but was flying missions of 1 hr 20 min duration on internal fuel and at operational speeds, which was felt to be satisfactory for training. The dual-control training aircraft is externally indistinguishable from the IDS aircraft, aside from the clue given by its fleet number. Since the rear seat is not raised, the instructor's field of view is not as good as in the two-seat Jaguar (for example), although it is better than from the back of the Phantom cockpit. The Tornado can be flown from the rear cockpit quite easily, although in the event of the sweep mechanism malfunctioning and leaving the wings in the fully aft position and flapless, it would have to be landed from the front cockpit because of the high angle approach. Landings are exceptionally short, thanks to the clamshell thrust reversers and lift-dump spoilers on the wings, both of which can be selected immediately after touchdown. During development, thrust reversal led to a tendency for the aircraft to wander during the landing run, but this "hunting" was cured by an augmented steering system, which uses a gyro reference to generate damping inputs.

The Tornado is extremely popular with all those who have flown it. Conversion to the type is straightforward, and single-engined handling is regarded as outstanding. Its Turbo-Union RB.199 Mk 101s' afterburners are used routinely for take-off and supersonic flight; in other situations afterburners may also be used to accelerate to penetration speed in high drag configurations, and for a single-engine overshoot at high weights. Because of the aircraft's design characteristics, gust response is low; in high-speed, low-level flight in extreme turbulence, it is as stable as the Buccaneer, and it handles better at low speeds due to its fly-by-wire control system.

The IDS version of Tornado is intended for use in a difficult environment, demanding a high degree of mental concentration by both pilot and navigator in order to operate the aircraft to its limits in all weather, day or night, in close proximity to the ground and opposed by what are probably the most highly developed defences in the world. Therefore, the aircraft has been designed to minimise aircrew fatigue. In addition to the Tornado's excellent stability and low gust response, it has an unusually quiet and comfortable cockpit. The Martin-Baker Mk 10 rocket seat is probably one of the most comfortable ejection seats ever developed. Wg Cdr O'Brien says that Tornado is the quietest aircraft he has ever flown, and that the cabin conditioning system is so effective that, whereas few combat aircraft are cool enough to be comfortable on a hot summer day, the Tornado cockpit can easily become too cold if you select minimum temperature. The crew also benefits from the comfort of a large cockpit, which is even more spacious than that of the Jaguar.

The nav-attack system is a generation ahead of current equipment in service with the RAF, providing considerably increased capabilities and thus making life easier for both crew members. Sqn Ldr Vaughan Morris (senior navigator, Standards Squadron) feels that "After sitting in the back seat of a Buccaneer, the Tornado is light-years away". *Luftwaffe Major* Bernd von Sivers, previously a *Kampfbeobachter* on the RF-4E, and now a navigator with Standards Squadron, reported that "Compared to the F-4 radar, this Tornado radar is superb, especially at low level. You see more than you want to see, and you have to learn to be selective".

The future programme

Tornadoes are currently coming off the lines at British Aerospace, MBB, and Aeritalia at a combined rate of eight or nine units per month, and this will grow to 12 units monthly when the programme reaches its peak. Flyaway cost was recently quoted officially in Germany as DM35·26m (approximately £7·8m) in late 1979 terms. On current plans, 820 Tornadoes will be built, including nine prototypes and six pre-series aircraft. A total of 809 will be delivered to the four services, ie, 805 of the series-built aircraft and four of the pre-series aircraft, brought up to production standard after completion of the flight test programme. Of this total, 385 will go to the RAF, 212 to the German *Luftwaffe,* 112 to the *Marineflieger,* and 100 to the *Aeronautica Militare Italiano.* Of the RAF complement, 220 will be interdictor/strike aircraft (Tornado GR Mk 1) and 165 for air defence (F Mk 2).

The Tornado GR Mk 1 will replace the Vulcan B2, the reconnaissance Canberras, and the overland Buccaneers serving with No 1 Group of Strike Command and with RAF Germany. This version is equipped with a terrain-following (TF) system, which flies the aircraft via the autopilot, keeping it close to the ground in all weathers, thus minimising the enemy's radar warning and the defences' chance of a successful engagement. The aircraft is navigated automatically via a series of waypoints to the target and back to base, the co-ordinates of all these points being stored in the computer memory, and the calculation being performed basically from a mix of Doppler radar and inertial data.

The navigator can check the computed position by various means, one of which is a Ferranti display combining radar mapping with a projected moving chart, which is stored in the form of 35-mm film, and is moved by the navigation computer to show the present aircraft position centrally on the screen. This combined display also assists the navigator to interpret the radar picture.

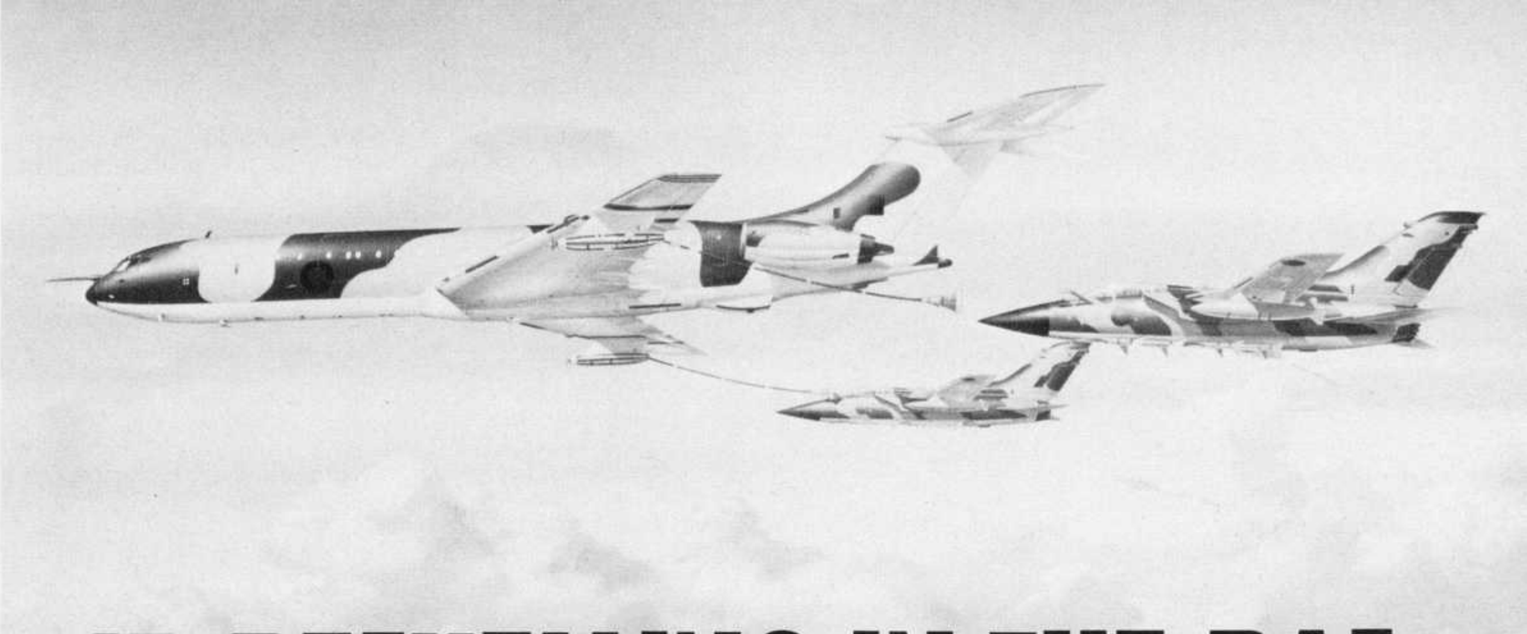
The RAF Tornado GR Mk 1 will be equipped with a laser ranger for precise weapon delivery, carried in a fairing under the nose. Attacks can be made either automatically or manually. The IDS Tornado can be armed with a wide variety of conventional and nuclear weapons, as specified by the different user nations, including air-to-surface missiles such as the MBB Kormoran anti-shipping weapon, the British JP233 airfield attack weapon, the German MW-1 multi-purpose bomblet and minelet dispenser, and other armaments still under development. The aircraft has three underfuselage pylons and four under the wings, the inboard wing pylons being articulated to stay in line of flight as the wing sweep varies. This variant of Tornado has two very advanced Mauser 27-mm cannon for self-defence and attacking ground targets of opportunity. Radius of action in a HI-LO mission is approximately 750 nm (1 390 km).

The Tornado F Mk 2 will replace the Lightning and Phantom in the air defence squadrons of No 11 Group of Strike Command and RAF Germany. Two prototypes are already flying, and the first production F Mk 2 will make its maiden flight in 1983. Although the F Mk 2 is manufactured on a tripartite basis by Panavia, on current plans it will serve only with the RAF, and there will therefore be a separate OCU for crews of this variant, probably located at Coningsby (currently the Phantom OCU base). The F Mk 2 has 80 per cent commonality with the strike version, but differs in having a longer fuselage to allow four BAe Sky Flash medium range air-air missiles to be accommodated under the fuselage and to increase internal fuel volume. A new air intercept radar is mounted in an extended nose radome, in place of the ground-mapping and terrain-following radar of the GR Mk 1. Two short-range AIM-9L Sidewinder missiles are carried on the sides of the inboard wing pylons, and only one cannon is fitted.

The Tornado programme will thus represent a massive transfusion for NATO air power, modernising strike, interdiction and air defence units over a wide area. As a deterrent to Warsaw Pact aggression, its theatre of operation will extend from Iceland to the Mediterranean. Its deployment will mean that, even if the Communist attack comes on the worst winter night, their front-line forces will be hit from the air, their supply lines interdicted, and their airfields rendered inoperable. In the air defence of the UK and adjacent sea areas, Tornado will provide a quantum advance in effectiveness. RAF Cottesmore is playing a key rôle in this vitally important programme, and is providing important lessons on how the forces of the NATO nations can work together to improve the defences of the West. □

ROY BRAYBROOK

TTTE fleet numbers on the fins of Cottesmore's Tornadoes — together with the unit badge — give a clue to the aircraft configuration, with "B", "G" and "I" for the nationality (British, German, Italian), numbers from 01 to 49 for dual control aircraft and numbers 50 upwards for the IDS variant.



AIR REFUELLING IN THE RAF

Air Refuelling has been an integral part of Royal Air Force operations since 1960, but RAF interest began in 1924 and, as Brian Gardner here records, the technique was nearly introduced in the late 1930's. This account, which is part of a detailed history the author now has in preparation, records the early RAF experiments with in-flight refuelling and its subsequent adoption as an integral part of operational practice.

AT THE International Air Congress in June 1923, Boulton and Paul designer John North suggested refuelling in flight as a means of achieving more efficient commercial aviation. Commenting on this suggestion, and also noting that refuelling experiments were already being made in America, Stanley Spooner, then editor of *Flight*, urged that similar experiments be carried out in Britain. The problem of carrying a reasonable payload in addition to a large quantity of fuel "... is one which concerns the Royal Air Force as much as it does commercial aviation, and we think the experimental work might very well be undertaken by the RAF ...".

Following a refuelling demonstration by French aviators in December 1923, the Royal Aircraft Establishment at Farnborough was directed to carry out experiments. These took place during February and March 1924 using a pair of Bristol Fighters (F4675 and A7260), between which water was transferred via a 60-ft (18,3-m) pipeline. The experiment was considered satisfactory, but to minimise risk the report recommended that the manoeuvre, if adopted, should be used only by very experienced personnel.

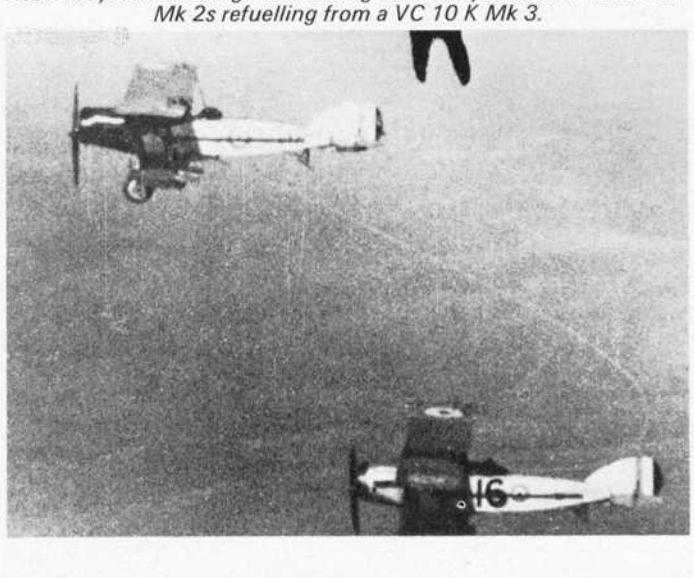
Trials were resumed in 1930, and the technique was seen as a means of getting flying-boats airborne in conditions preventing take-off with full fuel. Fuel delivery was to be made into a point in the tail gunner's station, and in September, contact was made between a D.H.9A trailing a 160-ft (48,7-m) pipeline and the tail of a Vickers Virginia. The "receiver" approached the "tanker" from underneath and climbed after passing the end of the pipe. Power was then reduced to "back" onto the nozzle which was caught by an observer in the tail. A second pilot faced aft to guide the pilot in command by means of hand signals. This method was abandoned in 1932 in favour of a wingtip-to-wingtip method, but after flight tests using a length of weighted garden hose one pilot reported: "... I consider this possible as a stunt, but as a service routine job, distinctly improbable." Refuelling methods were discussed at the Air Ministry in July 1933: although presenting "considerable problems" with large aircraft, the wingtip method, it was concluded, might be suitable for smaller types and trials would continue with two Westland Wapitis. It was also suggested that refuelling might be employed to increase the range of day-bomber and general-purpose types, "particularly when engaged in carrying out raids from aerodromes which are unsuitable for take-offs with heavy loads".

During 1932, Sir Alan Cobham was making preparations for a non-stop flight to Australia in an Airspeed Courier, using flight refuelling. He sought Air Ministry help in providing tankers and explained his scheme to Air Vice-Marshal Sir Hugh Dowding, Air Member for Supply and Research, who suggested that India might be a more reasonable destination in view of the cost and organisation involved. During the following two years, in addition to his National Aviation Day activities, Cobham experimented with refuelling methods, with this long-range flight in view. The RAE was asked to co-operate, and in July 1934, refuelling was demonstrated between the Courier and a Vickers Victoria, fitted up as a tanker. The latter aircraft was then positioned at Aboukir, and a No 70 Squadron Vickers Valentia, fitted with refuelling equipment, was made available at Hinaidi to refuel the Courier near Shaibah.

With Sqn Ldr W Helmore, Cobham left Portsmouth on 22 September 1934, but during the second refuelling near Malta, the throttle became disconnected and a wheels-up landing was made in the Courier at Hal Far, Malta. A further attempt was abandoned, but Cobham determined that past expense and experience should not be wasted and he formed the company Flight Refuelling Ltd to develop techniques and equipment.

Visiting the 1930 National Air Races in Chicago, Flg Off Richard Atcherley saw some of the refuelled endurance flights then taking place and became interested in the possibilities of the technique.

(Below) A rare photograph showing the first refuelling trials in which RAF aircraft were involved, using two Bristol Fighters. The trials were conducted by the RAE at Farnborough and water was passed through the 60-ft (18,3-m) hose. (RAE Photo, Crown Copyright Reserved). The heading illustration gives an impression of Tornado F Mk 2s refuelling from a VC 10 K Mk 3.



The use of flight refuelling by Lancasters of the Tiger Force to bomb Japan in 1945 was rendered unnecessary by the progress of the war, but the technique that would have been used is shown by this photograph of post-war trials over the South Atlantic. The tanker is the upper aircraft and the refuelling hose has been drawn into the receiver after making contact by means of the ejector method developed by Flight Refuelling Ltd.

During his subsequent posting in Transjordan he devised a new method of refuelling: "When two aircraft are to establish contact, each is provided with a trailing line having an engaging device at its end ... The lines are so arranged as to trail at different angles ... so that when one crosses another laterally, it will engage therewith. One of the lines may then be used as a heaving line ... and any object, such as the nozzle of a refuelling hose, can be connected to it". This draft was sent to the Air Ministry, but the scheme was considered to offer no improvement over known methods. In September 1934, Atcherley was posted to the RAE Farnborough, where he participated in the refuelling trials continuing there, and was able to further develop his ideas.

The future development of air refuelling as a standard Service procedure was discussed at Farnborough in January 1935. This was considered a "fairly high priority" by AMSR, and a programme of trials was arranged to evaluate the various methods proposed. Two Wapitis were used to test the "direct" method, in which the receiver formated on a bag of lead shot trailed from the tanker; an observer then caught the line and hauled down the hose, but this method was discontinued "as it is considered ... too dangerous with less skilled pilots". Atcherley's "indirect" method was first tested in March, using a Westland Wallace and Hawker Hart, and this method was later patented; another patent described a means of maintaining contact using a drogue to draw the fuel pipe across from the "Cow" aircraft to the "Calf". Tests of a "nose-to-tail" method were done with a Virginia and Handley Page Heyford, using both direct and indirect contacting methods, but trials of a "Towing method", devised by Wg Cdr J W Woodhouse and Sqn Ldr W Helmore of the RAE, were delayed pending the availability of suitable aircraft. Although the Vickers B.19/27 (J9131) and Vickers Vellore III (K2133) were offered, the latter aircraft was considered unsuitable and a Boulton Paul Overstrand was requested instead.

Air refuelling had meanwhile been demonstrated at the 1931 Royal Air Force Display at Hendon with a Virginia tanker and Wapiti receiver. A similar display was given in 1934 and, in the following year, a Wallace and Hart demonstrated the technique.

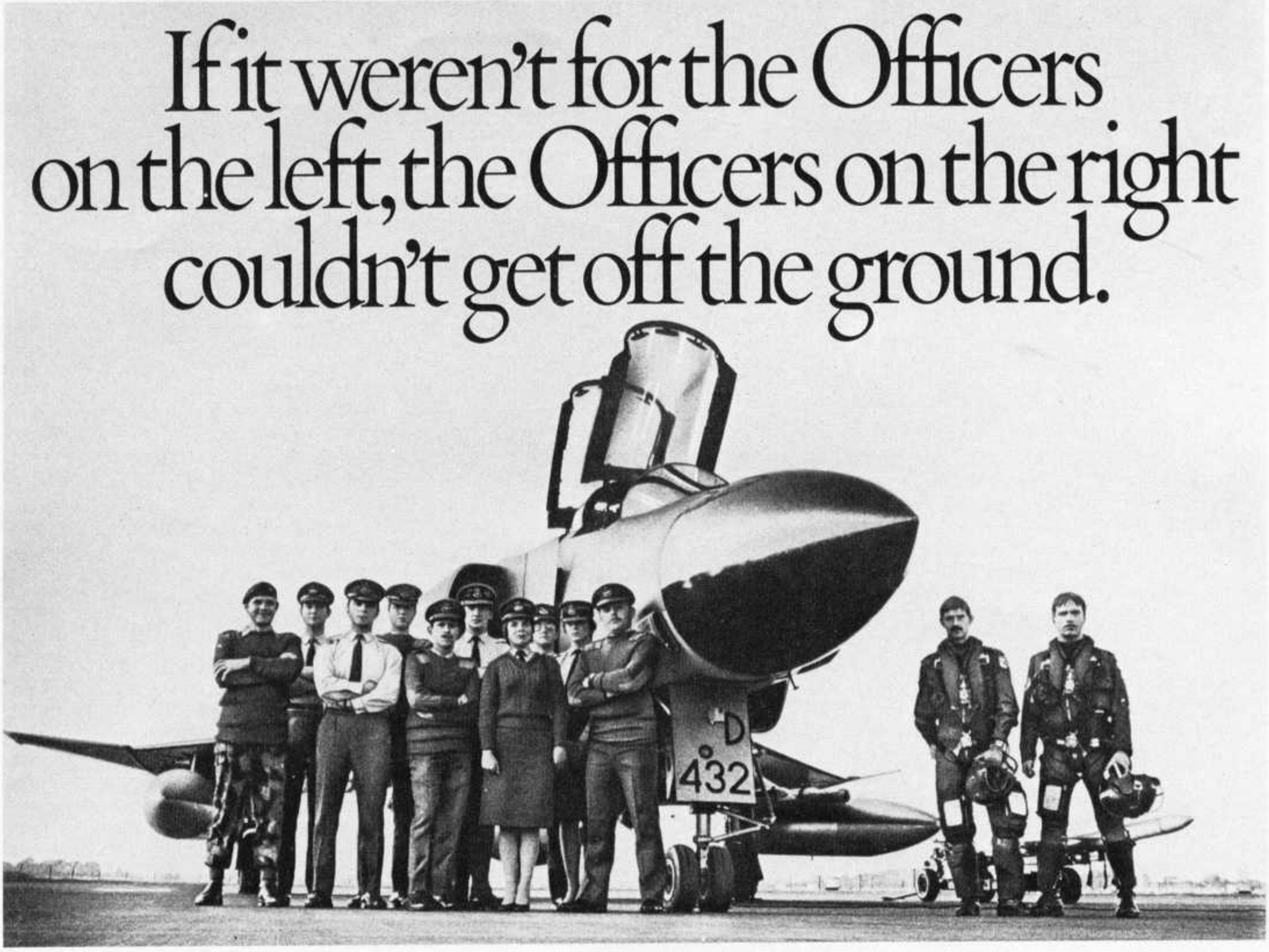
The need for a satisfactory refuelling method was becoming urgent by July 1935: the heavy bomber Specification B.1/35 included provision for refuelling in flight, and the "towing" method was initially specified, with a strongpoint in the nose gun station for the towing cable, along which the refuelling hose would be passed. The method was changed in 1936: "The operation will be carried out through openings in the underside of the aircraft ... the two aircraft will fly approximately line abreast ... the refuelling hose being suspended from the openings." Prototypes to B.1/35 were ordered from Armstrong-Whitworth, Handley Page and Vickers, and during construction of the mock-ups, RAE personnel visited the manufacturers to advise on the refuelling installations. By December 1937, when the requirement was deleted in favour of additional tankage and more powerful engines, only the Vickers Type 284 design was continuing, and this was subsequently developed into the Warwick.

Trials with the B.19/27 and an Overstrand (J9770) commenced in August 1936, but the "towing" method had by now been abandoned because of progress being made with other methods. These two aircraft demonstrated refuelling at the 1937 Royal Air Force Display.

Flight Refuelling Ltd was meanwhile continuing development, hoping to introduce the technique into Imperial Airways. Two Virginias were loaned to the company by the Air Ministry in 1936, "for the purpose of carrying out in collaboration with the RAE experiments in refuelling". A comparative demonstration to evaluate the merits of RAE and Flight Refuelling company refuelling methods was held at Farnborough on 31 August 1937, the B.19/27 and Overstrand being used by the RAE, while the company used the Armstrong Whitworth A.W.23 (K3585) and Handley Page H.P.51 (J9833). RAE refuelling experiments ended shortly afterwards, and Flight Refuelling was given a contract to continue development. The B.19/27 and Overstrand were transferred to Ford Aerodrome early in 1938 and were used "to determine the most suitable method of making and maintaining contact ...". The A.W.23 and a Fairey Hendon (K1695) were to be used to determine the reliability of refuelling by time schedule, irrespective of weather conditions.

During 1938 the Air Staff again took a considerable interest in the refuelling of bombers in flight. Flight Refuelling was asked to study "the effects of improved performance, range and load-carrying ability made possible by refuelling", and in February 1939 the Directorate of Technical Development asked the company to investigate the possibility of refuelling an aircraft of the Stirling type. The subsequent report indicated considerable improvements in take-off performance and load-carrying ability when refuelled by Handley Page Harrow or de Havilland Albatross tankers, and even greater benefits would follow if refuelling were to be incorporated into an

The looped hose method used until 1948 was obviously unsuitable for use by single-seat fighters. Largely at the instigation of the USAF, Flight Refuelling Ltd developed instead the "probe and drogue" method illustrated below. (Right) A trials Meteor 4 with nose-mounted probe approaches the drogue trailed from a tanker and (left) the Boeing YKB-29T, the world's first triple-point tanker, refuels three Meteors, including two Mk 8s of the RAF trials unit, No 245 Squadron, in 1951.



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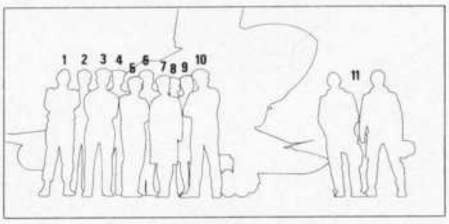

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QUALIFICATIONS

Generally, five or more acceptable GCE 'O' levels at Grade C or above (or equivalent) are required including English Language and Maths. If you've 'A' levels or a degree, so much the better. However, to become an Engineer, Education, Catering or Medical Officer, you will need relevant professional or specialist qualifications. The minimum application age is 17 (17½ for women). Current upper age limits vary from branch to branch. Formal application must be made in the UK.

In 1960, two squadrons of Gloster Javelin FAW Mk 9s became the first in Fighter Command to use flight refuelling routinely. As this illustration clearly shows, the probe installation was an inelegant addition to the Javelin's forward fuselage.

improved design. Development continued for a short time after the outbreak of war: various projects were investigated, including the conversion of Manchester bombers to receivers, but the Air Staff now considered air refuelling impractical on the scale of operations envisaged, and more urgent matters were now at hand.

To bomb Japan

Late in 1943 tentative plans were made for the bombing of Japan, to be put into effect after the defeat of Germany. To achieve the required radius of action when operating from Burma or China — in the absence of Allied bases nearer Tokyo — the bombers would be refuelled in flight. A force of up to 40 Lancaster squadrons — 20 tanker and 20 receiver units — would be employed, and if bases later became available within the unrefuelled range of the Lancaster, the entire force would be available as standard heavy bombers by removal of equipment from the tankers. Early in 1944 it was assumed that the German war would be over by 1 October, and aircraft modification and crew training would follow immediately; only 11 aircraft would be modified prior to this date for development trials.

Bomber Command considered the refuelling of such a large number of aircraft "... a difficult business fraught with dangers, within range of enemy fighters, and most uneconomical in the use of aircraft". Overloaded bombers with strengthened undercarriages were suggested as an alternative, but planning went ahead on the assumption that air refuelling would be required.

The modification programme and force composition changed frequently with the progress of the war: various problems delayed completion of the prototype tanker and receiver, and these commenced trials in October. The Lincoln (originally known as the Lancaster Mks IV and V) was now to equip the "VLR (very long range) Force" from late 1945, and operations were expected to last well into 1946. A nucleus planning staff was formed in late 1944 under the Force Commander Designate, Air Vice-Marshal Sir Hugh P Lloyd, and in February 1945, the project became known as "Tiger Force".

A considerable amount of effort went into the manufacture of equipment, with hundreds of sub-contractors involved. RAF St Athan was to be the installation depot for the refuelling equipment, and crew training was to be the responsibility of Flight Refuelling Ltd at Staverton, but in April 1945 the Air Staff decided to abandon air refuelling for the Tiger Force: the Americans were advancing in the Pacific and offered bases nearer Tokyo, and the potential for overloading, proved feasible in other operations, made the technique unnecessary. It was still being considered, however, by Transport Command for the supporting freight flights, and at the Command's request the company prepared a report dealing with a refuelled York service between Bengal and Manila, a distance of 2,300 miles (3 700 km). Preparations for the deployment of Tiger Force continued: units were allocated, and advance parties sailed for the Far East, but before any squadrons could be deployed, the two atomic bombs made their task redundant and the Force was disbanded.

Refuelling trials had meanwhile been undertaken by the Bomber Development Unit, with two crews from No 149 Squadron participating. The final report concluded: "Flight refuelling is undoubtedly a successful method of increasing range and bomb-load of an aircraft ... While a single aircraft can be refuelled with little difficulty, the question of refuelling large numbers of aircraft in a short space of time becomes more complicated."

Following cancellation of the refuelling contract, the Air Ministry recommended that tactical trials be carried out to prove the value of the technique. Trained crews were available, and sufficient modification sets, 80 per cent complete, were available to equip 50 aircraft. A conference was held in early August 1945 with Command representatives to discuss the desirability of further trials. Bomber Command considered that, "as an operation of war for any substantial part of the Command it is not a practical proposition" and strongly recommended that no further development, other than that being carried out by the BDU, be undertaken.

Transport Command remained very interested in refuelled York freighter services, and the company was asked to prepare a report on the feasibility of such services to Cairo and India, but with the end of hostilities, the Command was heavily committed to trooping flights and was unable to spare any York aircraft for modification or trials. The Command offered to participate in the projected civil trials, but in the event these were made by British South American Airways, using civilian crews and civil-registered Lancasters.

Coastal Command now decided to evaluate the technique with a Meteorological Flight, and a contract was placed for the conversion of 10 Warwick GR Mk II aircraft as receivers. Early in 1946, it was decided that the Halifax would equip the Met Flights instead, and contracts were placed for the conversion of 10 Halifax Met Mk VI aircraft as receivers and three Lancaster ASR Mk III aircraft as tankers. These aircraft were to be operated by Nos 518 and 203 Squadrons respectively, both from Aldergrove, but changes in Service requirements again resulted in this scheme being cancelled in November. The Avro Shackleton was to replace the Lancaster in the maritime reconnaissance rôle, and in 1946 the decision was taken to equip this aircraft for air refuelling. This requirement was later cancelled as it was considered that the aircraft already had an adequate range, and any extension would affect crew efficiency. Although the first prototype (VW126) had a reception coupling fitted, no refuelling trials were made; air refuelling was again considered for this type during the 1950's.

Fighter refuelling had also been suggested in 1945, but it was not then considered a practical proposition, and Cobham's proposals for trials met with little response.

Post-war activities

The post-war years were lean ones for Flight Refuelling Ltd. Civil trials were carried out by BSAA and BOAC, but neither Corporation would be committed to adoption of the technique, and Service interest was minimal. Cobham was still trying to sell the idea to the RAF and Command staffs suffered a "slow bombardment" of letters, reports, requests for interviews and invitations to demonstrations.

In 1948, the USAF decided to adopt air refuelling for Strategic Air Command and British equipment was ordered as an interim measure, pending the development of an improved system. They also asked for a method of refuelling fighters, and during the winter of 1948/49, various schemes were studied, resulting in development of the "probe and drogue", first demonstrated in April 1949, and now widely used by the RAF and other air forces.

Demonstrations to senior RAF officers and Government officials, and the 12-hour refuelled flight by a Meteor in August, did much to renew official interest in Britain. It was now a practical proposition for jet fighters and had obvious applications such as long-range deployments, but its use in a combat zone was still considered impractical. The Air Staff attitude was to maintain official interest in "Cobham's activities" and to encourage further development for possible future use.

Fighter Command evaluation trials were proposed in 1950 and a contract was placed for the conversion of 16 Meteor F Mk 8s to receivers. In addition to one Lincoln tanker already being used by the company for development (RA657), two other Lincolns (RE293 and SX993) were now to be modified as tankers for use in the trials. These were made between May and October 1951 by No 245 Squadron, based at Horsham St Faith and commanded by Sqn Ldr C F Counter. The first sortie was on 8 May, and the rest of the month was devoted to practising the technique and training pilots, but in June the Squadron began combining refuelling with other exercises. Two Meteors, flown by Squadron pilots, were loaned to the company in July to demonstrate simultaneous refuelling from the three-point YKB-29T tanker modified by Flight Refuelling Ltd for the USAF. During October, the Squadron carried out low-level exercises and night refuelling trials, and participated in Exercise "Pinnacle" by maintaining standing patrols off the Norfolk coast, supported by a Lincoln tanker. Long-range flights around the UK were made in preparation for a proposed non-stop flight to Malta, but this was cancelled because of the political situation in the Middle East.

Although the Squadron trials proved satisfactory, Fighter Command was unwilling to adopt the technique if the provision of tankers, which were "large, expensive and vulnerable", meant a reduction in the number of fighters on economic grounds. It was decided not to adopt the technique, "at least for the present", but future types were to include provision for air refuelling in their design.

During the early 1950's Flight Refuelling investigated new types of fighter and bomber under development: manufacturers were visited and refuelling installations proposed, but in the absence of an official requirement nothing further could be done. The application of air refuelling to various operational tasks was, however, being studied by the Air Ministry.

V-force refuelling

Evaluation of potential targets during the late 1940's showed that a radius of action of 2,500 naut miles (3 490 km) was desirable for satisfactory coverage, but an aircraft designed to carry a 10,000-lb (4 540-kg) bomb load over this distance would be extremely large and heavy, and present serious runway problems. A radius of 1,500 nm (2 095 km) was finally decided upon, and the new jet bombers were designed to meet this requirement. Subsequent range extension might be achieved, it was thought, by overloading and the use of rocket-assisted take-off. As early as 1948, air refuelling was considered, but the technique then in use was unsuitable for high-speed and high-altitude operation. The advent of the probe and drogue changed this situation, however, and Flight Refuelling

Like the Javelin, the English Electric Lightning sprouted a refuelling probe somewhat as an afterthought, attached beneath and extending forwards from the port wing; all but the first few production Lightnings were built to accept this probe installation, and all Fighter Command aircraft since the Lightning have had the facility designed in from the outset. The Canberra tanker is a "special" used by Flight Refuelling Ltd; the RAF never had tankers of this type.

In-flight refuelling was adopted by Bomber Command as an essential complement to its V-Force operations, nearly a decade before Fighter Command was committed to its use. The first tanker for RAF squadron service was the Valiant, converted from the bomber rôle as the BK Mk 1. This photograph shows the single-point refuelling system; a Valiant is also the receiver.

submitted numerous reports showing how range and bomb load of the new aircraft could be increased by employing air refuelling. Finally convinced, the Air Staff decided in 1952 to adopt the technique for the "V-bomber" force. Some Valiants would be equipped as tankers with removable refuelling equipment, and all Valiant, Vulcan and Victor aircraft would be capable of receiving fuel. Design studies began in 1953, and early in 1954 the Valiant B Mk 2 (WJ954) engaged in formating trials with a Canberra tanker. Trials with a production Valiant B Mk 1 were carried out during 1956, and Valiant-to-Valiant trials began in 1957.

By April 1958 the technique had been cleared for Service use, and No 214 Squadron, commanded by Wg Cdr M J Beetham (now Air Chief Marshal Sir Michael Beetham, GCB, CBE, DFC, AFC, ADC, Chief of the Air Staff), was nominated as the trials and development unit. During the trials, which ended in May 1960, several long-distance refuelled flights were made, and the compatibility was demonstrated with the other V-bombers. No 90 Squadron converted to the tanker rôle in August 1961, but both units retained their bomber commitments until April 1962, when they officially became tanker squadrons.

Operational squadrons began converting to the receiver rôle during 1960. Vulcan receiver training began late in the year in preparation for a non-stop flight to Australia, this being accomplished the following June by a No 617 Squadron crew flying a Vulcan B Mk 1A. The 9,993-nm (18 507-km) distance between RAF Scampton and Sydney was covered in a little over 20 hours, the Vulcan being refuelled by Valiant tankers detached to Akrotiri, Karachi, and Tengah. This, and other long-distance flights by Vulcan squadrons, demonstrated the global mobility and extended range now made possible. Victor squadrons began conversion during 1962.

Fighter refuelling

Fighter Command introduced the air refuelling technique in June 1960, when Nos 23 and 64 Squadrons, equipped with the Javelin FAW Mk 9, began receiver training. In August, a No 23 Squadron Javelin was flown to Akrotiri non-stop, refuelled and escorted by Valiant tankers. This was the first of several long-range exercises by these units, the only ones to employ air refuelling with the Javelin. Lightning F Mk 1A Squadrons, Nos 56 and 111, began training in the new rôle during 1962, the first overseas refuelling exercise taking place in July. Other Services also made use of the Valiant tankers, including the Royal Navy, which introduced air refuelling in 1960 with Scimitar and Sea Vixen fighters, and the USAF. A joint RAF/USAF exercise was held in 1961 to demonstrate the compatibility of the Valiant tanker with B-66, F-100F and F-101A receivers, and the KB-50 tanker with Valiant, Vulcan, Victor and Javelin receivers.

Fighter deployments had shown up the disadvantages of a single-point tanker: only one receiver could be refuelled at a time, thus extending the time taken for multiple refuellings, and additional airborne tankers were required to avoid the necessity for receiver diversion in the event of tanker equipment failure. During 1961/2 proposals were made for two- and three-point Valiant tankers, but these were turned down in favour of a three-point installation in the Victor; a number of Mk 1 and 1A bombing aircraft becoming available as squadrons re-equipped with the Victor B Mk 2. Three squadrons of Victor tankers were required to supplement the Valiant force, and eventually replace it in the late 1960's, and Treasury approval for the conversion was obtained in 1963. Following the discovery of fatigue defects, however, the Valiant force had to be withdrawn from service in January 1965, and the Victor conversion programme was then accelerated to make good this sudden loss of tankers. The prototype conversion (XA918) had flown in September 1964 and was used to test the compatibility of all current receiver types.

Six interim, two-point, Victor BK Mk 1As were quickly produced for fighter refuelling and these entered service with No 55 Squadron in May 1965. Twenty-four three-point conversions followed, as the Victor K Mk 1 and 1A, and these became operational with Nos 57, 214 and 55 Squadrons respectively from June 1966. All were based at RAF Marham, with a supporting Air Refuelling School and Tanker Training Flight. The Tanker Force was originally under the operational control of No 3 Group, which was responsible to Bomber Command for operations and training, but since April 1968, this control has been exercised by No 1 (Bomber) Group of Strike Command, and detailed planning for refuelling exercises is the responsibility of an Air-to-Air Refuelling Planning Cell at No 1 Group Headquarters.

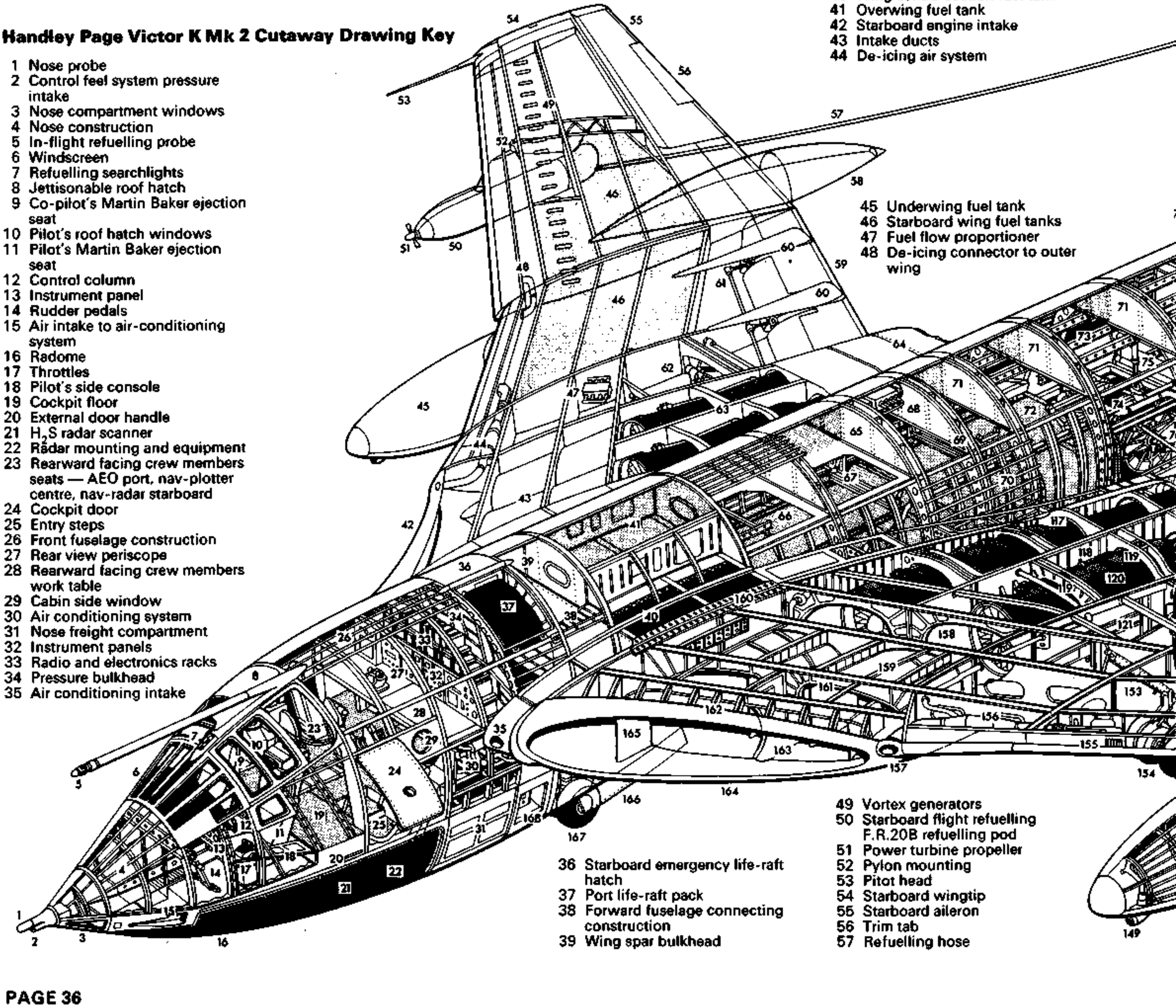
Refuelling far and wide

Tanker support became increasingly important in the late 1960's for a number of reasons. Soviet probing flights became more frequent, requiring extended fighter escort missions by Lightnings, and later Phantoms, of the air defence squadrons: a Victor tanker is always available to support such missions and to enable them to remain airborne as long as necessary. The withdrawal of British Forces from the Far East involved a rapid reinforcement commitment, and in the largest air-to-air refuelling exercise then undertaken, 10 Lightning F Mk 6s of No 11 Squadron were flown to Singapore and back, a distance of 18,500 miles (29 772 km), refuelled by Victor tankers of Nos 55, 57 and 214 Squadrons. Departing from the UK in early January 1969, the Lightnings were each refuelled 13 times by Victors based at Marham, Akrotiri, Masirah and Gan, the fighters staging through Muharraq (Bahrain) and Gan. Before returning to the UK a month later, the Squadron carried out air defence training from Tengah.

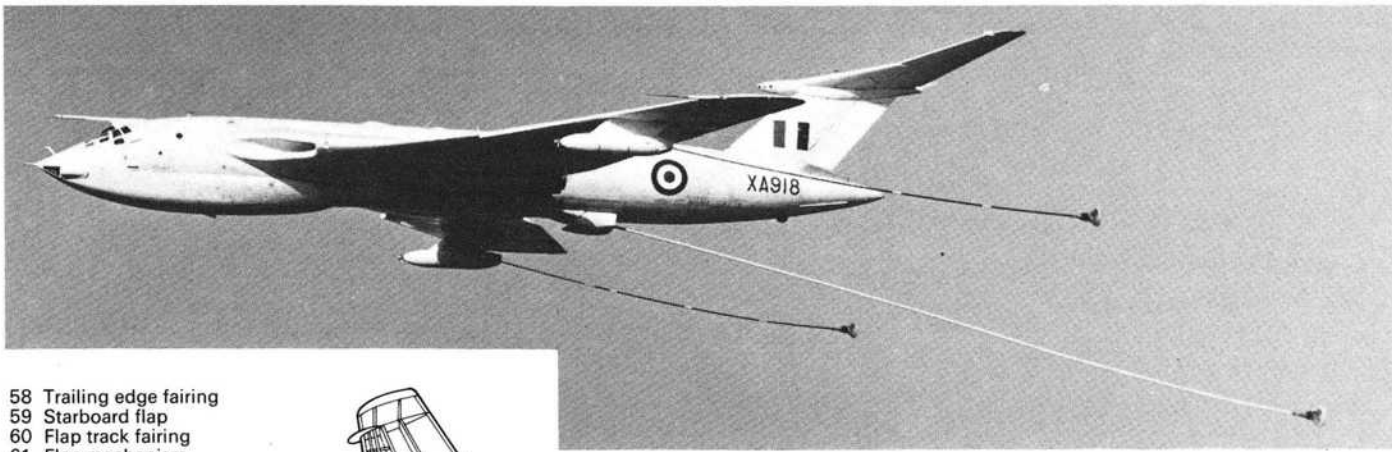
In May 1970 three Phantom FGR Mk 2s of No 54 Squadron participating in Exercise "Bersatu Padu" flew to Singapore non-stop in a little over 14 hours with the aid of nine in-flight refuellings. The run-down of the aircraft-carrier fleet meant that land-based strike aircraft had to operate farther out to sea: in exercises in the mid-1970's, tanker support enabled RAF Phantoms to mount a defensive patrol over a naval task force some 900 miles (1 450 km) from their base in Scotland, and Buccaneers from Honington to carry out attacks against simulated enemy shipping operating more than 1,100 miles (1 770 km) from the coast.

Demonstrating the rapid deployment made possible by in-flight refuelling, 12 armed Phantoms were dispatched from RAF Coningsby at short notice during the Turkish invasion of Cyprus in July 1974. Flying through the night and refuelled by Victor tankers from Marham (which then landed at Malta), the fighters were available to the United Nations commander by first light the

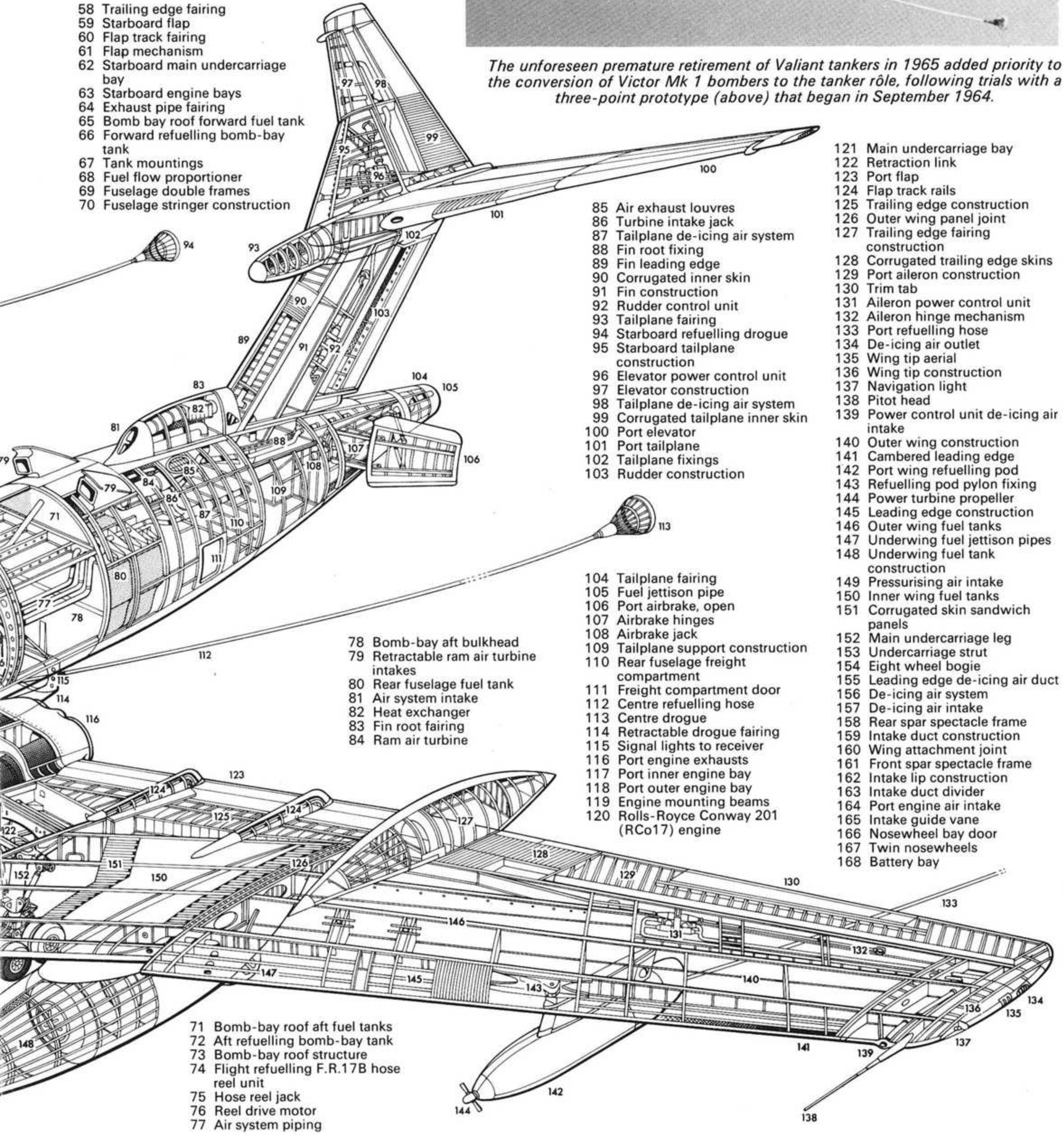
Handley Page Victor K Mk 2 Cutaway Drawing Key



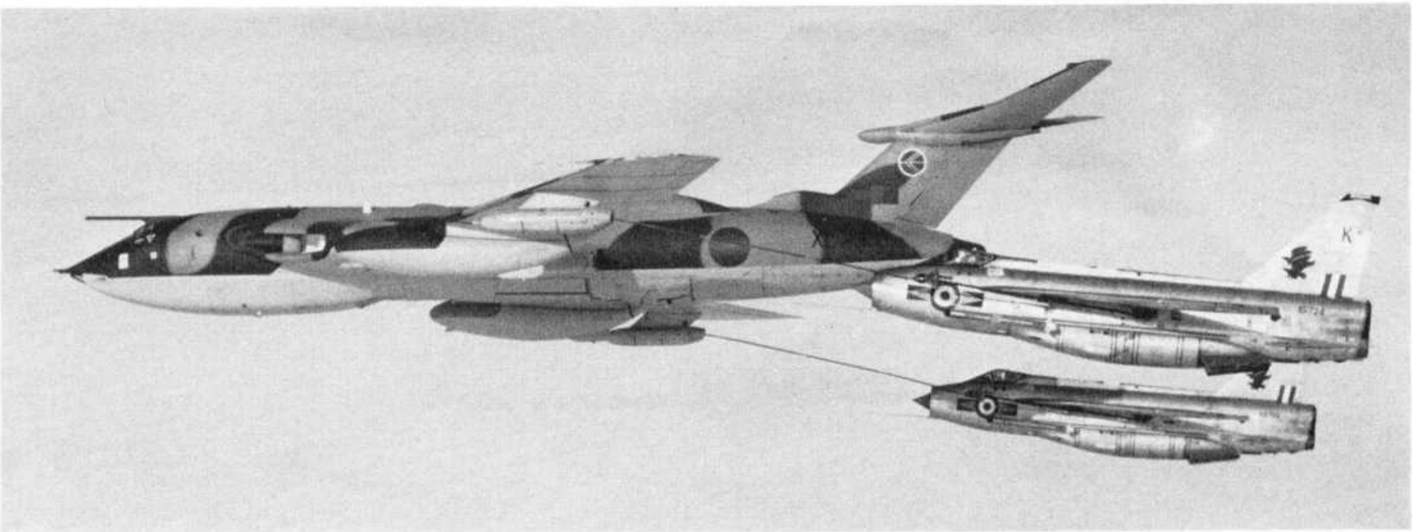
1 Nose probe
2 Control feel system pressure intake
3 Nose compartment windows
4 Nose construction
5 In-flight refuelling probe
6 Windscreen
7 Refuelling searchlights
8 Jettisonable roof hatch
9 Co-pilot's Martin Baker ejection seat
10 Pilot's roof hatch windows
11 Pilot's Martin Baker ejection seat
12 Control column
13 Instrument panel
14 Rudder pedals
15 Air intake to air-conditioning system
16 Radome
17 Throttles
18 Pilot's side console
19 Cockpit floor
20 External door handle
21 H_2S radar scanner
22 Radar mounting and equipment
23 Rearward facing crew members seats — AEO port, nav-plotter centre, nav-radar starboard
24 Cockpit door
25 Entry steps
26 Front fuselage construction
27 Rear view periscope
28 Rearward facing crew members work table
29 Cabin side window
30 Air conditioning system
31 Nose freight compartment
32 Instrument panels
33 Radio and electronics racks
34 Pressure bulkhead
35 Air conditioning intake
36 Starboard emergency life-raft hatch
37 Port life-raft pack
38 Forward fuselage connecting construction
39 Wing spar bulkhead
40 Wing centre-section fuel tank
41 Overwing fuel tank
42 Starboard engine intake
43 Intake ducts
44 De-icing air system
45 Underwing fuel tank
46 Starboard wing fuel tanks
47 Fuel flow proportioner
48 De-icing connector to outer wing
49 Vortex generators
50 Starboard flight refuelling F.R.20B refuelling pod
51 Power turbine propeller
52 Pylon mounting
53 Pitot head
54 Starboard wingtip
55 Starboard aileron
56 Trim tab
57 Refuelling hose



The unforeseen premature retirement of Valiant tankers in 1965 added priority to the conversion of Victor Mk 1 bombers to the tanker rôle, following trials with a three-point prototype (above) that began in September 1964.



58 Trailing edge fairing
59 Starboard flap
60 Flap track fairing
61 Flap mechanism
62 Starboard main undercarriage bay
63 Starboard engine bays
64 Exhaust pipe fairing
65 Bomb bay roof forward fuel tank
66 Forward refuelling bomb-bay tank
67 Tank mountings
68 Fuel flow proportioner
69 Fuselage double frames
70 Fuselage stringer construction
71 Bomb-bay roof aft fuel tanks
72 Aft refuelling bomb-bay tank
73 Bomb-bay roof structure
74 Flight refuelling F.R.17B hose reel unit
75 Hose reel jack
76 Reel drive motor
77 Air system piping
78 Bomb-bay aft bulkhead
79 Retractable ram air turbine intakes
80 Rear fuselage fuel tank
81 Air system intake
82 Heat exchanger
83 Fin root fairing
84 Ram air turbine
85 Air exhaust louvres
86 Turbine intake jack
87 Tailplane de-icing air system
88 Fin root fixing
89 Fin leading edge
90 Corrugated inner skin
91 Fin construction
92 Rudder control unit
93 Tailplane fairing
94 Starboard refuelling drogue
95 Starboard tailplane construction
96 Elevator power control unit
97 Elevator construction
98 Tailplane de-icing air system
99 Corrugated tailplane inner skin
100 Port elevator
101 Port tailplane
102 Tailplane fixings
103 Rudder construction
104 Tailplane fairing
105 Fuel jettison pipe
106 Port airbrake, open
107 Airbrake hinges
108 Airbrake jack
109 Tailplane support construction
110 Rear fuselage freight compartment
111 Freight compartment door
112 Centre refuelling hose
113 Centre drogue
114 Retractable drogue fairing
115 Signal lights to receiver
116 Port engine exhausts
117 Port inner engine bay
118 Port outer engine bay
119 Engine mounting beams
120 Rolls-Royce Conway 201 (RCo17) engine
121 Main undercarriage bay
122 Retraction link
123 Port flap
124 Flap track rails
125 Trailing edge construction
126 Outer wing panel joint
127 Trailing edge fairing construction
128 Corrugated trailing edge skins
129 Port aileron construction
130 Trim tab
131 Aileron power control unit
132 Aileron hinge mechanism
133 Port refuelling hose
134 De-icing air outlet
135 Wing tip aerial
136 Wing tip construction
137 Navigation light
138 Pitot head
139 Power control unit de-icing air intake
140 Outer wing construction
141 Cambered leading edge
142 Port wing refuelling pod
143 Refuelling pod pylon fixing
144 Power turbine propeller
145 Leading edge construction
146 Outer wing fuel tanks
147 Underwing fuel jettison pipes
148 Underwing fuel tank construction
149 Pressurising air intake
150 Inner wing fuel tanks
151 Corrugated skin sandwich panels
152 Main undercarriage leg
153 Undercarriage strut
154 Eight wheel bogie
155 Leading edge de-icing air duct
156 De-icing air system
157 De-icing air intake
158 Rear spar spectacle frame
159 Intake duct construction
160 Wing attachment joint
161 Front spar spectacle frame
162 Intake lip construction
163 Intake duct divider
164 Port engine air intake
165 Intake guide vane
166 Nosewheel bay door
167 Twin nosewheels
168 Battery bay



Succeeding the Victor K Mk 1s and Mk 1As, the three-point Victor K Mk 2s now equip the RAF's two operational squadrons (Nos 55 and 57) as well as No 232 OCU. One of the latter's K 2s is here seen refuelling a pair of Lightning F Mk 6s of No 11 Squadron.

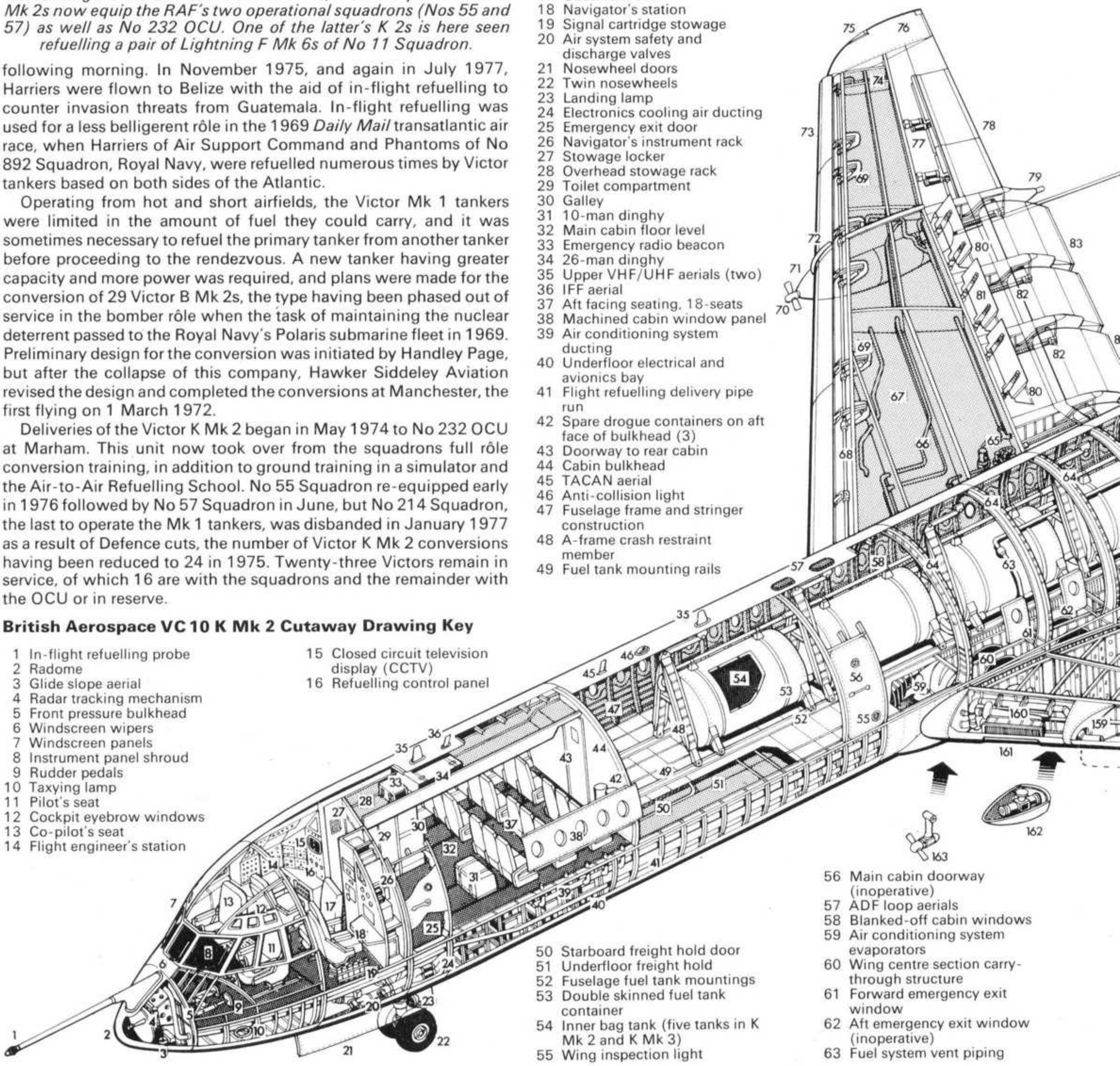
following morning. In November 1975, and again in July 1977, Harriers were flown to Belize with the aid of in-flight refuelling to counter invasion threats from Guatemala. In-flight refuelling was used for a less belligerent rôle in the 1969 *Daily Mail* transatlantic air race, when Harriers of Air Support Command and Phantoms of No 892 Squadron, Royal Navy, were refuelled numerous times by Victor tankers based on both sides of the Atlantic.

Operating from hot and short airfields, the Victor Mk 1 tankers were limited in the amount of fuel they could carry, and it was sometimes necessary to refuel the primary tanker from another tanker before proceeding to the rendezvous. A new tanker having greater capacity and more power was required, and plans were made for the conversion of 29 Victor B Mk 2s, the type having been phased out of service in the bomber rôle when the task of maintaining the nuclear deterrent passed to the Royal Navy's Polaris submarine fleet in 1969. Preliminary design for the conversion was initiated by Handley Page, but after the collapse of this company, Hawker Siddeley Aviation revised the design and completed the conversions at Manchester, the first flying on 1 March 1972.

Deliveries of the Victor K Mk 2 began in May 1974 to No 232 OCU at Marham. This unit now took over from the squadrons full rôle conversion training, in addition to ground training in a simulator and the Air-to-Air Refuelling School. No 55 Squadron re-equipped early in 1976 followed by No 57 Squadron in June, but No 214 Squadron, the last to operate the Mk 1 tankers, was disbanded in January 1977 as a result of Defence cuts, the number of Victor K Mk 2 conversions having been reduced to 24 in 1975. Twenty-three Victors remain in service, of which 16 are with the squadrons and the remainder with the OCU or in reserve.

British Aerospace VC 10 K Mk 2 Cutaway Drawing Key

1 In-flight refuelling probe
2 Radome
3 Glide slope aerial
4 Radar tracking mechanism
5 Front pressure bulkhead
6 Windscreen wipers
7 Windscreen panels
8 Instrument panel shroud
9 Rudder pedals
10 Taxying lamp
11 Pilot's seat
12 Cockpit eyebrow windows
13 Co-pilot's seat
14 Flight engineer's station
15 Closed circuit television display (CCTV)
16 Refuelling control panel
17 Observer's seat
18 Navigator's station
19 Signal cartridge stowage
20 Air system safety and discharge valves
21 Nosewheel doors
22 Twin nosewheels
23 Landing lamp
24 Electronics cooling air ducting
25 Emergency exit door
26 Navigator's instrument rack
27 Stowage locker
28 Overhead stowage rack
29 Toilet compartment
30 Galley
31 10-man dinghy
32 Main cabin floor level
33 Emergency radio beacon
34 26-man dinghy
35 Upper VHF/UHF aerials (two)
36 IFF aerial
37 Aft facing seating, 18-seats
38 Machined cabin window panel
39 Air conditioning system ducting
40 Underfloor electrical and avionics bay
41 Flight refuelling delivery pipe run
42 Spare drogue containers on aft face of bulkhead (3)
43 Doorway to rear cabin
44 Cabin bulkhead
45 TACAN aerial
46 Anti-collision light
47 Fuselage frame and stringer construction
48 A-frame crash restraint member
49 Fuel tank mounting rails



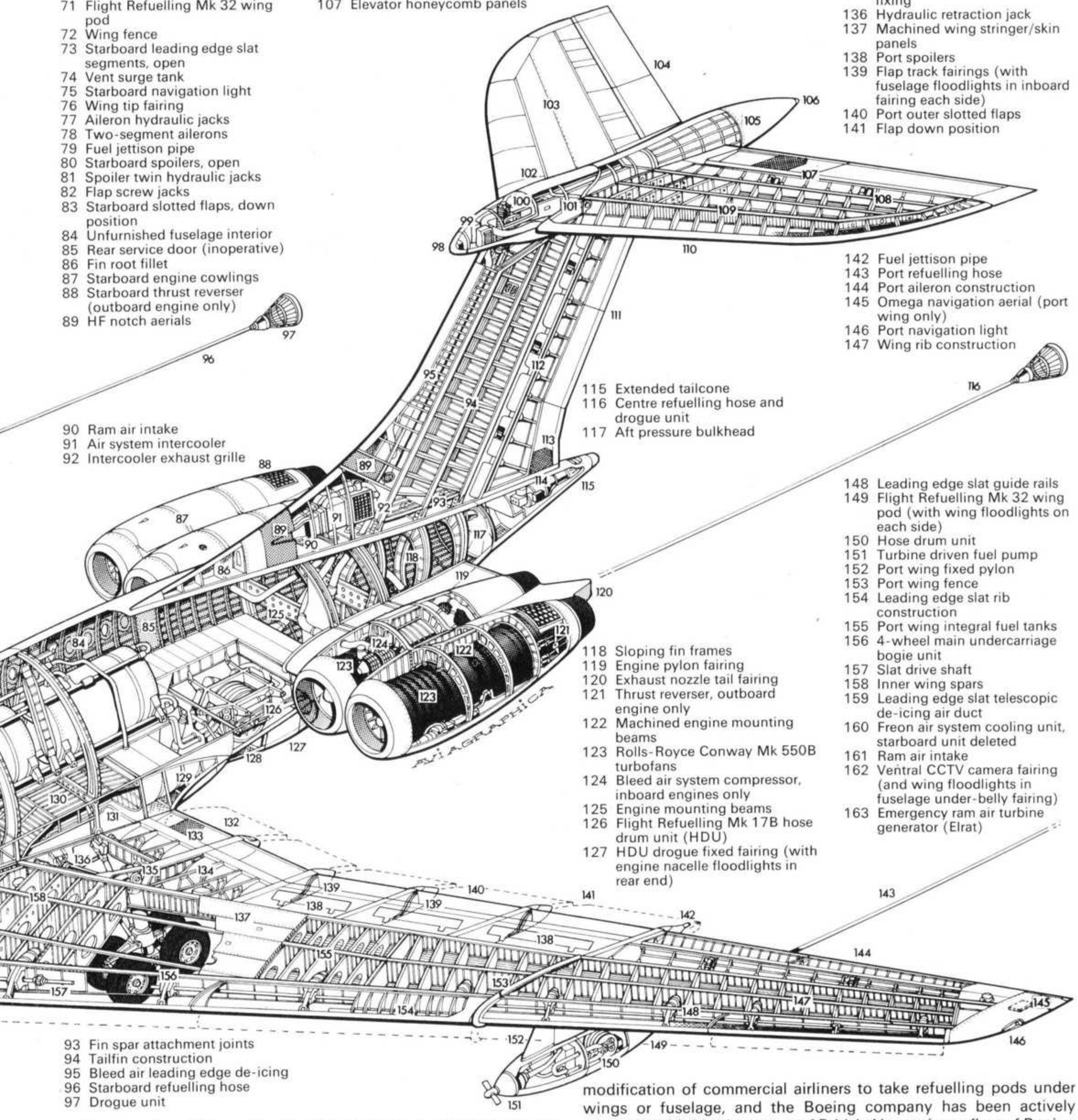
50 Starboard freight hold door
51 Underfloor freight hold
52 Fuselage fuel tank mountings
53 Double skinned fuel tank container
54 Inner bag tank (five tanks in K Mk 2 and K Mk 3)
55 Wing inspection light
56 Main cabin doorway (inoperative)
57 ADF loop aerials
58 Blanked-off cabin windows
59 Air conditioning system evaporators
60 Wing centre section carry-through structure
61 Forward emergency exit window
62 Aft emergency exit window (inoperative)
63 Fuel system vent piping

64 Wing attachment fuselage main frames
65 Wing tank boost pumps
66 Fuel system piping
67 Starboard wing integral fuel tanks
68 Leading edge slat drive shaft
69 Slat rails and jacks
70 Wind driven fuel pump turbine
71 Flight Refuelling Mk 32 wing pod
72 Wing fence
73 Starboard leading edge slat segments, open
74 Vent surge tank
75 Starboard navigation light
76 Wing tip fairing
77 Aileron hydraulic jacks
78 Two-segment ailerons
79 Fuel jettison pipe
80 Starboard spoilers, open
81 Spoiler twin hydraulic jacks
82 Flap screw jacks
83 Starboard slotted flaps, down position
84 Unfurnished fuselage interior
85 Rear service door (inoperative)
86 Fin root fillet
87 Starboard engine cowlings
88 Starboard thrust reverser (outboard engine only)
89 HF notch aerials

98 Aft glide slope aerial
99 VOR localiser aerial
100 Tailplane actuator screwjack
101 Tailplane pivot fixing
102 Fin/tailplane bullet fairing
103 Starboard tailplane
104 Two-segment elevators
105 Tailplane bullet fairing
106 Tail navigation light
107 Elevator honeycomb panels

108 Hydraulic elevator jacks
109 Port tailplane construction
110 Bleed air leading edge de-icing
111 3-segment rudder construction
112 Rudder hydraulic jacks
113 Honeycomb trailing edge panels
114 Rolls-Royce/Turboméca Artouste Mk 520 APU

128 Retractable air-inlet door for hose drum unit
129 Trailing edge wing root fillet
130 Pressure floor above wheel bay
131 Main undercarriage wheel well
132 Inboard slotted flaps
133 Flap honeycomb skin panels
134 Flap shroud ribs
135 Main undercarriage leg pivot fixing
136 Hydraulic retraction jack
137 Machined wing stringer/skin panels
138 Port spoilers
139 Flap track fairings (with fuselage floodlights in inboard fairing each side)
140 Port outer slotted flaps
141 Flap down position



142 Fuel jettison pipe
143 Port refuelling hose
144 Port aileron construction
145 Omega navigation aerial (port wing only)
146 Port navigation light
147 Wing rib construction

90 Ram air intake
91 Air system intercooler
92 Intercooler exhaust grille

115 Extended tailcone
116 Centre refuelling hose and drogue unit
117 Aft pressure bulkhead

118 Sloping fin frames
119 Engine pylon fairing
120 Exhaust nozzle tail fairing
121 Thrust reverser, outboard engine only
122 Machined engine mounting beams
123 Rolls-Royce Conway Mk 550B turbofans
124 Bleed air system compressor, inboard engines only
125 Engine mounting beams
126 Flight Refuelling Mk 17B hose drum unit (HDU)
127 HDU drogue fixed fairing (with engine nacelle floodlights in rear end)

148 Leading edge slat guide rails
149 Flight Refuelling Mk 32 wing pod (with wing floodlights on each side)
150 Hose drum unit
151 Turbine driven fuel pump
152 Port wing fixed pylon
153 Port wing fence
154 Leading edge slat rib construction
155 Port wing integral fuel tanks
156 4-wheel main undercarriage bogie unit
157 Slat drive shaft
158 Inner wing spars
159 Leading edge slat telescopic de-icing air duct
160 Freon air system cooling unit, starboard unit deleted
161 Ram air intake
162 Ventral CCTV camera fairing (and wing floodlights in fuselage under-belly fairing)
163 Emergency ram air turbine generator (Elrat)

93 Fin spar attachment joints
94 Tailfin construction
95 Bleed air leading edge de-icing
96 Starboard refuelling hose
97 Drogue unit

Designed for a 14-year life, the Victors will be due for replacement by the early 1990's. They are shortly to be supplemented by nine VC 10 tankers which are being converted by British Aerospace at Filton from commercial airliners — five Standard VC 10s which will become K Mk 2 tankers and four Super VC 10s which will be K Mk 3s. The VC 10 tankers are required in particular to support the forthcoming Tornado F Mk 2 air defence fighters. Beyond the Victor and VC 10, studies are already underway for a future tanker, possibly a version of the A300 Airbus if not a variant of a completely new multi-rôle large aircraft. Additional tanker aircraft might be made available by the modification of commercial airliners to take refuelling pods under wings or fuselage, and the Boeing company has been actively promoting this idea in respect of British Airways' new fleet of Boeing 757s and the Boeing 737s already in service with British airlines. Such a scheme is likely to involve an operating penalty which would call for compensation to be paid to the operator by the government — a scheme that may be hard to justify in a period of financial stringency. The air refuelling tanker is, nevertheless, an essential item in the RAF inventory, playing a vital rôle in allowing the combat aircraft to perform their appointed tasks. □

The author acknowledges the assistance of Flight Refuelling Ltd and the Public Record Office in the preparation of this article.

SORTIE WITH THE TANKERS

The following account describes a flight made by the author in a Victor K Mk 2 on a scheduled Harrier refuelling exercise.

BRIEFING for the flight, callsign "November 17", covered, as a matter of routine, emergency procedures, fuel loads, take-off speeds and navigation details. Originally the sortie had been scheduled over a North Sea "towline", but low cloud and drizzle threatened to cancel the exercise; when conditions improved in the West, however, a new towline was selected and the mission proceeded. With 105,000 lb (47 670 kg) of fuel, take-off weight was 221,000 lb (100 330 kg); decision speed was 139 knots (257 km/h) and rotate speed, 156 knots (289 km/h). Briefing complete, the crew went out to the Victor, checked the Form 700 and climbed aboard. The aircraft was "combat-ready", having had most of the pre-flight checks completed earlier by another crew. Ejector seat pins were removed and engine starting checks run through, the four Conways being started by air supplied from the Artouste AAP (airborne auxiliary powerplant).

Clearance obtained, the Victor taxied out and began its take-off run, but at about 90 knots (167 km/h) the captain aborted take-off after seeing a number of birds rise in front of the aircraft. Brake 'chute deployment was confirmed by the Nav-Radar crewman looking through his periscope, and the aircraft taxied back to dispersal for a birdstrike inspection after a number of badly-damaged birds had been noted lying on the runway. The crew transferred at once to another "combat-ready" aircraft whilst ATC arranged new timings with the Harrier squadron involved in the exercise. Weights and speeds were similar and this time the take-off was uneventful, the captain calling "committed" at decision speed and the aircraft then being accelerated to 300 knots (556 km/h) and climbed to Flight Level 350 (35,000 ft/10 670 m).

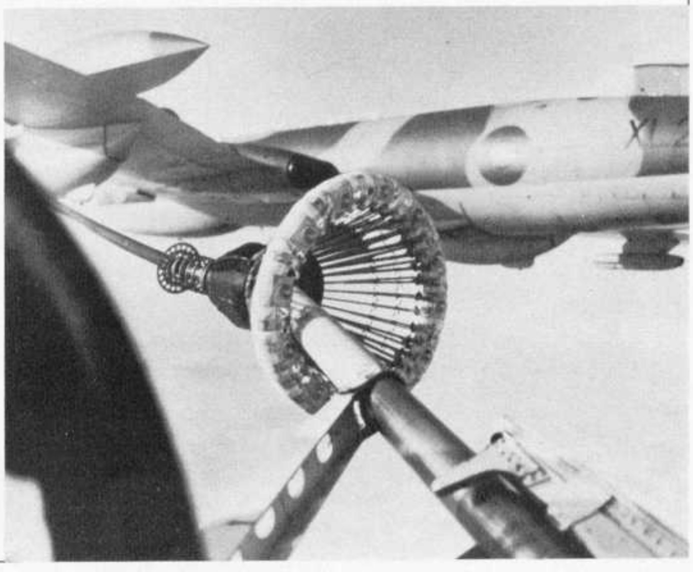
Top-of-climb checks were made and fuel contents compared with the pre-planned figure. Now under London Military Radar control, November 17 headed for Area 7 in the South-West and a "Charlie" rendezvous, this being performed under ground radar control. Radio contact was established with the Harrier leader, then at FL 220, and the Victor descended to FL 250, using airbrakes to increase the rate of descent. Pod hoses were trailed and pre-tanking checks carried out, and the Harriers' fuel requirements confirmed as dry or wet prod, with amount of offload. The first section was now within 10 miles (16 km) and the Nav-Rad was looking for them on his screen. As they approached, he monitored them continuously through the electrically-controlled periscope and provided a commentary for the captain: "Red light off ... fifteen feet ... ten feet ... five feet ... contact, fuel flow, your radios."

The second Harrier approached, but on making contact there was no indication of fuel flow on the control panel at the Nav-Rad position, although the receiver pilot confirmed fuel flow. Contact was broken and remade; fuel flow was now indicating and the fault was noted for subsequent debrief. There was now a Harrier T Mk 2 on the port drogue and a GR Mk 3 on the starboard side: both appeared almost stationary through the periscope. Red section Harriers having refuelled and cleared, White section approached, and again the Nav-Rad provided a commentary. London Military requested further intentions after this refuelling and were advised. "November 17" with "two chicks in tow" was now at FL 270 and 270 knots, 0·7M. White section having completed their prods, Red section took another turn; Red One made a dry contact this time and advised the captain of an unserviceable red light in the port pod: another snag for the debrief. Whilst the captain checked the fuel state and plotted weight and index, the co-pilot transferred fuel between tanks to keep the centre of gravity within limits.

At this point, the Air Electronics Officer announced that No 4 generator had failed, and that corrective drills had been unsuccessful. He recommended a return to base unless operational requirements dictated otherwise. London Military was advised of the curtailment of the exercise and a north-easterly heading was approved for the return. Red Two required more fuel so was asked to RV on the return leg, but other prods were declined.

As the flight had been scheduled to last for another two hours, the Victor was still above landing weight. The co-pilot calculated the amount of fuel to be jettisoned to get the aircraft down to landing weight, and transferred fuel to the underwing tanks in preparation for dumping. Briefing was completed for a TACAN approach, but the Duty Controller then advised of new diversions because of changing weather conditions.

Tanking-complete checks were made, with the exception of the trailing hoses, and fuel was dumped from the underwing tanks. A handover was made to Eastern Radar, and at FL 90, over the sea, the hoses were wound in and pod fuel dumped. It was now raining and an SRE approach was requested: the aircraft was vectored to avoid the worst of the weather, and at 2,000 ft (610 m) gear and flaps were extended and pre-landing checks completed. On landing, the brake 'chute was deployed and visually checked; taxying instructions were requested and the aircraft returned to dispersal. After shut-down and debrief, the crew returned to the first aircraft, which had meanwhile been checked for birdstrike damage and found serviceable, and restored it to "combat-ready" state before handing in their safety equipment and advising Operations of the sortie details. To an observer, the flight revealed many facets of the air-to-air refuelling rôle and showed how incidents and emergencies are overcome with the minimum of fuss and drama by crews who through constant training and operational missions are maintained at a high state of efficiency. □



"That Eagles Might Fly"

A personal account, by Flt Lt J Turner, of pilot training in the RAF

PILOT TRAINING in the Royal Air Force is one of the most exacting courses of instruction that exists anywhere in the world. It is open to any man aged 17-26 with a minimum of five 'O' levels who can convince the Officer and Aircrew Selection Board at RAF Biggin Hill that he has the necessary co-ordination, character and medical fitness. There are many applicants for the small number of places and selection standards are set high because it costs up to £1·7 million to train each pilot to a standard where he is fit for operational flying.

Service life starts with an 18-week period of Officer Training where, amongst a multitude of other things, the author of this account learned somewhat to his surprise that it is possible to lead a group of fellow trainees across the Brecon Beacons at night, despite all being cold, hungry and exhausted, for the RAF has always looked for qualities of leadership in its pilots, as well as flying skill. Eventually, Flying Training starts but it takes more than one course to produce an operational fighter pilot. You will visit at least six different stations and successfully complete over nine individual courses before arriving on a squadron. The courses all have one thing in common; they start in a classroom — but some end in the most unusual places; a decompression chamber, sitting beside a camp fire in Snowdonia eating a chicken caught that evening, or at a party to celebrate the awarding of your Pilot Brevet. So what is pilot training really like?

The first course takes place at the Aeromedical Training Centre, RAF North Luffenham. Having set your heart on becoming a pilot, you are told in great detail that not only your heart but your whole body was ill-designed for flying. However, the doctors who run the Centre make the best of the situation and fit you with equipment to reduce your body's shortcomings; a flying helmet to block out the noise of aircraft engines and protect your head should you end up on the wrong end of a parachute, and an oxygen mask to keep you alive at high altitude. The effects of *g* forces as you pull out from a loop (reduced blood flow to the brain, tunnel vision, blackout) are patiently explained, as are the dangers of decompression sickness, (not only deep sea divers can get the "bends"), as well as the symptoms of hypoxia, which occur when you attempt to live without an oxygen supply (blueness of the fingernails, euphoria, death).

You adjust to the discomfort and claustrophobia with your head encased in the helmet while your face is flattened by the oxygen mask. It is generally accepted by new pilots that the helmet, once fitted correctly, becomes comfortable when your head has changed shape to match the helmet, rather than vice-versa. There follows a spell in a decompression chamber, since experience is the best teacher. Once the trainee is installed, complete with helmet and mask, the air is pumped out to simulate the atmosphere as you climb to 20,000 ft (6 100 m) above sea level while a doctor explains the physiological effects as they occur. "Notice the expansion of the gases in your ears/stomach as we ascend. Swallowing will help ease any pain in your ears." When finally established at 20,000 ft (6 100 m), you are "invited" to remove your oxygen mask. After watching your fingernails turn blue, you are given a piece of paper and told to write your name, the first line of a nursery rhyme and to do some simple arithmetic. With the mask back in place and your brain working normally you are left looking at a sheet of paper with your name at the top and a child's scrawl at the bottom. Occasionally aircraft oxygen systems malfunction but, having experienced hypoxia, you should now recognise the symptoms and get the aircraft quickly down to a height where you can breathe normal air before they become severe enough to make you lose control.

Unless you already have logged 30 hours of recognised flying experience prior to entry in the RAF, the first flying course consists of 15 hours flying in the Chipmunk. These hours are designed to ensure that only people with a good chance of successfully completing pilot training start on the more costly jet aircraft course. The Chipmunk is something of a veteran. On starting the engine the cockpit is filled

The primary trainer used by the RAF for the first phase of pilot training continues to be the Jet Provost; the heading photo shows two Mk 5s of the RAF College, Cranwell. Students joining the RAF from the Universities will have flown first on the Bulldog (below).

with the smell of cordite from the cartridge starter, but that is soon forgotten as the aircraft checks are completed and the engine "wound up" to start taxying -- which is not as easy as it might appear since the aircraft sits back on its tail wheel with the engine rising in front of the cockpit, obscuring the forward view. Actually to make progress in one direction it is necessary to weave from left to right, alternately peering down each side of the engine cowling to ensure you are not about to run into something or somebody. During take-off, the Chipmunk swings sideways just as the Spitfire did — perhaps not so severely, but enough to unnerve the student and sharpen his co-ordination. Airborne, it is delightful — if you ignore the pounding from the four pistons in front of you and the nagging from the instructor who is determined to teach you something even if he loses his voice in the process!

The course lasts six weeks and you are soon back in the classroom learning about jet engines, aerodynamics, meteorology, fuel systems, electrical systems, mechanical systems — in fact everything that makes up a jet aircraft. You are taught about air traffic control, radio navigation aids and airmanship, which is really applied common sense for pilots. Having accumulated all this after hours of study and proved your knowledge in examination after examination, you are considered ready to start flying in the Jet Provost.

Towards first solo

During the next year you will fly approximately 150 sorties in the Jet Provost, about one-third of which will be solo. Students look forward to this flying with a lot of enthusiasm if not a little trepidation. The first hurdle is to learn to fly, but if you thought that was the total aim you would be very wrong. Flying is only the beginning. To reach the end of the course you will have to fly in cloud, in close formation, at night, at low level, high level, right to the limits of the aircraft's performance. You will remember the first hurdle for the rest of your life and it will probably leave quite an impression on your instructor.

It has often been said that the Royal Air Force has the best pilots in the world. Much of the credit for this is due to the instructors produced by the Central Flying School at RAF Leeming, where operational pilots are taken and taught to teach. Some students are convinced that part of this process includes surgery to remove any sense of humour, but they appreciate the effort and lost heart beats expended by their instructors by the end of the course. Airborne instruction is mainly a matter of demonstration, practice, correction and more practice, accompanied by inspiration, persuasion, cajolement and, just occasionally, threats of physical violence from the instructor when you insist on repeating the same mistakes. Your instructor's aims are to impart not only skills but experience and the correct mental attitude. You will need aggression tempered with a sense of responsibility in your future career. While airborne your life and that of many others will be in your hands. The many rules must be remembered and obeyed. Aviation has no place for irresponsibility.

The first four sorties investigate the effects of the flight controls. "Watch what happens as I pull back on the stick. Now you do it." Each lesson is progressively more complex, the student doing a greater proportion of the flying until you can take-off, fly the aircraft and land it, remembering the checks to be done at the right time. You know how to recover the aircraft should you fly too slow and stall and have practised the drills required in the event of a system malfunction. Several sorties are spent "in the circuit": take-off, fly round the airfield, make an approach. Back on the runway push the throttle forward and take-off again. Each time do all the checks, adjust your "circuit pattern" to allow for the other students doing the same exercise and endeavour to fly at the correct speed and height. At some stage in this process the instructor will break the flow, telling you to land and taxi to the control tower. He then unstraps and climbs out of the aircraft, throwing back at you: "Do one circuit, just like the last four. You've proved to me you can do it, now prove it to yourself. If the first approach isn't right go around and make another, and please don't crash because I've signed for the aircraft!" This will be your first solo flight in a jet aircraft.

Now you are on your own. A short taxi to the runway where you do the pre-take-off checks. Line up on the runway and open up the throttle, checking the engine instruments to ensure the engine is still running properly. Release the brakes and as you accelerate down the runway notice your heart is beating faster than you can ever remember and is trying to work its way into your throat. It's already time for the after take-off checks, followed by a turn into the circuit pattern. A quick glance to the right confirms the instructor's seat is still empty. You've got airborne on your own; to get back on the ground safely is the next task.

Pre-landing checks, double check that the undercarriage is down and turn onto the final approach. Adjust for crosswind, correct the speed and aim for the runway. At the right speed the wheels hit the ground with a squeal of scorched rubber, inaudible to you over the noise of the engine. Throttle to idle, check the brakes and decelerate before turning off at the far end of the runway. Don't forget the after-landing checks as your pulse rate slowly returns to normal and you taxi back to dispersal. News of a "first solo" travels fast and the other students who had gathered outside the squadron building to watch your flight are already dispersing, though you probably didn't have time to notice them.

The first hurdle over, there are many more to come. These are the flying tests which you will now work towards, flown with an examiner instead of your normal instructor and arranged at regular stages throughout the course. There are General Handling tests to ensure your aerobatics, practice emergencies, circuits and airmanship are safe and accurate. Later come instrument flying tests to prove you can make a landing approach through cloud to a runway, and navigation tests when you plan and fly a route from your airfield to another at high, medium and low level, using radio aids and visual features on the ground. Each test requires progressively higher standards from you and is preceded by a work-up phase flown dual and solo, as your instructor improves your performance and techniques and you practise on your own.

On many days you will not fly at all, perhaps because of bad weather. However, "not flying" does not mean "not working". Thirty hours are spent in the Instrument Trainer, practising instrument flying and procedures as well as emergency drills. There is also book work to be done, increasing your understanding of aircraft systems and aviation, studying and preparing maps, improving your knowledge of all the techniques taught on the course. Each sortie requires preparation on the ground. Pilot navigation requires the use of mental arithmetic, and it is accepted among the students that you always seem to leave half of your brain on the runway when you take-off. This leads to the simplest calculation becoming very difficult and taking a long time to complete. Controlling the aircraft and thinking at the same time has always been a stumbling block for student pilots: many instructors must have heard their student, thinking out loud, say, "Two-thirds of twelve is, err ... er ...". Practising the types of navigation calculations used, while on the ground, makes them easier whilst airborne when there is little time to spare.

Just as in any other profession, military flying has its own language, which the student quickly assimilates. Everything is abbreviated. General handling becomes GH, instrument flying is IF, air traffic control ATC. It is not uncommon to hear a whole mass of these acronyms and ciphers in a conversation: "We should have done GH but the weather was too bad so the QFI decided to do IF. We did an SID, UPs, QGH to PAR, an SRA followed by a VOR/DME to ILS. I really got my head chewed off when I forgot to set the QFE and nearly missed the DH." The phonetic alphabet becomes second nature, since you use it on the aircraft radio — and a "nought" is always a zero.

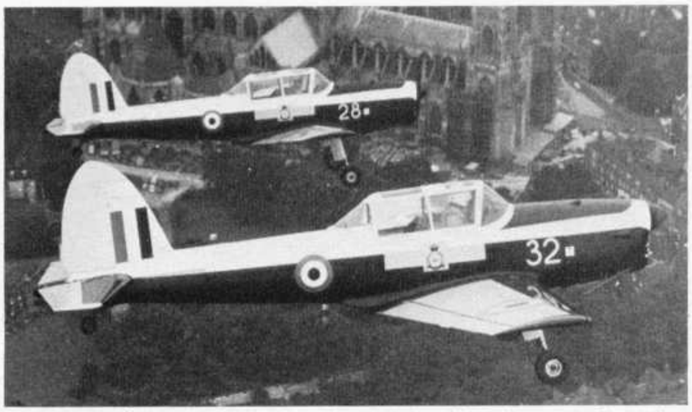
Not all students are able to achieve the standards required in flying within the number of sorties available. This is no place for the slow learner, for extra sorties are an expensive luxury which the taxpayer cannot afford. Of the total number of initial trainees about 20 per cent will eventually reach a 'Fast Jet' squadron. Some others will be streamed into the multi-engine or helicopter world after the Basic Flying Course, and some will be transferred to other aircrew categories or the ground branches. Their departure is noted with some sadness and a realisation of your own vulnerability. It is also a good incentive to work even harder. More than luck is needed to pass this course — you need ability and dedication.

On to Advanced Training

Eventually you reach the Final Navigation Test and Final Handling Test, flown with a senior examiner. In order to pass these you must show yourself suitable to graduate to the Advanced Flying Training School when you will be flying a much faster and more complex aircraft. Having satisfied the requirements, you celebrate with the others who made it and pack your bags, setting off for Anglesey and RAF Valley but travelling via North Luffenham to do another aeromedical course, this time covering the oxygen system of the Hawk T Mk 1.

At Valley it is back to the classroom again, learning about the new aircraft systems you will have to handle, discovering that the laws of aerodynamics learnt at Basic Training change dramatically once an aircraft goes supersonic. Halfway through this "ground school" you take a break from the classroom to enjoy a weekend of survival

The second principal phase of pilot training in the RAF is now conducted exclusively on the British Aerospace Hawk, which is in service for advanced training at No 4 FTS, Valley, and for Weapons Training at Nos 1 and 2 TWUs at Brawdy and Chivenor.



Elderly de Havilland Chipmunks, built in Britain to a Canadian design, remain in use with the RAF to assess the aptitude of student pilots before they start their training proper.

training in the mountains of Snowdonia, for whilst at Valley you will fly over some of the most inhospitable areas of the United Kingdom and should you eject from the aircraft will need to survive until a rescue helicopter can collect you. This short course teaches you how to build shelters, trap wild life and fish with the emergency equipment included in the survival pack which accompanies you on the end of your parachute. These subjects were all covered theoretically during Basic Training but now you can put them into practice. Since it is also possible that you may in the future be shot down over enemy territory the arts of camouflage and night navigation on foot are learnt. Low flying at seven miles a minute is easy compared with walking through a forest in the middle of Snowdonia at night without getting lost, battered by pine branches and exhausted.

Ground school concludes with a week spent flying the Hawk simulator, practising the checks and becoming familiar with the switches. Many of the controls are not duplicated in the instructor's rear cockpit and on your first flight you will need to make a large number of switch selections during the sortie. There is one further requirement to meet before you start flying the Hawk. The dinghy pack and parachute harness differ from those of the Jet Provost and you must be able to operate them should you end up in the sea. You've done dinghy drills before, but never in such surroundings. The proving ground, or more exactly sea, is the outer reaches of Holyhead Harbour.

Kitted out with all the equipment in which you will fly, complete with parachute harness attached to a long rope, you are thrown off the back of an RAF Marine Craft and dragged through the water "at a fast walking pace". All you have to do is release the harness, inflate the dinghy and climb aboard, all in double quick time as the sea temperature gets very low in the winter. When the dinghy has been baled out you can sit back and enjoy the view of the surrounding hills, rocks and car ferries, concentrating on not being sea-sick before the Search and Rescue helicopter arrives. Finally the helicopter winchman fishes you out of the sea and unceremoniously deposits you back on the deck of the boat. Perhaps you once thought that pilots simply had to fly aircraft!

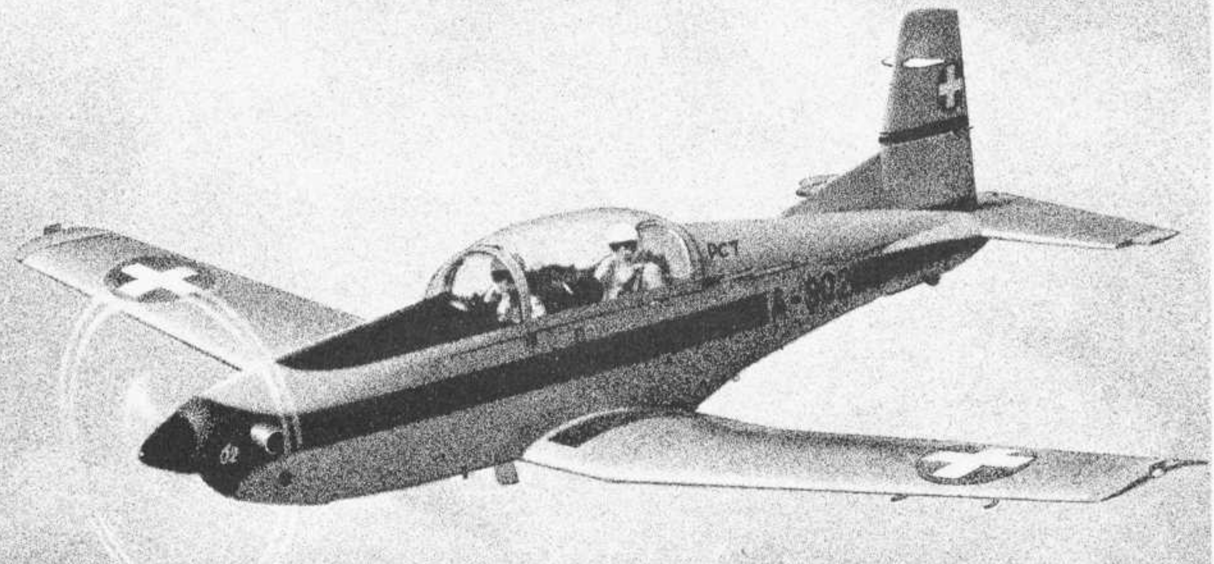
Now you can get airborne again. The Hawk rapidly becomes as familiar as the Jet Provost. Your first solo on the Hawk includes a flight round the Island of Anglesey and is a chance to see more of the local area. From this point the applied flying starts, staying in close formation through more exacting manoeuvres — "hanging on" is the expression used — tail-chasing or following another aircraft throughout the sky as it loops, rolls and spirals, neither closing or opening the gap between you. Low level navigation takes on a new light as you learn to fly down valleys or adjust your flight to allow for the weather conditions, mentally replanning your route as you go.

Towards the end of the course you spend less time thinking about flying the aircraft, which has now become second nature, and more about operating it. No longer is formation flying a matter of hanging on, now you must lead while another student formates on you. Tactical formation, similar to that used on operational squadrons, is introduced. Naturally you must still be proficient at general handling, able to carry out aerobatic sequences and fly accurate circuits. Your instrument flying has to be good to allow you to fly solo in poor weather, and occasionally a real emergency may sharpen your emergency drills.

You still spend long periods on the ground revising, practising and planning. Now you need to study aircraft identification, plus aircraft and weapon systems performance which become increasingly important before you reach an operational squadron. Each sortie still requires preparation — and did you really understand the points your instructor made in the debrief of your last sortie? Throughout training you have gone through the process of preparation, briefing, flying and debriefing. While each sortie only lasts one hour it may well require over three and a half of dedicated concentration.

There are still flying tests — these will continue throughout your career — but a pass in this Final Handling Test means you have qualified for the Pilot Brevet. This is awarded at a "Wings Ceremony" which is always followed by a big party. You deserve congratulations on completing Advanced Flying Training (after all, several of your friends were not so successful) but there is still a long way to go before becoming a Junior Pilot on your first squadron. You still have not fired a gun or rocket, or dropped a single bomb, and have yet to learn how to engage another aircraft in combat. These will be taught at the Tactical Weapons Unit. Once these new "arts" have been mastered the introduction to your operational aircraft — Phantom, Harrier, Jaguar, Buccaneer, Lightning or Tornado — will be made at an Operational Conversion Unit where you will really learn to fly and fight. From the Conversion Unit you will be posted to your first squadron and there commence a six-month "work-up" period. Only after all that will you start to repay your training as an Operational Fighter Pilot. That is what flying training is all about. □

An unusual formation mounted by examples of the three principal RAF pilot trainers — Hawk, Jet Provost and Bulldog — led by a Jetstream, used for multi-engine pilot training. All four types are products of British Aerospace.



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WARPAC'S TACTICAL AIR POWER
...the perilous imbalance

THE FUNDAMENTAL PRINCIPLE pervading all Soviet military thought today is the primacy of the offensive, and, in the Soviet view, it is axiomatic that any successful aggressive action equates with immediate establishment and subsequent retention of air supremacy. Without supremacy in the air, a ground offensive must inevitably develop at a slower tempo, affording the opposition time to organise defence and perhaps frustrate the advance.

Air supremacy was, for many years, the trump card held by the West; air power was the one sphere of military endeavour in which there was confidence of technological if not numerical superiority over the Warsaw Pact (WarPac) forces. Thus, the main combat element of the Soviet Air Forces of most concern to NATO in Europe, the tactical component known in Soviet parlance as Frontal Aviation *(Frontovaya Aviatsiya)*, or FA, maintained a primarily defensive posture; its most important tasks were attenuation of the NATO air threat and the protection of rear areas from NATO interdiction.

From the early 'seventies, Soviet tactical aviation began to undergo primary reorientation; a radical shift in emphasis from the defensive to the offensive made possible by the progressive erosion of NATO's technological lead. Today, that lead upon which the West relied so heavily is tenuous indeed and now limited to certain aspects of propulsion technology and avionics. Indeed, in some aspects, such as attack helicopters, the Soviet Union is now leading the West by a substantial and widening margin.

How has the West lost over the past decade the vital lead in military aviation technology that it had held for so many years? Technical advance is inextricably linked with money spent, and in a period when Western defence expenditure has consistently diminished in *real* terms, the Soviet Union has been willing to spend the money necessary to make up the technological leeway. The 'seventies saw Soviet defence expenditure, already dramatically higher than that of the West, grow in real terms by some 35 per cent! At the beginning of the last decade, military expenditure by the Soviet Union accounted for between 11 and 13 per cent of the gross national product (GNP); by the beginning of the 'eighties it had risen at least a further one per cent to range between 12 and 14 per cent, or more than double that of any Western nation as a proportion of the GNP.

This immense and continuing drain on the Soviet Union's national resources has been accepted in furtherance of a determination to become militarily the world predominant power in every sphere, and the dramatic effects of such colossal expenditure on the quality and capability of the Soviet armed forces are nowhere more apparent than in the Air Forces in general and in Frontal Aviation in particular.

Not that the Soviet government is forthcoming on the subject of military expenditure. The only information that it issues is restricted to a single-line entry under *Defence* in the annual state budget which claims with singular naïveté that expenditure was virtually static throughout the 'seventies, and actually decreased from a peak of 17,900m roubles in 1972 to 17,120m roubles in 1979! Such figures are demonstrably false; there is no way in which they can possibly be reconciled with the immense observed increases in military capabilities over this period — tangible evidence too overwhelming to be seriously contested. Military spending in 1978, for example, certainly totalled between 70,000m and 75,000m roubles compared with an announced 17,230m roubles.

Between 1970 and 1980, Soviet military expenditure grew in real terms at an annual average rate of 3·7 per cent, serious crises in the overall Soviet economic situation notwithstanding, and spending on the Soviet Air Forces *per se* consistently grew faster than the average rate of defence expenditure as a whole. The growth rate dropped fractionally during the closing years of the decade, but is now picking up once more as new weapon procurement programmes — and there are many in the pipeline — are implemented.

More than 40 per cent of expenditure has been devoted to air power throughout the 'seventies and into the 'eighties, this emphasis on air capability also being seen in spending on equipment. The year 1979 may be taken as a typical example. In that year the proportion of the total procurement budget expended on aircraft was 27 per cent, whereas only some 10 per cent was devoted to vessels for the Navy and nine per cent to equipment for the Army. Furthermore, about 20 per cent of the budget was devoted to research and development — a percentage that has been maintained throughout the past 10 years — as compared with 10 per cent of very much smaller budgets in the USA and UK. In fact, Soviet research and development expenditure is greater than that of the entire Western World!

With such inordinate military investment, it is scarcely surprising that Western service chiefs have expressed intense concern, not merely at the immense numerical imbalance but at the pace at which Soviet technical development, as demonstrated by the Soviet Air Forces' latest combat aircraft, has overtaken the West in nearly all respects. Forty major airframe and aero engine factories, supported by a host of smaller complexes, have produced upwards of 25,000 military aircraft over the past 10 years, and are currently manufacturing for Soviet Air Forces, the non-Soviet WarPac countries and the various foreign recipients of Soviet military aid 1,300-1,400 fixed-wing military aircraft and 500-600 helicopters annually — sufficient to re-equip the entire front line inventories of the RAF, the *Armée de l'Air* and the *Luftwaffe* every 18 months!

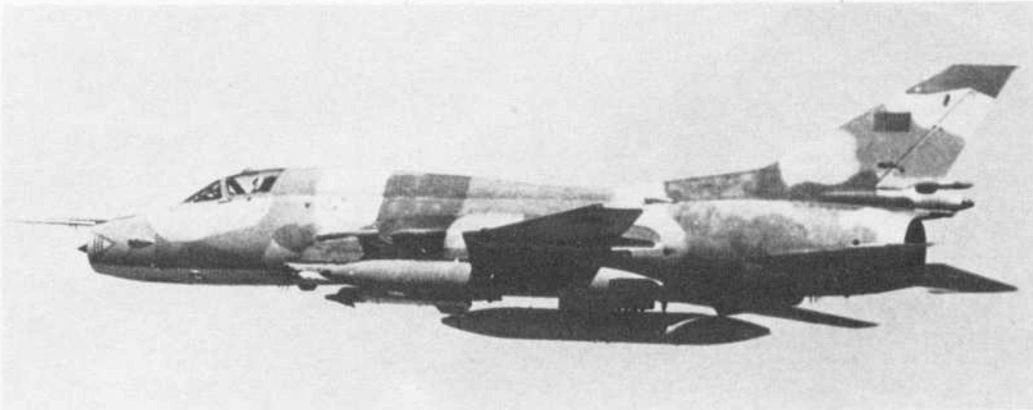
Emphasis on TacAir

While in recent years effort has been, and is continuing to be, directed towards enhancing the capabilities of the Soviet Air Forces across the entire spectrum, it is in the sphere of tactical aviation that the most impressive gains have been made. Not that there have been dramatic technical breakthroughs, nor dramatic surges in manufacture of tactical aircraft. It is the cumulative result of year-by-year improvement realised by vast investment over a prolonged period that has radically changed the situation and presented NATO with the perilous imbalance in respective air capabilities that it now faces.

The Frontal Aviation inventory was dominated at the beginning of the 'seventies by comparatively unsophisticated aircraft characterised by high agility, but short on both payload and endurance by Western standards. NATO then possessed a usefully exploitable measure of air superiority. These aircraft have been almost entirely supplanted by types that have entered production over the course of the past decade; dual-rôle warplanes offering double the tactical radius and treble the warload potential. With very respectable LO-LO-LO penetration capabilities and relatively sophisticated avionics, these afford WarPac for the first time a credible all-weather capability; they tote a varied assortment of recently-introduced air-to-surface ordnance, from laser-guided bombs and electro-optical- and laser-guided missiles, to cluster munitions and specialised airfield attack weapons.

Frontal Aviation, which now presents this daunting threat, is by far the largest of the three distinctive elements comprising the Soviet Air Forces, the others being the so-called Long-range Aviation *(Dal'nyaya Aviatsiya)* and the Transport Aviation *(Voenno-transportnaya Aviatsiya)*. The Air Force of the Anti-aircraft Defence of the Homeland *(Protivo-vozdushnaya Oborona [Strany])*, the most extensive air defence organisation in the world, constitutes a separate armed service, while the Naval Air Force *(Aviatsiya Voenno-Morskovo Flota)* is subordinate to the Navy. Subordinate to the authority of the commander of the "front", or group of armies, to

(Head of opposite page) A photograph of the Sukhoi Su-24 Fencer two-seat counterair and interdiction aircraft which has been referred to as the "most lethal warplane in the Soviet inventory"! (Top right) A Fitter-F, one of several export versions of the Sukhoi Su-20 tactical fighter (also see page 48) which is second in numerical importance in Soviet Frontal Aviation to the Flogger family of fighters, the principal versions of which are also illustrated on this page. (Above) Seen in Czechoslovak service is the MiG-23BM Flogger-F which is an optimised air-ground model. (Right) The MiG-23MF Flogger-B air-air fighter which is extensively used in the air defence cover rôle by Frontal Aviation, and (below) MiG-27 Flogger-Ds of an accompaniment regiment assigned to the Trans-Baikal Military District. There are now upwards of 1,600 Floggers of various versions in the Frontal Aviation inventory.



The Sukhoi Fitter family of ground attack fighters provides an extraordinary example of incremental design development, the example illustrated left being one of the latest members of the family, Fitter-H which features an extensively recontoured fuselage. There are currently some 700-800 examples of the variable-geometry Fitter now included in the inventory of Frontal Aviation, the fixed-geometry Su-7 Fitter-A having now been phased out of the FA, although small numbers remain with non-Soviet WarPac air forces (eg, that of Czechoslovakia).

which its elements are assigned, Frontal Aviation now fields some 4,800 fixed-wing tactical aircraft and over 1,000 armed helicopters; it has reserves of almost half as many again.

Between 65 and 70 per cent of Frontal Aviation is deployed in the non-Soviet WarPac countries and the westernmost Military Districts of the Soviet Union, this proportion being clearly assigned to European "contingencies". To these forces facing NATO in Europe can be added the non-Soviet WarPac air forces which contribute about 2,400 fixed-wing air defence, counterair, ground attack and reconnaissance aircraft, with the first category predominating, plus more than 800 helicopters. As yet, these "satellite" air arms have still to undergo a comparable capability upgrading to that of Frontal Aviation, although they have absorbed a modest infusion of late-generation Soviet aircraft over the past two-three years. There is some evidence that these "satellite" forces are viewed in certain respects by their Soviet mentors as forward extensions of the Soviet air defence system, providing the necessary defensive depth to counter NATO deep penetration interdiction.

Frontal Aviation is divided into 16 FA Armies comprising 112 regiments and seven independent squadrons assigned to the Forces Groups outside the borders of the Soviet Union and to the various Military Districts into which the Soviet Union is divided. An FA Army is variable in its size which is based on the importance of the area to which it is assigned. For example, the 16th FA Army assigned to the Group of Soviet Forces in Germany possesses approximately 1,000 tactical aircraft, the 37th FA Army in Poland as a component of the Northern Group of Forces has some 350 tactical aircraft, while the 13th FA Army in the Leningrad Military District has fewer than 200 aircraft and the 5th FA Army in the Kiev Military District barely 100 aircraft. For practical organisation purposes, the largest unit of the FA Army is the Division *(Divisiya)*, and there are usually divisions devoted to air defence cover *(prikrytiye)*, support *(podderzhka)* and air accompaniment *(soprovozhdeniye)**, plus autonomous reconnaissance *(razvedka)* and transport *(transportnaya)* regiments. A Division consists of three and sometimes more regiments *(polki)* each usually possessing three squadrons *(eskadrilii)* of 16-18 aircraft, including a rotational reserve.

In keeping with Soviet determination that no future conflict will be fought over Soviet soil, an extensive network of air bases for Frontal Aviation use has been established in the buffer zone of "satellite" states around the Soviet Union's western periphery. Indeed, so affluent is the WarPac in air bases that it is claimed that the forward bases to which FA regiments deploy periodically in peacetime would not need to be used in a conflict until Soviet ground forces have advanced West of the Rhine! US intelligence agencies state that there are sufficient air bases within 100 naut miles (185 km) of the Federal German border to support some 2,560 combat aircraft and additional bases within 200 naut miles (370 km) for a further 1,630 aircraft.

As with NATO, the WarPac has divided the European theatre into North, Central and Southern sectors, the main concentration of Frontal Aviation being, needless to say, on the Central Sector which is divided into forward and rear areas, the former including the 325-naut mile (600-km) deep "satellite" territory buffer zone and the westernmost Military Districts. US intelligence estimates indicate that within four days of mobilisation NATO would face in the Central Sector 2,100 WarPac fixed-wing tactical aircraft and 900 helicopters within 54 naut miles (100 km) of the FLOT (Front Line of Troops), a further 1,300 fixed-wing aircraft and 1,100 helicopters within 110-215 naut miles (200-400 km) of the FLOT and yet a further 1,300 fixed-wing aircraft and 200 helicopters within 215-325 naut miles (400-600 km) of the FLOT (ie, to the Soviet border). From the FLOT to a distance of 300 naut miles (555 km) within WarPac airspace about 2,350 air-air fighters would be available to oppose any NATO penetration. If these estimates are accurate, they present a daunting picture of the tactical air power that WarPac can mount rapidly in support of operations in the Central Sector.

Potent offensive aircraft

The third-generation combat aircraft that have entered service with Frontal Aviation since the early 'seventies have, to a greater or lesser degree, dual-rôle capability as an intrinsic design feature, but their respective design bureaux have expended much effort in evolving variants optimised for specific tasks and an outstanding example is provided by the variable-geometry MiG-23. Introduced into the ranks of both Frontal Aviation and the IAP-VO *Strany* (the interceptor fighter component of the P-VO *Strany*) during 1971-72 as a straight air-air fighter, with, in the case of Frontal Aviation, a nominal secondary fighter-bomber capability, the MiG-23 has evolved as a family of closely-related tactical aircraft, which, currently being produced at a rate of about 50 a month, are now numerically the most important types in FA service and also represent approximately 25 per cent of the total 2,500 fighter inventory of the IAP-VO *Strany*.

Assigned the reporting name *Flogger* by the Air Standards Coordinating Committee, the MiG-23 in its air-air forms (ie *Flogger-B* and *Flogger-G*) shares the air defence cover task in the FA Armies with late-series MiG-21 *(Fishbed)* versions, which it is expected to have totally displaced by 1984-85. It possesses a secondary ground support rôle in keeping with the Soviet view that Frontal Aviation exists only as an adjunct to the Army and all FA aircraft must therefore be capable of the primary service's direct support. Very capable aeroplanes carrying the large and powerful J-band *High Lark* radar, which has a maximum search range of some 45 naut miles (85 km) and the ability to track targets at up to 30 naut miles (55 km), *Flogger-B* and *-G* are powered by the Tumansky R-29 turbofan which has maximum basic and reheat thrust ratings of 17,635 lb (8 000 kg) and 25,350 lb (11 500 kg) respectively.

These two versions of the primarily air-air MiG-23 differ essentially in that *Flogger-G* embodies minor aerodynamic changes resulting in some gain in agility. Both retain the 23-mm twin-barrel GSh-23L cannon on the fuselage centreline and a quartet of AAMs distributed between stations under each air intake trunk and the fixed wing glove, and although the AA-2 *Atoll* is still widely used, the primary armament of air-air *Floggers* would now seem to be a mix of semi-active radar homing AA-7 *Apex* medium-range and IR-homing AA-8 *Aphid* dogfight missiles. For their secondary ground support task, these versions of *Flogger* carry UV-16-57 or similar rocket packs, or such drop weapons as 1,102-lb (500-kg) bombs in lieu of the AAMs.

Maximum speeds range from M=1·1 at sea level to M=2·3 transiently around the tropopause in clean condition, a typical combat radius with centreline fuel tank and minimal allowance for dash or combat being 510 naut miles (945 km), but *Flogger* would be at a distinct disadvantage in air combat with the F-15 Eagle from

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**Air defence cover is self explanatory, but "support" and "air accompaniment" are respectively taken to mean the delivery of air-to-ground ordnance in the vicinity of the frontline and the delivery of ordnance in support of ground forces operating beyond breached enemy defences. The Soviet Union does not usually employ the western terms "interdiction", "counterair" or "close air support".*

several aspects. It must be borne in mind, however, that the Soviet fighter is of much earlier concept, and there is mounting evidence that the ability of such advantages as those enjoyed by the F-15 to confer real leverage on the outcome of air-air combat depends on tactical and doctrinal circumstances.

While there has been as yet no evidence to suggest development of a more advanced air-air version of *Flogger*, the Soviet penchant for the incremental evolution of a basic design should not be discounted, and in view of the importance of this basic type to Frontal Aviation — there are currently some 1,600 *Floggers* of all versions in the FA inventory of which upwards of 40 per cent fulfil the air defence cover mission — which is likely to be maintained throughout the 'eighties, it is reasonable to anticipate further uprating of the basic turbofan, adaptation for progressively more advanced versions of *High Lark* and other radar systems and, by mid-decade, the application of new AAMs. Two all-aspect shoot-down missiles that could have some relevance to *Flogger*'s future intercept capability and are currently reported to be under development, with operational status expected around the mid-'eighties, are referred to as the AA-XP-1 and -2. These have high- and low-altitude launch ranges of 19 and 11 naut miles (35 and 20 km) and 38 and 21·5 naut miles (70 and 40 km) respectively.

The development of dedicated air-ground versions of *Flogger* specifically to FA requirements followed on that of the basic air-air model, providing Frontal Aviation with its first credible LO-LO-LO strike and interdiction capability at night and in adverse weather. The first of the air-ground members of the MiG-23 family to achieve operational status, *Flogger-F* (MiG-23BM), began to reach FA support and air accompaniment regiments in quantity in 1975-76. Apart from having an R-29B turbofan incorporating modifications optimising it for the primary air-ground mission, *Flogger-F* features extensive commonality with the air-air version, but from the cockpit forward is entirely new, the nose being recontoured and a deeper windscreen with sloping quarterlights being introduced to improve visual target acquisition. The downward-tapered nose with flattened base line houses a laser rangefinder and marked target seeker, Doppler, terrain avoidance radar and an enlarged nosewheel. Some armour protection for the pilot has been introduced into the flattened sides of the nose — which, judging by the number of small vortex generators that they carry, must have presented the Mikoyan-Gurevich team with some airflow problems.

The GSh-23L cannon is retained by *Flogger-F*, together with the five external stores stations of the air-air versions, these being capable of carrying (with reduced internal fuel) up to 9,920 lb (4 500 kg) of ordnance for short-range missions, loads including up to six 1,102-lb (500-kg) "iron" bombs. Alternative loads include various bomblet packs or rocket pods, and presumably the AS-7 *Kerry* ASM on the glove hardpoints, this M=0·6 beam rider having a range of about 5 naut miles (9,5 km) and weighing some 2,650 lb (1 200 kg). It is to be assumed that *Flogger-F* will also eventually carry the AS-X-9 M=0·8 anti-radiation homing missile with a 48 naut mile (90 km) range or the semi-active laser-guided M=0·8 AS-X-10 with a 5 naut mile (9,5 km) range.

Whereas *Flogger-F* could be considered, by Soviet standards of evolutionary design, a minimum-change air-ground member of the MiG-23 family, a version tailored more closely for ground attack followed it rapidly into FA service. This, *Flogger-D*, was evidently considered to embody sufficient changes to warrant a new type designation, emerging as the MiG-27. In developing this dedicated version, the Mikoyan-Gurevich team consciously sacrificed high-altitude M=2·0 capability to obtain improved low- and medium-altitude mission radius, the turbofan of the MiG-27 sharing a common core with that of the MiG-23 but having a larger LP compressor and shorter, simplified two-position exhaust nozzle. Consistent with the primary requirement of high subsonic speeds at low levels and having a simplified afterburner augmenting an estimated 14,330 lb (6 500 kg) dry thrust by some 25 per cent, the Tumansky turbofan of the MiG-27 breathes via larger-area fixed inlets with belled lips and small fixed splitter plates.

The forward fuselage of the MiG-27 *Flogger-D* is essentially similar to that of *Flogger-F*, apart from some augmentation of the side armour, and to enhance grassfield operational potential, tyres of slightly increased diameter and greatly increased width have been applied to the main undercarriage members. These have necessitated the enlarging of the wheel bays by bulging the bay doors and the adjacent fuselage structure, increasing the local fuselage cross section. The twin-barrel GSh-23L cannon common to all other *Floggers* has given place in *Flogger-D* — and its progressive development, *Flogger-J* — to a six-barrel 23-mm Gatling-style rotary cannon, the first such weapon to be applied to a Soviet aircraft. The current production *Flogger-J* is characterised by a longer nose embodying two optical flats as compared with the one of *Flogger-D*, and small fillets have been introduced above each intake box, these giving more lift and thus a slightly enhanced turning performance. Although suffering some degradation of speed performance by comparison with the MiG-23s, these MiG-27 versions are believed to have maximum speeds of around M=0·95 at sea level and M=1·6 at altitude. Estimated combat radius LO-LO-LO with a 176 Imp gal (800 l) centreline tank and four 1,102-lb (500-kg) bombs plus two AA-2 *Atoll* AAMs for self-defence is about 210 naut miles (390 km) at M=0·8, allowing for dash and escape at M=0·95.

It is anticipated that production of the *Flogger* family will continue until 1986-87 and match in quantity the MiG-21 *Fishbed*, over 6,000 of which have been manufactured since 1956; this older aircraft is being retained in production for export only at a rate of some 200 aircraft annually. Numerically less important than the *Flogger* family in the ranks of Frontal Aviation, but with some 700-800 in current FA service and production running at 17-18 monthly, the semi-variable-geometry second-generation *Fitter* family is the second most important type serving with the support and air accompaniment regiments.

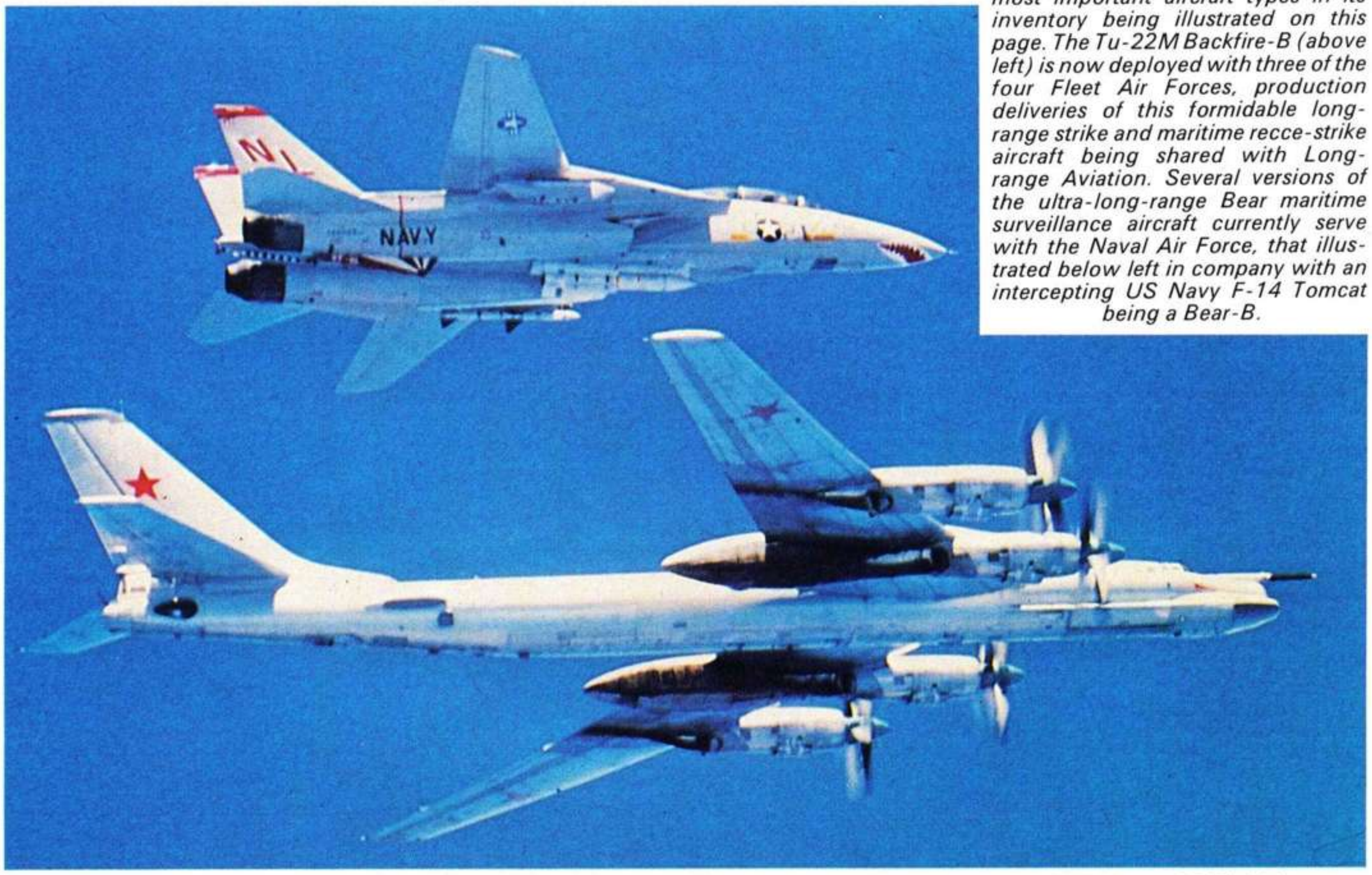
The Fitter family

The Sukhoi-designed *Fitter* series provide an even more astonishing example of incremental design development than does the *Flogger* family, demonstrating once more that the traditional Soviet reluctance to relinquish a sound basic design until its potential has been exploited to the ultimate remains unchanged. The original Sukhoi Su-7 *Fitter-A* was a second-generation ground attack fighter which began to enter Frontal Aviation service at the end of the 'fifties, but had little to offer apart from good low-level gust resistance and manoeuvrability, and highly-regarded handling qualities, its payload/range capabilities being abysmal by Western standards of the day. However, what apparently started out as a low-cost exercise in variable wing sweep using the Su-7 airframe with pivot points at half-span, evidently demonstrated very real gains, for, with a more powerful Lyulka AL-21F turbojet replacing the AL-7F, the semi-variable-geometry derivative entered production as the Su-17 *(Fitter-C)*, beginning to reach Frontal Aviation in 1971.

The *Fitter-C* proved capable of lifting from much shorter airstrips almost double the ordnance load of its non-VG predecessor and carrying it some 25-30 per cent farther. Thus, by comparatively simple and economical means, the Sukhoi bureau evolved a third-generation, multi-rôle warplane toting respectable payloads over reasonable distances. The next stage in the evolution of the *Fitter* family came in 1976, with the introduction of *Fitter-D*, which was the first model to be equipped with terrain-avoidance radar and a laser marked target seeker, the laser ranger being accommodated within the lower half of the intake centrebody and the fuselage nose being lengthened to permit a flat elongated-lozenge-shaped avionics housing to be mounted beneath the nose, ahead of the nosewheel bay. Exported (as *Fitter-F*) from 1977, the Sukhoi fighter now introduced a vertically asymmetric increase in rear fuselage diameter and a deeper dorsal fin (a two-seat equivalent being *Fitter-E*), but even more radical changes came mid-1979 with the service introduction of *Fitter-H* (and its two-seat conversion training equivalent, *Fitter-G*).

The current production version of this Sukhoi tactical fighter, *Fitter-H* mates the changes introduced by *Fitter-F* with a new forward fuselage which is both deepened (to incorporate internally the equipment pack mounted externally under the nose of the preceding single-seat model) and drooped (to improve visual target acquisition). The decking behind the aft-hinging canopy is both raised and broadened (to produce optimum aerodynamic form and maximum internal fuel capacity), and the vertical tail surfaces are enlarged (to compensate for the inevitable destabilising effect of the deeper forward fuselage). The performance of *Fitter-H* can be assumed to be much the same as that of *Fitter-C* and *-D*, with a M=2·17 maximum speed being reached transiently in clean condition, the sea level maximum being of the order of M=1·06. Combat radius of *Fitter-H* with fuel tanks on the outboard wing pylons and a 4,410-lb (2 000-kg) ordnance load is about 235 naut miles (435 km) LO-LO-LO and 365 naut miles (675 km) HI-LO-HI, some 1,100 Imp gal (5 000 l) of internal fuel capacity being available for its AL-21F-3 engine, which has a max military rating of 17,195 lb (7 800 kg) boosted to 24,700 lb (11 200 kg) with full reheat.

Although Frontal Aviation is by far the largest of the Soviet Air Forces, the capabilities of all elements of Soviet air power have been dramatically enhanced in recent years and the Naval Air Force, in particular, has increased its potency, three of the most important aircraft types in its inventory being illustrated on this page. The Tu-22M Backfire-B (above left) is now deployed with three of the four Fleet Air Forces, production deliveries of this formidable long-range strike and maritime recce-strike aircraft being shared with Long-range Aviation. Several versions of the ultra-long-range Bear maritime surveillance aircraft currently serve with the Naval Air Force, that illustrated below left in company with an intercepting US Navy F-14 Tomcat being a Bear-B.



The only fixed-wing aircraft yet deployed aboard the Kiev-class anti-submarine carriers is the Yak-36MP Forger VTOL fighter, two examples of which are seen below aboard the Minsk. *Forger possesses the primary rôles of fleet defence against shadowing maritime aircraft, reconnaissance and anti-shipping strike. A third Kiev-class carrier, the* Novorissiisk, *is currently undergoing sea trials.*

The most recent addition to Frontal Aviation and certainly one of the most important is Su-24 *Fencer-A*, which has been referred to by some Western analysts of WarPac capability as the "most lethal warplane in the Soviet inventory"! The first Soviet purpose-designed interdiction aeroplane, *Fencer* has a terrain-following penetration and strike faculty immeasurably superior to that of any other FA aircraft and apparently the ability to penetrate NATO airspace at low altitude from bases beyond the practical reach of most of NATO's counterair and interdiction equipment. There are now upwards of 500 *Fencers* deployed within the Baltic, Carpathian and, most recently, Far Eastern Military Districts, and the production rate is currently 8-9 monthly.

The Soviet equivalent of the General Dynamics F-111, the variable-geometry *Fencer* is very similar to its USAF counterpart, but some 12 per cent smaller and lighter. FA service introduction began late in 1974, and *Fencer* apparently has two Tumansky R-29B turbofans similar to that of *Flogger-F* for which there is maximum internal fuel capacity of about 2,860 Imp gal (13 000 l). Maximum take-off weight is 87,080 lb (39 500 kg), and in addition to a similar 23-mm six-barrel Gatling-style cannon to that carried by *Flogger-D* and *-J*, *Fencer* can carry 22 "iron" bombs of 220-lb (100-kg) or 551-lb (250-kg) each, or 16 of the 1,102-lb (500-kg) bombs distributed between a total of nine weapons stations, those stations beneath the intake trunks, the wing glove and the movable wing panels taking adaptor shoes for a variety of air-to-surface missiles.

Maximum ordnance can, of course, be carried over only a restricted LO-LO-LO profile, but trading off some of its ordnance for maximum internal fuel and a pair of 440-Imp gal (2 000-l) combat tanks, *Fencer* has a HI-LO-HI combat radius of about 910 naut miles (1 700 km) with a 4,400-lb (2 000-kg) ordnance load, assuming a M=0·9 cruise at 36,000 ft (11 000 m) plus a 100-naut mile (185-km) dash-and-escape radius at sea level at M=1·2. Thus, from, say, Chernyakhovsk, near the Soviet Baltic coast and one of the current operating bases for this type, *Fencer* can reach most potential targets

The armed helicopter force now being fielded by Frontal Aviation and the non-Soviet WarPac forces has assumed truly major proportions and presents a serious threat to NATO. The Hind-D, tailored for the combat rôle, is illustrated top right and immediately right in Czechoslovak service, the most proliferous Soviet armed helicopter being Hip, seen below in East German service in its Hip-C form.

in the UK. With two combat tanks and low-drag ordnance on four pylons, *Fencer* is believed to be capable of reaching 40,000 ft (12 190 m) within about 1·5 minutes of brakes-off, and maximum speeds of M=2·3 above 36,000 ft (11 000 m) and M=1·2 at sea level.

This formidable trio of basic tactical fighter types is supported in Frontal Aviation by a steadily diminishing number of MiG-21s, with the *Fishbed-L* and *-N* versions of the MiG-21bis preponderating in the air defence cover rôle and in excess of 200 examples of *Fishbed-H* (MiG-21R and -21RF) remaining for tactical reconnaissance. The latter augment some 150 MiG-25s in both *Foxbat-B* and *-D* forms, the former combining photo-reconnaissance and ELINT (Electronic Intelligence) capabilities and the latter being an optimised ELINT version, these both being derivatives of the *Foxbat-A* interceptor of the IAP-VO *Strany*. A small number of Yak-28 *Brewer-E* electronic air defence suppression aircraft are still included in the FA front line inventory, but their task has now been largely assumed by a version of the semi-variable-geometry Sukhoi *Fitter*.

Enhanced battlefield potential

Whereas the *Flogger* and *Fitter* families, and *Fencer*, have greatly heightened existing Frontal Aviation capabilities since the mid-'seventies, a newfound capability has been introduced by the Mil Mi-24 *Hind* series of assault and anti-armour helicopters which are unquestionably more potent than anything yet fielded by the West. Appreciably more than 1,000 *Hind* helicopters, in a number of versions, have been manufactured since the Mi-24 first began to enter the Frontal Aviation inventory at the end of 1972 as an assault transport helicopter possessing some close support and anti-armour capability *(Hind-A)*, and production is continuing at a rate of 15-20 monthly.

The bulk of Mi-24 production over the past five-six years has been devoted to versions tailored for the combat rôle (*Hind-D* and *-E*), and although between 20 and 25 per cent of deliveries in the two most recent years have been for export to non-Soviet WarPac and other countries, Frontal Aviation regiments deployed in the Central Sector alone have more than 500 *Hind* helicopters for the support mission, including about 200 and 100 respectively of the extremely formidable *Hind-D* and *-E*, the latter being expected to replace the former over the next two-three years.

While retaining the basic airframe, power plant and transmission of the assault transport Mi-24, and the ability to accommodate a squad of eight fully-equipped troops, *Hind-D* introduced a redesigned forward fuselage for the primary gunship task, with tandem vertically-staggered cockpits and a barbette-mounted four-barrel 12,7-mm Gatling-type machine gun providing air-air as well as air-ground capability. The structure was hardened, sensors in an undernose pack included radar and low-light-level TV, and provision was made for four underwing pods with a total of 128 57-mm rockets plus four AT-2 *Swatter* 55-lb (25-kg) radio command-guided anti-armour missiles with terminal homing on wing endplate pylons.

Since *Hind-D* achieved operational status late 1975, considerable attention has evidently been devoted to upgrading the capabilities of the basic model, resulting in the *Hind-E* appearing in FA regiments early 1979. Retaining the paired 1,500 shp Isotov TV2-117A turboshafts and with further structural hardening, *Hind-E* has the *Swatter* missiles replaced with tube-launched AT-6 *Spirals* homing onto targets illuminated by a laser designator and, with a range of some 4-5 naut miles (7,5-9,0 km), offering markedly improved stand-off ability. Further augmenting their already spectacular firepower, at least some *Hind-E* helicopters have the barbette-mounted machine gun replaced with a 23-mm multi-barrel Gatling-type cannon with a 3,200 rpm fire rate, markedly increasing effectiveness in the anti-helicopter mission.

Far outnumbering *Hind* in the FA helicopter-equipped regiments is its progenitor, the Mi-8 *Hip*, of which over 6,000 have been built since 1961. Powered in its latest versions by 2,200 shp Isotov TV3-117 engines which replace the 1,700 shp TV2-117As, *Hip* serves Frontal Aviation in several forms, the principal of these being the basic assault transport *Hip-C*, which can carry 128 57-mm rockets in four packs on lateral outriggers; *Hip-D* which performs electronic duties, and *Hip-E* which has a flexibly-mounted 12,7-mm gun in the nose and can carry 192 57-mm rockets in six packs plus four AT-2 *Swatter* anti-armour missiles. The primary task of *Hip* is to deposit assault troops, equipment and supplies immediately behind the enemy lines and evacuate casualties, and for this purpose it can carry up to 28 fully-equipped troops, 8,820 lb (4 000 kg) of freight or 12 casualty litters. Production of *Hip* is continuing at the present time at a rate of some 60 monthly, but, of late-'fifties concept, it is likely to give place to a more modern — or at least modernised — helicopter on the assembly lines within the next two years, this possibly being the Mi-18.

Also a product of late-'fifties technology is the Mi-6 *Hook*, Frontal Aviation's standard heavy lift helicopter, with 350-400 of the 850 or so helicopters of this type built remaining in service with FA transport regiments and continuing as a vital element in the Soviet battlefield mobility concept. *Hook* has been out of production for some years, but its successor in FA service has now emerged with operational capability expected during the mid-'eighties. This, the Mi-26 *Halo*, owes much to its predecessor, but has a rather larger tailboom, an exceptionally large eight-bladed rotor and almost double the installed power of *Hook*, this believed to be in excess of 20,000 shp. Several other new helicopters have attained at least the pre-production stage in the Soviet Union recently, these including the Mil Mi-17 and the Kamov Ka-126 and Ka-32, but their relevance, if any, to Frontal Aviation is as yet unknown.

For the mid-'eighties

There can be no doubt that the modernisation of all facets of Frontal Aviation will continue during the 'eighties, and a number of new tactical aircraft are likely to achieve initial operational capability around mid-decade. These include a new fixed-wing close support aircraft analogous to the A-10 Thunderbolt II but somewhat smaller and ascribed to the Sukhoi design bureau. Referred to as the Ram-J (having been first observed by satellite reconnaissance at the Ramenskoye experimental establishment), this aircraft is, according to US intelligence sources, powered by a pair of 11,240 lb (5 100 kg) Tumansky R-13-300 turbojets and has a gross take-off weight of the order of 36,000 lb (16 330 kg). Equipped with a Gatling-type anti-armour rotary cannon system, it allegedly possesses 10 external ordnance stations (eight wing and two fuselage) each capable of carrying a 1,102-lb (500-kg) bomb, a rocket pod or (four inboard wing stations) a mix of the several types of anti-armour and anti-

The MiG-25 Foxbat fulfils an important reconnaissance rôle with Frontal Aviation. Combining photographic reconnaissance and electronic intelligence capabilities, two Foxbat recce aircraft assigned to the Trans-Baikal Military District are illustrated below.

radiation missiles now entering the FA inventory. There is some disagreement among Western intelligence agencies as to the likely timescale for initial operational capability by this Sukhoi CAS aircraft, but circumstantial evidence suggests that it is unlikely to be deployed in regimental strength much before 1983-84.

US intelligence sources also allege that three new fighter development programmes are in progress in the Soviet Union, two of which may have some relevance to Frontal Aviation in the second half of the decade. While believed to be primarily intended for IAP-VO *Strany* operation, their deployment in one form or another by Frontal Aviation seems likely in view of Soviet emphasis on dual-rôle capability in most combat aircraft development programmes. Referred to as Ram-K and Ram-L, these aircraft are respectively ascribed to the Mikoyan and Sukhoi bureaux. The former, which is expected to attain initial operational capability in the intercept rôle with the IAP-VO *Strany* from 1984-85, is a 60,000-lb (27 215-kg) category variable-geometry aircraft with a thrust-to-weight ratio of 1·3:1·0, a maximum speed capability ranging from M=1·1 at sea level to M=2·3 at the tropopause, and a combat radius of 550 naut miles (1 020 km). It is expected to have a track-while-scan radar with a 60 naut mile (110 km) search mode and a 45 naut mile (83 km) track capability, and an internal cannon will augment a six-missile armament.

The parallel Sukhoi development is of fixed-wing geometry, is expected to have a similar speed capability to the Mikoyan fighter, a 1·2:1·0 thrust-to-weight ratio, a 500 naut mile (925 km) combat radius and an armament comprising an internal 30-mm cannon and eight missiles. Its track-while-scan radar is credited with a 130 naut mile (240 km) search range and a 100 naut mile (185 km) track range. If these intelligence assessments are reasonably accurate, then both the Mikoyan and Sukhoi fighters will be formidable aircraft and the Soviet Union's favoured incremental evolution policy will almost certainly assure them places in Frontal Aviation's inventory in due course.

During the past decade, the tactical air component of the Soviet Air Force has been subjected to a total and relentless programme of modernisation and the present decade will almost certainly witness a continuation of this programme, with the last vestiges of the technological gap that for so long favoured the West disappearing. Almost 3,000 Allied combat aircraft (including those of the *Armée de l'Air*) are currently deployed in Europe, some 500 of them belonging to the USAF. Only about one quarter of NATO's conventional tactical air assets are devoted primarily to air-air missions and the stocks of late model air-air missiles available to NATO for these aircraft are well below what are considered to be minimal requirements.

The Fishbed-H, seen above in Polish service, still fulfils an important tactical reconnaissance function with both Frontal Aviation and the non-Soviet WarPac air forces.

The numerical imbalance in NATO's Central Region in tactical aircraft is of the order of two to one in WarPac's favour. A similar situation exists in the Northern Region, and although this imbalance is currently less marked in the Southern Region, considering the immense areas to be defended, the danger is no less parlous. The adverse implications for NATO are accentuated by the asymmetry existing between the requirements for tactical air of the two sides. By and large, the conventional defence of the West depends more heavily on air power than would a WarPac offensive, for NATO must not merely gain and hold air superiority over the battlefield, it must bring to bear enough firepower to help compensate for its numerical inferiority on the ground. Assuredly, the imbalance has never been more perilous. □

LIGHTNING ***from page 23***

marks had gone only as far afield as Cyprus, even with tanker support.

Some 62 Lightning F 3s were built to various modification standards, the first (XP693) flying on 16 June 1962. Deliveries to AFDS commenced in January 1964 and in the course of that year the F 3 was used to equip the Leuchars wing, with No 74 Sqn converting from the F 1 and No 23 Sqn converting from the Javelin. Around the end of the year Nos 56 and 111 Sqn at Wattisham converted from the F 1A to the F 3, and in 1967 No 56 Sqn moved to Akrotiri (Cyprus), where the unit remained until 1976.

The T 5 is the two-seat equivalent of the F 3. A prototype (XM967) flew on 29 March 1962, and the first of 20 production aircraft followed on 17 July 1964. Deliveries to the OCU began in April 1965.

To conclude the story of Lightning development as an interceptor for the RAF, the F 6 was in essence a late-model F 3 with all the long-range modifications, being originally referred to as the F 3* or F 3A. It had the cambered wing with extended tip chord, the enlarged ventral tank, and provision for overwing 260-Imp gal (1 182-l) ferry tanks.

An early-build F 3 (XP697) flew in this configuration on 17 April 1964. In November 1965 deliveries of the first of 62 production F 6s took place to AFDS, followed shortly by the equipping of No 5 Sqn, also at Binbrook. The following year saw No 74 Sqn at Leuchars converting from the F 3 to the F 6, as did the co-based No 23 Sqn in 1967, when No 74 Sqn moved to Tengah (Singapore). In the same year the final two Lightning squadrons were formed, No 11 Sqn at Leuchars with the F 6, and No 29 Sqn at Wattisham with the F 3, making a total of nine operational units.

One modification introduced in 1967 was a spring-type arrester hook, which in emergency engaged with a runway cable attached to a hydraulic arrester gear. This was developed after it had been found that, on running a Lightning into a conventional arrester barrier, the upper part of the barrier would ride over the cockpit and slash open the spine, often setting fire to the starter fuel. A later modification was to place two cannon in the forward end of the ventral tank, reducing its fuel volume to 535-Imp gal (2 432-l).

This combination of gunpod and fuel tank was one of a number of developments of the F 6 undertaken by BAC for the export Lightning. The other principal change was the use of two underwing pylons to carry single 1,000-lb (455-kg) bombs. The company also proposed a series of further developments, including twin carriage of bombs on the two underwing pylons, and a variety of weapons (including bombs) on the overwing pylons. However, the writer has no evidence that either customer adopted these proposals.

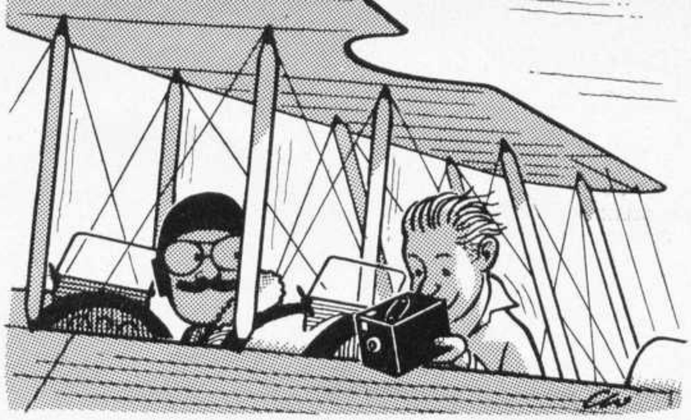
The single-seat export aircraft is the Mk 53, of which 34 were bought by Saudi Arabia and 12 by Kuwait. The two-seater is the Mk 55, of which six were bought by Saudi Arabia and two by Kuwait. The first F 53 (RSAF serial 53-666) made its maiden flight on 1 December 1966, and the first delivery took place in December 1967. Deliveries to Kuwait took place in 1968. In order to stop Yemeni incursions, the Saudi deliveries were preceded by the delivery of five ex-RAF F 2s and two ex-RAF T 4s under a programme which included Hunters and Thunderbird SAMs and was code-named *Magic Carpet*. The F 53 is the only Lightning variant thus far to have been used in anger, the type being employed late in 1969 for ground strikes against border positions in Yemen. Kuwait operated its Lightnings for only seven years, then grounded them in favour of the Mirage.

Britain's own phasing-out of the aircraft began in 1971, with No 74 Sqn disbanding in Singapore. In 1974 Nos 111 and 29 Sqn converted to the F-4 Phantom, as did No 23 Sqn in the following year. Lightnings were withdrawn from Nos 92 and 56 Sqn in 1976, and from 19 Sqn in 1977.

This left Nos 5 and 11 Sqn at Binbrook, flying a mixture of F 6s and F 3s, plus a training flight and a number of Lightnings in storage. Recent reports indicate a total of 19 F 3s, 43 F 6s, and 10 T 5s, ie, 72 in all at that station, of which approximately 40 are in storage. In July 1979 it was announced that the stored Lightnings would be used to form a third squadron of the Binbrook wing, to strengthen UK air defences pending the advent of the Tornado F 2. This scheme was abandoned early in 1981 as an economy measure, however, although it was said that Lightning reserves would be maintained so that the strength of the two remaining squadrons could be quickly supplemented in time of real emergency.

It thus seems that what is now (since 1977) the British Aerospace Lightning will remain in service until around 40 years from when it was first conceived. No mean achievement, surely, for an aircraft that began life simply as a transonic research vehicle! □

(Right) ***1921:*** *The young Wren-bird in an Avro 504K, revelling in his first flight.* *(Below)* ***1981:*** *Three-score years later, Chris Wren prepares to celebrate his diamond jubilee in a Hawker Hunter T 7 piloted by Gp Capt Ned Frith, AFC, Superintendent of Test Flying and Training at the Aircraft & Armament Experimental Establishment, Boscombe Down, Wiltshire.*



Sixty years of flying . . .

and still going strong!

Chris Wren, specialist for half a century in aviation cartooning and journalism, here discourses entertainingly on flying in the '30s and the '80s.

IN THE SUMMER of 1921 a boy of 13, rather tall for his age, hurried out to an Avro 504K, a World War I biplane, his young mind a whirl of emotions. Uppermost was elation, followed closely by apprehension. Standing at the edge of the field were his smiling father and anxious mother. They had paid five shillings — 25 pence — to indulge their eldest boy's ambition to sample the thrilling hazards of flying.

Now, half a century and ten years on, there remain clear memories of a first flight which had everything a boy could wish for — right from the excitement of the start-up when the leather-helmeted god of a pilot called out "Contact!" as the signal for a mechanic to swing the propeller and release a tempest of noise and vibration and raging slipstream which smelled exquisitely of burnt castor oil, the rotary engine's lubricant. I was lucky — the flight, the first after lunch, was used to publicise the operation and ranged over Yarmouth town and seafront and fields as I poked my Brownie box camera over the side.

The flight confirmed my intention, announced some years before, my dear old father told me, to be a pilot. He had been a Royal Flying Corps mechanic in the 1914-18 war and had encouraged my enthusiasm for aviation after planting its seed when he took me to watch flying meetings at Hendon Aerodrome before that war. Years later, he told me that I had been watching such early fliers as Blériot, Grahame-White and Sopwith.

Alas, my ambition to fly was thwarted by two shortcomings in my otherwise flawless character — imperfect eyesight and inherent cowardice. So I settled for second best and have for six decades revelled in being flown by brave men with good eyesight.

"Weekend Fliers"

Following the 1921 flight, I spent the next eleven years on the outside of aviation, looking in or, rather, up, and getting airborne whenever I could afford it, which was a little more frequent after I started work as a commercial artist at £1 a week.

Then in 1932 I discovered, and joined, the Auxiliary Air Force, an RAF reserve force nicknamed by the Press the "Weekend Fliers" because the AAF squadrons were manned mainly by part-timers who flew at weekends (as well as two evenings a week during the summer). Each squadron was equipped with two-seat biplanes, several of which were trainers so that we ground crews got plenty of back-seat flying, some of it handling the controls.

I had joined No 604 (County of Middlesex) Bomber Squadron, which had the amiable Westland Wapiti, described by cynics as being as safe as the Rock of Gibraltar but only half as fast, thanks to the "built-in headwinds", a reference to the fixed undercarriage and all the struts, wires and other dragmaking excrescences that included a naked, air-cooled radial engine nailed on the front end. The Wapiti cruised at barely 100 mph (160 km/h) and laughably became a *fighter* when the rôle of 604 and other Auxiliary squadrons was changed to that function in 1934.

The following year we swapped our Wapitis for Hawker Demons, the fighter version of the fine Hart bomber. Its performance was about 50 per cent better than that of its forerunner but it still conformed to the old formula with the pilot's head and the air gunner's upper half battered by a slipstream of around 160 mph (257 km/h). To get an idea of what that was like, try sticking your head out of a car's sunshine roof at half that speed.

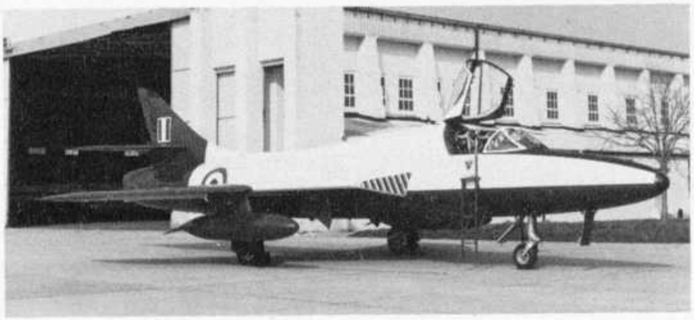
Slipstream

The occupant of the Demon's rear cockpit had a foldaway seat on which he sat facing the tail, secured by a lapstrap. However, most of us preferred to face forwards, sitting astride the seat or standing up and attached to the floor by what we called a "dog lead", a stout cable about as long as your leg which clipped onto a swivelling ring on the parachute harness under your crotch. It allowed the gunner to stand up and swing his Lewis gun around on its rotating gun-ring, which was spring-loaded to help move it against the slipstream.

Our parachute pack was stowed on the cockpit wall, the wild idea being that in an emergency we could extract it, clip its two rings onto the two hooks on our harness, unfasten the dog lead and get out — an operation which was difficult to effect even when the aircraft was standing on the ground.

The British have for centuries been convinced that warriors have to

(Below) ***1932:*** *The Westland Wapiti, ". . . as safe as the Rock of Gibraltar but only half as fast" and widely used by the RAF and the Auxiliary Air Force during the early '30s.*



(Left) ***1935:*** *Hawker Demons of No 604 Squadron, AAF, in echelon formation with Chris Wren in the gunner's cockpit of K4504 of which he was a ground-crew member. (Left below)* ***1981:*** *Hawker Hunter T 7 in the distinctive red, white and blue decor of A&AEE which led to its being called "The Raspberry Ripple".*

be uncomfortable to be effective, a principle extended to the RAF although, it must be admitted, the state of the aeronautical art in those days rarely allowed for better things. Piston engines and propellers inflicted vibration and fearful noise on crews, cockpits were open to the elements, heavy clothing hampered movement and radio communications were primitive as were the sparse navigation aids and unreliable oxygen systems, while air traffic control was in its infancy.

Take-off

To go flying in the '30s you'd just get in, strap in, start up, warm up the oil, run up the engine, taxy out and you were in business. In the air you were on your own, although if you had a serviceable radio and there was not too much interference, you might be able to report your position or call for help — if you could hear and be heard above the tumult of noise that surrounded you.

Radio communication between aircraft was practically non-existent. In formation flying, the leaders made hand signals to indicate their intentions. None of your Red Arrows' "Smoke on — GO!"

Navigation depended on the crew's ability to use dead reckoning, the compass and maps.

But in spite of all these afflictions — or perhaps because of them, for there is a perverse attraction about overcoming difficulties — we all loved flying. And there was the pleasure and privilege of belonging to a unique "club", the Auxiliary Air Force, which was embodied in the Royal Air Force a week before the outbreak of World War II in 1939. Its contribution of some 20 squadrons and 2,000 trained air and ground crews fortified the Regular force and helped to ensure the ultimate victory. It was subsequently awarded the prefix "Royal".

The second world conflict, like the first, accelerated the development of aviation, progress which has continued apace and which it has been my good fortune to observe and record for nearly fifty years in my capacity as an aeronautical writer and cartoonist.

Jet flight

To mark the 60th anniversary of the Wren-bird's first flight and, as the RAF put it, "For services Wrendered" in the form of publicity and entertainment, the Service offered me what they called "some geriatric aerobatics (2*g* max)" on a check flight in a Hawker Hunter T Mk 7 trainer, a type in which I had already dived through the "sound barrier" in 1957, piloted by Bill Bedford, then Hawker's chief test pilot.

Although the years have dealt kindly with me, my first reaction was a sensible "Many thanks but . . .". However, pride overrode common sense and I accepted, partly persuaded by their suggestion that I might like to write about the contrast between flying in the '30s and the '80s.

Thus it was that I found myself walking a little uneasily into the medical section at Boscombe Down airfield in Wiltshire — the qualm before the storm, I suppose. My pilot and old friend Group Captain Ned Frith, Superintendent of Test Flying and Training at that centre of test flying, assured the MO that we would not be scaling the heights so no pressure chamber tests were needed. At the end of the modest medical, the MO said with a smile "Splendid! How about signing on?" A great relief — well, you never know.

In the flying clothing stores I was carefully fitted with a *g*-suit (a sort of fairly brief, two-piece set of underwear which inflates to counteract excessive *g*), coveralls, boots, jersey, inner helmet, bonedome, oxygen mask and leg restraint straps. Then came twenty minutes of intensive instruction on the ejector seat, with advice on survival in a variety of chilling situations. In the ground services office, the aircraft's serviceability form was examined and signed by the Group Captain, then out to the Hunter, elegantly painted red, white and blue — hence its "Raspberry Ripple" nickname.

Get in, strap in, plug in, clip in. Ned closed the canopy and started up. No vibration, no noise. Contact Air Traffic Control. We taxied out, Ned checking all the time from his check list. ATC cleared us onto the runway for take-off. Final checks. The Rolls-Royce Avon was wound up to 7,200 rpm to test the brakes which were then released. Vivid acceleration. Three minutes later we levelled off at 10,000 ft (3 050 m) between two cloud layers.

The tranquillity of straight and level jet flight is misleading. You don't realise you're doing over 600 mph (966 km/h) — or *I* didn't when Ned said "Take over . . . you won't need any rudder". I firmly eased the stick to the left and at once the *g* began to bear down in a tightish turn, leading the *g*-suit to tighten its grip a little, so I eased off. Later, Ned snapped the willing Hunter into a roll or two, then demonstrated weightless flight in a parabolic curve exactly matching gravity, floating a pencil in the air.

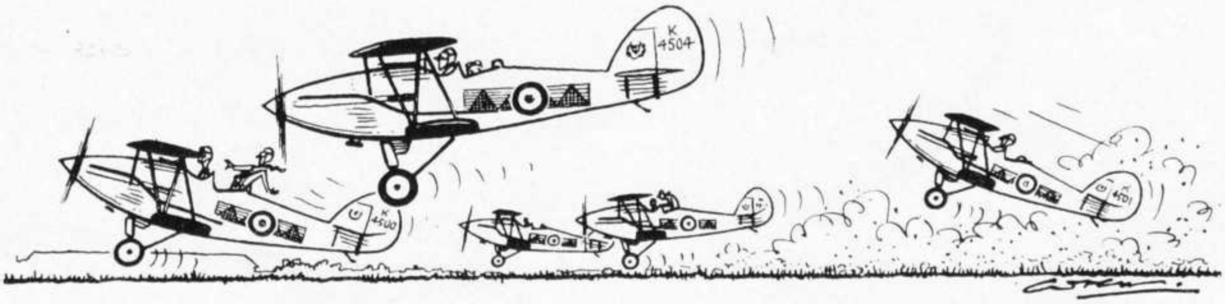
Flame-out

We did a practice GCA (Ground Controlled Approach) into Brize Norton to the controller's crisp, calm and clear instructions. The Hunter skimmed the runway and was up and away, climbing and turning for Boscombe Down. "We'll simulate a flame-out approach," said Ned and throttled back to 5,500 rpm which, with two notches of flap, simulates dead-engine conditions. Another serene talk-down to touchdown, a switch tripped to stream the braking parachute and the delightful flight is over.

Taxying in, I reflect on the differences brought about in 45 years: jet flight is immensely quieter and smoother, communications are incomparably better; one is now constantly under radar surveillance by our superb Air Traffic Controllers who also provide instant succour for those in peril; safety is a first priority; vastly improved aircraft performance imposes greater physical and mental demands; more aids and systems mean more to learn and control; the workload is much heavier.

But one thing never changes — the lively, capable spirit of the Professionals, the Royal Air Force. □

(Right) ***1936:*** *A scurrilous example of Wrennery showing No 604 Squadron Demons landing at Hendon, their home base. Chris Wren also designed the AAF fighter squadrons' triangular markings shown here.*



MARITIME PATROL IN THE RAF

An historical account of the land-based maritime force, by Michael J F Bowyer

FLYING high or low, over the oceans of the Arctic or the tropics, skimming the bright blue Mediterranean or a grey ferocious Atlantic, aircraft of Royal Air Force Coastal Command and its associates have roamed for nearly 50 years. By day and by night, as bombers and fighters, photographers and patrollers, the RAF's maritime force has played a wider part in the Service's activity than any other single Command. For fleeting moments during war, aircraft of the Command have been, and would again become, involved in combat as fierce as any, and sometimes far out to sea where the elements constitute a challenge as great as any foe.

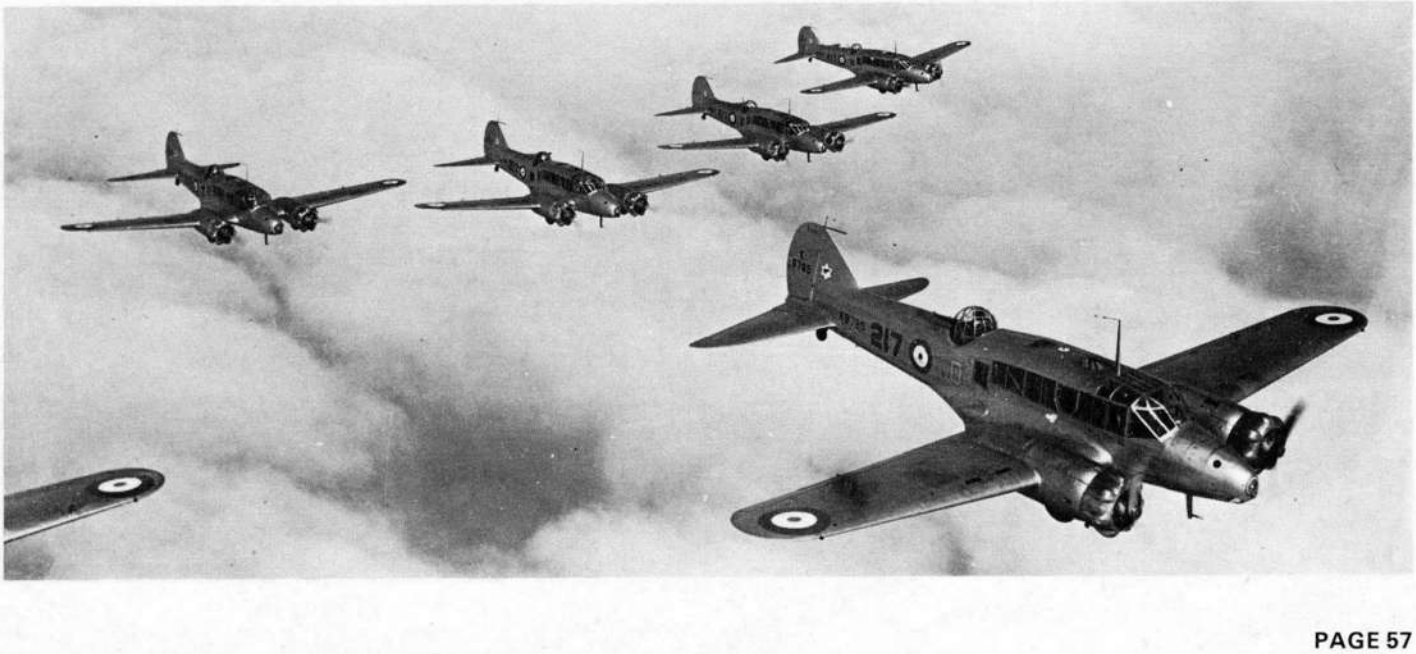
Following the 1914-18 War there was a vigorously contested campaign to obtain control of the maritime air force, both the Admiralty and the Air Ministry putting forward strong cases. In 1937 the Admiralty won the Fleet Air Arm, which comprised the seaborne force, leaving the land and shore-based aircraft in RAF hands. At this time a fair proportion of the latter were seaplanes, whose numbers gradually declined over the next 20 years. Preventing any further dismemberment of the RAF was a hard fought battle, but as the Second World War approached it was clear that inter-service rivalry was being overtaken by the grim nature of the unfolding scene.

By 1939 Coastal Command was well organised but poorly equipped. Naval staff were liaising at Command Headquarters and within the three Groups. Command's rôle was to assist in maintaining British trade links whilst denying the enemy his. Watching the activities of enemy shipping was thus a main feature.

Royal Air Force expansion had centred on a strong bomber force and an equally effective defensive fighter force to protect the bomber stations and the home base generally. To suggest that Coastal Command was neglected is incorrect: truth was that there was belief that the British and French navies were sufficiently strong to wage war at sea — aided by a limited measure of airborne reconnaissance.

North Sea patrol, as in the 1914-18 war, was a primary task when hostilities broke out. Indeed, Coastal Command began flying war patrols at dawn on 24 August 1939, thereby commencing the RAF's operational flying in respect of World War II. Their purpose was to find the *Deutschland*, but it had escaped when the reconnaissance Ansons were fog bound; *Graf Spee*, too, had sailed into the Atlantic undetected. Such surface raiders of the German fleet were

When the RAF entered World War II, squadrons of Coastal Command were quickly in action, although somewhat inadequately equipped. The principal land-based patrol-bomber was the Avro Anson, seen (below) in service with No 217 Squadron. Today, the same basic rôle is performed — with rather greater sophistication! — by the British Aerospace Nimrod MR Mk 2 (heading photo).



The Vickers Vildebeest torpedo-bomber, representative of the inter-wars period, was still in front-line service with two home-based Coastal Command squadrons in 1939 and the type flew operationally against Japanese forces attacking Singapore at the end of 1941.

considered the main maritime threat, and to prey upon Atlantic shipping they first needed to sail through the North Sea between Norway and Scotland. Thus, it was in that area where Ansons from Montrose and Leuchars, aided by a few Hudsons, concentrated their daylight patrols. Only by using the Hudsons could that channel be effectively surveyed, but there was only one such squadron operating at the start of the war. Submarines, despite their effectiveness in World War I, were considered to pose a less serious threat than surface raiders.

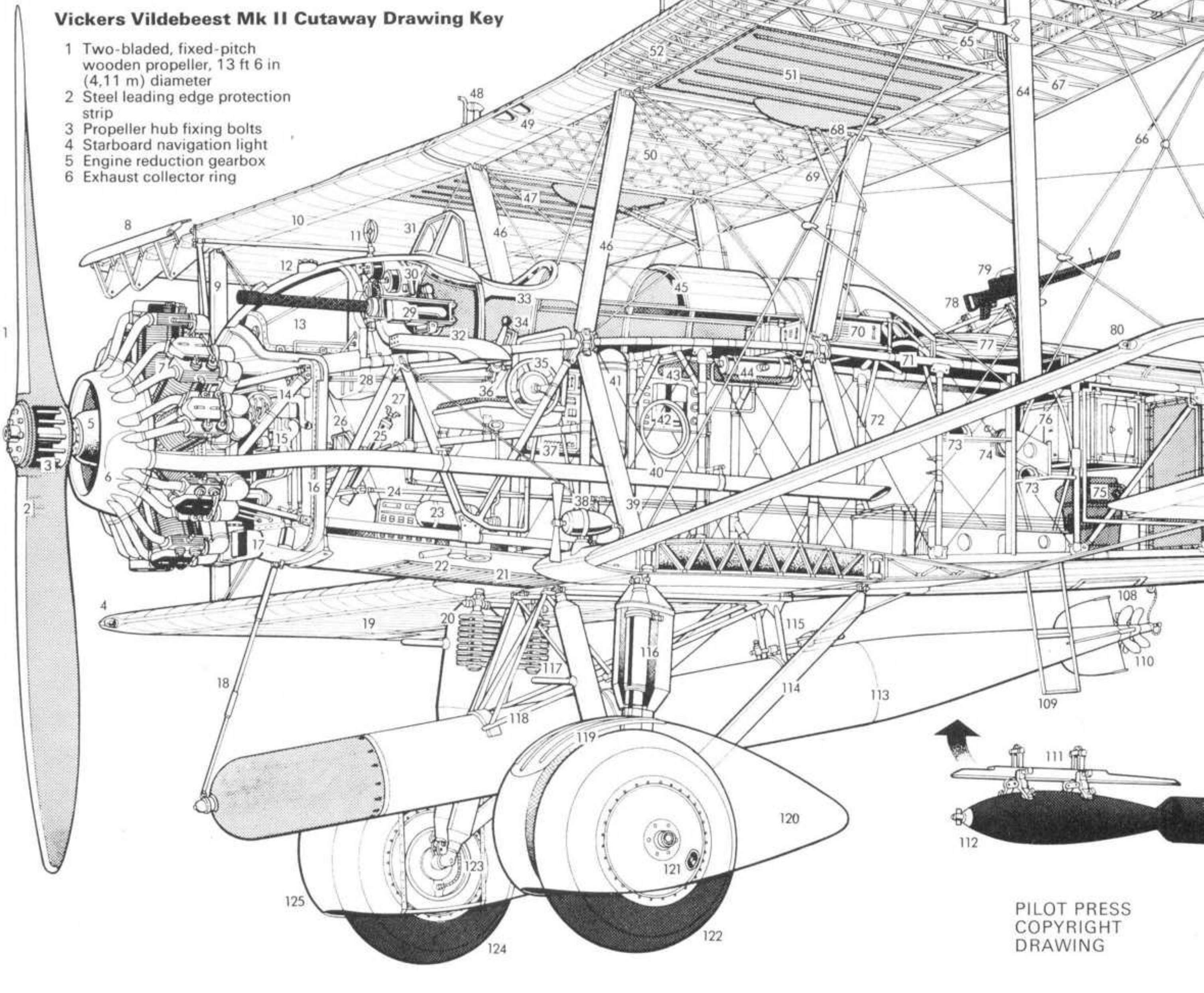
Within hours of the outbreak of war, the Command's land based strength was fully stretched by a task that had been virtually unforeseen, the protection of coastal convoys carrying essential goods along the east and south coasts of Britain, and which drew almost immediate attention from the *Luftwaffe*. In response, the RAF formed five Coastal Patrol Flights — and armed them with Tiger Moths to fly what were cynically known as "scarecrow patrols".

Coastal's early war

Coastal Command's main equipment at the outbreak of war was the Avro Anson, one example of which, from No 500 Squadron, on 5 September 1939 made the RAF's first attack on a U-Boat. The Anson was a military counterpart of the six-seat Avro 652 airliner that had been ordered for Imperial Airways in April 1934. Avro soon after tendered a scheme for a twin-engined coastal reconnaissance landplane in the form of a modified "652" layout, and a prototype, ordered in September 1934, first flew on 24 March 1935. Increased cabin glazing, a single gun in a manually traversed Armstrong

Vickers Vildebeest Mk II Cutaway Drawing Key

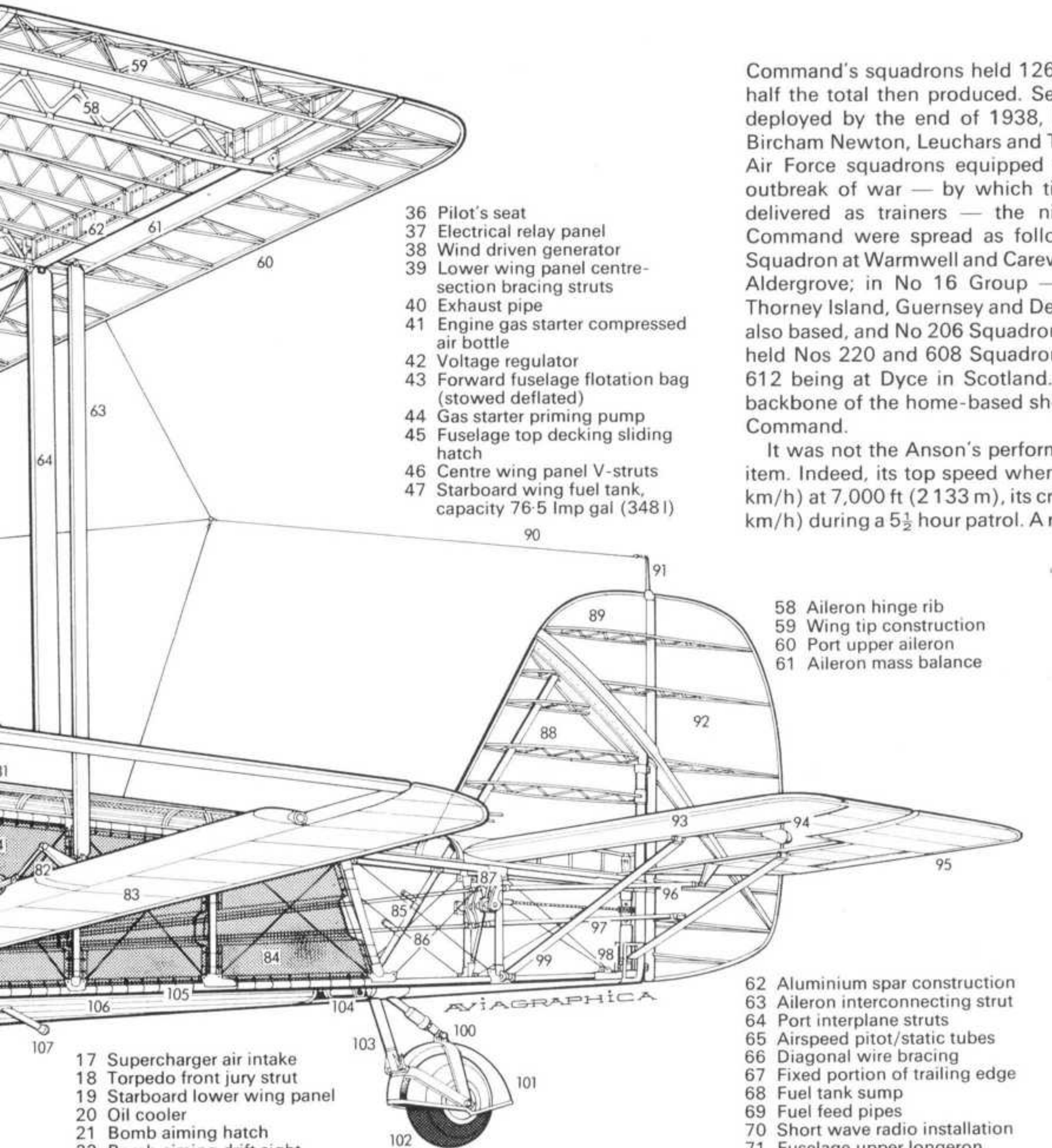
1 Two-bladed, fixed-pitch wooden propeller, 13 ft 6 in (4,11 m) diameter
2 Steel leading edge protection strip
3 Propeller hub fixing bolts
4 Starboard navigation light
5 Engine reduction gearbox
6 Exhaust collector ring
7 Bristol Pegasus I.M.3 supercharged 9-cylinder radial engine
8 Starboard wing automatic leading edge slat
9 Starboard interplane strut
10 Wing panel fabric covering
11 Ring and bead gunsight
12 Oil filler cap
13 Oil tank, capacity 14·5 Imp gal (66 l)
14 Engine mounting struts
15 Engine accessory units
16 Fireproof bulkhead



Whitworth turret and provision for small bombs, differentiated the aircraft from its civilian predecessors. A few weeks of official trials were sufficient to prove the usefulness of the aircraft and resulted in an initial order for 162 Ansons, one which had risen to 1,206 by the outbreak of hostilities although the majority of these were destined for training purposes. At the end of 1935 the first production Anson flew, the rapidity of that event indicating its rather low level of sophistication.

Manston-based No 48 Squadron became, in March 1936, the first to equip with Ansons. When sufficient for six Coastal Command squadrons had been delivered the original squadron passed its aircraft to the School of Air Navigation, also at Manston. By that time, March 1938, the Anson had become fully established as a trainer. Other squadrons already Anson armed were No 206 equipped in June-July 1936, No 220 in September 1936, No 269 early 1937, No 217 in March 1937 and No 224 in June 1937. By mid-1938, Coastal Command's squadrons held 126 Ansons with 25 in reserve, about half the total then produced. Seven squadrons were operationally deployed by the end of 1938, based at Abbotsinch, Aldergrove, Bircham Newton, Leuchars and Tangmere. Two additional Auxiliary Air Force squadrons equipped with Ansons in 1939 and at the outbreak of war — by which time nearly all Ansons were being delivered as trainers — the nine Anson squadrons in Coastal Command were spread as follows: in No 15 Group — No 217 Squadron at Warmwell and Carew Cheriton and No 502 Squadron at Aldergrove; in No 16 Group — No 48 Squadron split between Thorney Island, Guernsey and Detling, where No 500 Squadron was also based, and No 206 Squadron at Bircham Newton. No 18 Group held Nos 220 and 608 Squadrons at Thornaby, with Nos 269 and 612 being at Dyce in Scotland. Until 1941 Ansons remained the backbone of the home-based short range patrol element of Coastal Command.

It was not the Anson's performance which made it such a useful item. Indeed, its top speed when loaded was about 175 mph (281 km/h) at 7,000 ft (2 133 m), its cruising speed around 140 mph (225 km/h) during a 5½ hour patrol. A range little short of 800 miles (1 287



17 Supercharger air intake
18 Torpedo front jury strut
19 Starboard lower wing panel
20 Oil cooler
21 Bomb aiming hatch
22 Bomb aiming drift sight
23 Flotation bag compressed air bottle
24 Bomb release switches
25 Gun priming pump
26 Rudder pedals
27 Control column
28 Ammunition tank, 600 rounds
29 Vickers 0·303-in (7,7-mm) Mk II machine gun
30 Instrument panel
31 Windscreen panels
32 Cartridge case ejection chute
33 Cockpit coaming
34 Engine throttle, boost and mixture control levers
35 Trim control handwheel
36 Pilot's seat
37 Electrical relay panel
38 Wind driven generator
39 Lower wing panel centre-section bracing struts
40 Exhaust pipe
41 Engine gas starter compressed air bottle
42 Voltage regulator
43 Forward fuselage flotation bag (stowed deflated)
44 Gas starter priming pump
45 Fuselage top decking sliding hatch
46 Centre wing panel V-struts
47 Starboard wing fuel tank, capacity 76·5 Imp gal (348 l)
48 Upper navigation light
49 Pilot's hand holds
50 Centre wing panel rib construction
51 Port wing fuel tank, capacity 76·5 Imp gal (348 l)
52 Leading edge nose ribs
53 Fuel tank vent pipe
54 Leading edge fabric covering
55 Port automatic leading edge slat
56 Slat hinge brackets
57 Aluminium lattice rib construction
58 Aileron hinge rib
59 Wing tip construction
60 Port upper aileron
61 Aileron mass balance
62 Aluminium spar construction
63 Aileron interconnecting strut
64 Port interplane struts
65 Airspeed pitot/static tubes
66 Diagonal wire bracing
67 Fixed portion of trailing edge
68 Fuel tank sump
69 Fuel feed pipes
70 Short wave radio installation
71 Fuselage upper longeron
72 Aluminium tube fuselage framework
73 Boarding steps
74 Trailing aerial winch
75 Reconnaissance camera
76 Long wave radio installation
77 Gun mounting Scarff ring
78 Mk IIIA Lewis gun
79 Ammunition drum
80 Port navigation light
81 Fuselage dorsal frames and stringers
82 Aileron operating hinge control
83 Port lower aileron
84 Rear fuselage flotation bags (permanently inflated)
85 Fin mounting strut
86 Tailplane control cable runs
87 Rudder and elevator cross-shaft
88 Tailfin construction
89 Rudder horn balance
90 Aerial cable
91 Aerial attachment mast
92 Fabric covered rudder construction
93 Port tailplane
94 Tail navigation light
95 Port elevator
96 Elevator hinge control rod
97 Rudder control rod
98 Tailplane trim screw jack
99 Tailplane bracing struts
100 Tailwheel shock absorber strut
101 Mudguard
102 Castoring tailwheel
103 Tailwheel fixing strut
104 Fuselage lifting bar attachment
105 Lower longeron
106 Fuselage fabric covering
107 Trailing aerial fairlead
108 Reconnaissance camera hatch
109 Fixed boarding ladder
110 Torpedo drive propellers
111 Universal bomb rack (four each wing)
112 HE Bomb, maximum bomb load 1,100 lb (500 kg)
113 18-in (46-cm) torpedo
114 Main undercarriage rear strut
115 Torpedo depth setting gear
116 Main undercarriage oleo leg strut
117 Boarding step
118 Torpedo sling
119 Wheel spat walkway
120 Wheel spat fairing
121 Tyre inflation valve
122 Port mainwheel
123 Wheel brake
124 Starboard mainwheel
125 Starboard mainwheel spat fairing

km) was coupled with an action radius of 250 miles (402 km) when carrying the usual 250-lb (113,5-kg) bomb load. Hardly impressive, yet the Anson's value as a coastal reconnaissance aircraft was more than might be supposed. Unlike most RAF squadrons those of Coastal Command frequently set out on patrols following positioning flights, terminating them at home base. Thus, an Anson could patrol the entire length of the East Coast, refuel and then return. Presence of any aircraft was usually sufficient to discourage an enemy attack upon a convoy.

Nevertheless, the Anson was clearly outdated even before the war; but the British aircraft industry was unable to supply sufficient aircraft to meet all the RAF's pre-war plans. More skilled labour was just not available, tooling took time and aero engines were in short supply. Therefore the government shopped in America, facing no mean furore at home. Choice, so far as the maritime rôle was concerned, fell upon the militarised Lockheed 14. Not a particularly brilliant performer, its operational capability in a similar task was nevertheless far superior to the Anson's although it could not usurp the Avro aeroplane's two claims to fame for being the RAF's first operational aeroplane to have a retractable undercarriage and the first Expansion Period low-wing monoplane to join a squadron.

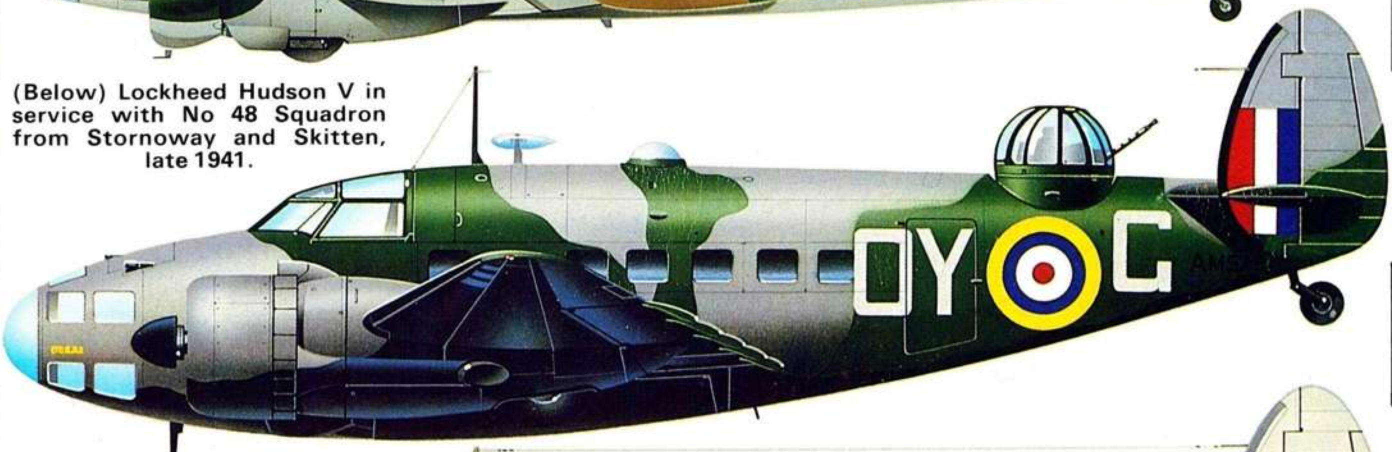
Lockheed 14 Hudsons shipped to Britain, where power operated dorsal turrets were fitted, commenced trials in April 1939. Now that the aircraft were arriving, using them for the non-operational purposes publicly promised was quietly overlooked and on 27 April 1939 No 224 Squadron received Coastal Command's first Hudson. The squadron was operational when hostilities commenced, by which time No 233 Squadron also had them. Another four were with No 220 Squadron, and by 3 September 1939, 53 Hudsons had reached squadron hands. Although the Anson was being replaced, it was to serve operationally into 1942.

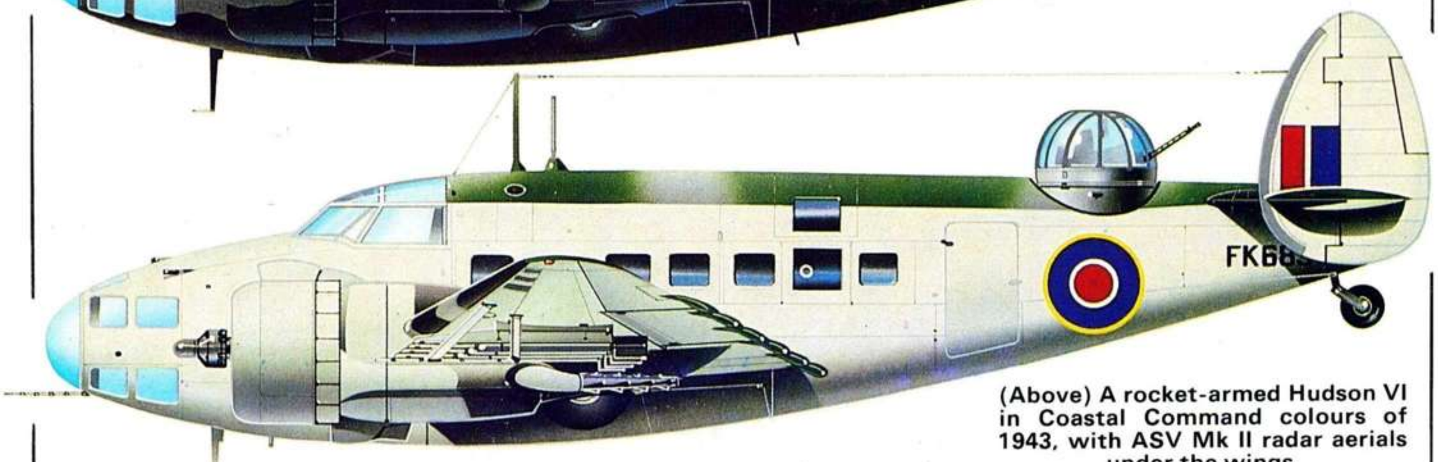
The value of the Hudson's range, permitting sorties to Norwegian waters, was emphasised when the *Altmark*, which had supported the *Graf Spee*, was located by a No 220 Squadron Hudson in a fiord. No

(Below) Avro Anson I in the pre-war markings of No 220 Squadron at Bircham Newton, 1937.

(Below) Avro Anson I of No 206 Squadron as operational from Manston, late 1939.

(Below) Lockheed Hudson V in service with No 48 Squadron from Stornoway and Skitten, late 1941.





(Above) A rocket-armed Hudson VI in Coastal Command colours of 1943, with ASV Mk II radar aerials under the wings.

(Below) Bristol Blenheim IVF fighter of No 248 Squadron, as used from Dyce in the later months of 1940.

(Below) Bristol Beaufighter TF Mk X, with rocket armament, serving with No 455 (RAAF) Squadron in Coastal Command strike wing, 1944.

(Below) De Havilland Mosquito FB Mk VI with underwing rockets, as used by No 143 Squadron as part of the Banff Wing, early 1945.

attack on the ship was acceptable in neutral territory, and had it been feasible then it would have been impossible to use the prime anti-ship weapon.

The strike force

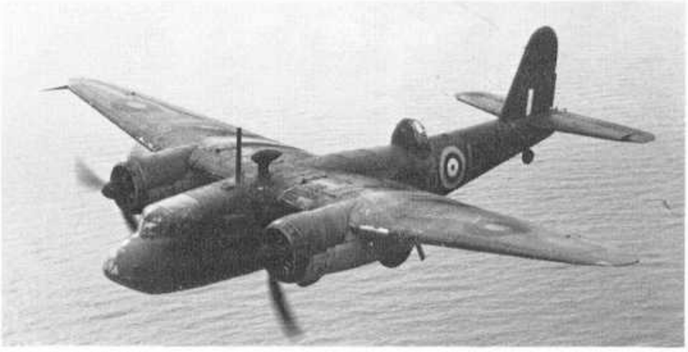
One torpedo's ability to cripple, probably sink, even a large warship kept it the maritime aircraft's prime offensive weapon throughout World War II. Torpedoes are still very much in use today, but their tactical and guidance systems are far removed from those used in "release and run" low-cloud operations in the last war. Coastal Command had only two torpedo-strike squadrons in September 1939, each holding 17 antiquated Vickers Vildebeest III biplanes, in No 22 Squadron at Thorney Island and No 42 Squadron at Bircham Newton. Vildebeests came into service in 1933 and the similar Mk III — with a third seat in the rear cockpit — was produced in 1936; they were, in essence, little different from naval biplane torpedo bombers of the 1920's. So bad was the replenishment situation within the Vildebeest squadrons that two aged Mk Is had to be taken from storage after the war began to maintain front line strength. When HM King George VI visited the BEF in France he was escorted across the Channel by Vildebeests — he could surely not have been impressed. Hope had been for new designs to be in service by then, but the development of specialised torpedo droppers had become much delayed.

Not only aircraft but torpedoes, too, were in short supply: if the aircraft's patrol point moved, they needed to carry their precious weapons with them. Few operational patrols took place with the Vildebeests carrying torpedoes, and their final anti-submarine sorties from Britain were flown on 20 December 1939. At the time of the Japanese invasion of Malaya in December 1941, however, both Nos 33 and 100 Squadrons were still flying Vildebeests there. With a cruising speed of 100 mph (160 km/h), and an operational radius of 185 miles (290 km), their inadequacy was only too sadly obvious.

There were, however, special reasons for that slow speed. If a torpedo-dropping aircraft released its weapon too high, the torpedo would break on water impact. If the angle of release was incorrect the torpedo would steeply dive. Should the release speed be in error the torpedo could fail, or not run true. Accurate release, therefore, needed ample training, considerable skill and an element of luck as well as an aircraft with contradictory qualities. It needed to be rapidly placed into the low-level attack mode, ideally present a slender head-on outline, have the ability to decelerate to release speed very rapidly yet have sufficient power for a fast escape in which excellent manoeuvrability was required. Perhaps surprisingly, the Navy's Swordfish biplane proved to be the most effective British torpedo bomber of the early war years, despite its slow top speed; the RAF wanted something more sophisticated. Torpedo attack was a highly exacting rôle employing an expensive weapon, and maintaining a force with such specialised qualities was very costly. Inevitably, torpedo-bomber specifications became merged with requirements for bombing and general reconnaissance rôles — which reduced the effectiveness of chosen torpedo-bomber designs.

The Botha comes and goes

On 27 August 1935 the Air Staff issued a specification (M.15/35) for a monoplane torpedo-bomber possessing the forementioned features and internal stowage for its weapon load. Bristol and Blackburn tendered required twin-engined layouts, the former submitting a brochure showing a Blenheim with a lengthened fuselage and increased size of weapon bay. Blackburn chose a high wing layout which stemmed from their flying-boat experience. After examining the tenders the Chief of the Air Staff decided on 23 January 1936 that these designs should be combined with those already promulgated for a new general reconnaissance aircraft to replace the Anson, which resulted in a fresh Specification, 10/36, being issued. Ample range in a maritime design was of crucial



The Blackburn Botha was designed to a specification intended to provide Coastal Command with a worthy successor for the Anson. Sadly, it was an operational failure — although over 600 were built.

importance, the chosen power plants needing to have good economy whilst offering excellent reliability and ample power during attack situations. Slow flying qualities needed special attention, and excellent stability was vital. View from maritime aircraft needed to be good as well.

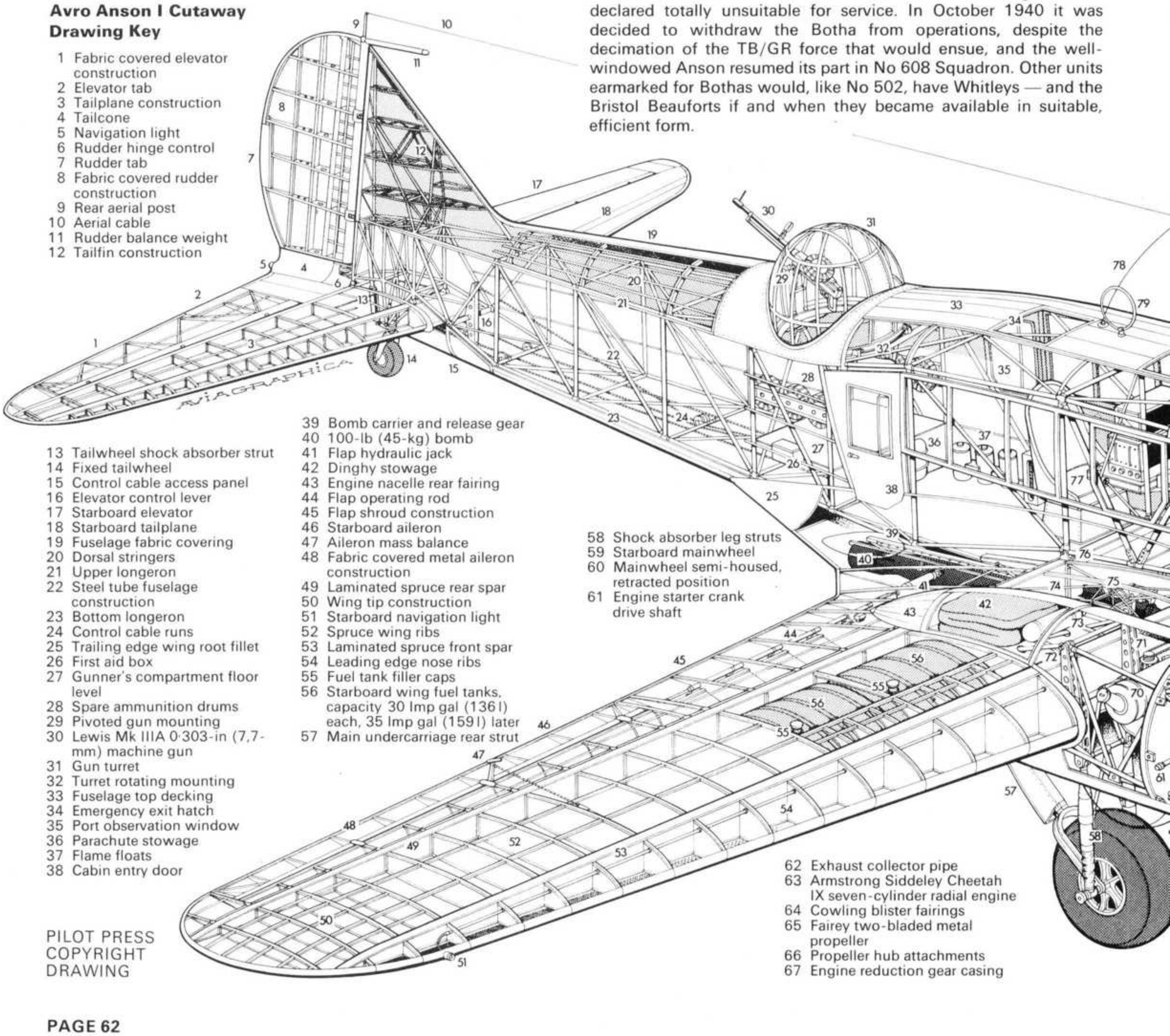
Both Blackburn and Bristol had opted for untried power plants forecast as suitable for the requirement. In the event however, they were to demand more development effort than could ever be afforded to them. After dismissing their own Perseus VI, Bristol's preference was for the new compact two-row Taurus radial engine. Blackburn's design evolved around Bristol Aquilas until in October 1937 the Chief of the Air Staff finally persuaded the company to settle for Bristol Perseus engines, which could greatly improve the medium altitude bombing capability of the aircraft whose previous best performance had been set for 5,000 ft (1 524 m). With Perseus, it should perform well at 15,000 ft (4 572 m), but unfortunately the Perseus never became a good engine.

In November 1936 244 examples of the Blackburn Botha were ordered to Specification 10/36, for delivery by March 1939. As the design was being finalised it became clear that the aircraft's layout was far from ideal, and the view poor for all except the pilot. Alterations were demanded. Unusual, too, was the strangely shaped dorsal turret, the aerodynamics of which were to cause problems later. In its early form the Botha, first flown on 28 December 1938, suffered from stability problems. Far from easy to fly, it was tiring for the pilot. Constant engine problems plagued it and available power was far less than required. A top speed of around 230 mph (370 km/h) was attained at 12,500 ft (3 657 m), 200 mph (322 km/h) at sea level and a stalling speed of around 78 mph (125 km/h), which made it only marginally suitable for torpedo dropping.

Air Staff preference was nevertheless shown for the Blackburn Botha and not for the Bristol competitor. In June 1940 No 608 Squadron at Thornaby-on-Tees received Bothas which commenced North Sea patrols in August. Engine problems were numerous and aircraft not fitted with the latest standard Perseus Xa engines were declared totally unsuitable for service. In October 1940 it was decided to withdraw the Botha from operations, despite the decimation of the TB/GR force that would ensue, and the well-windowed Anson resumed its part in No 608 Squadron. Other units earmarked for Bothas would, like No 502, have Whitleys — and the Bristol Beauforts if and when they became available in suitable, efficient form.

Avro Anson I Cutaway Drawing Key

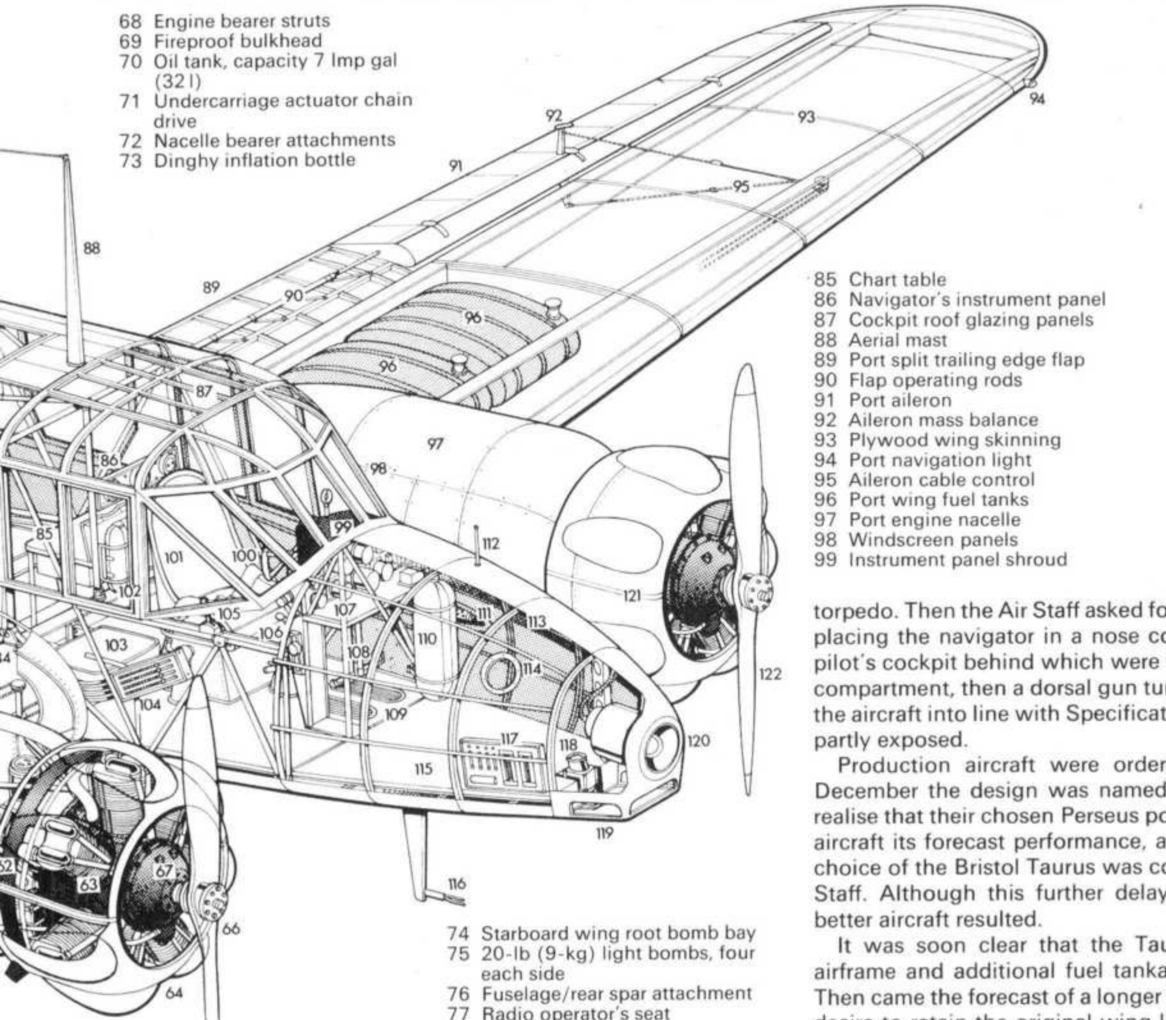
1 Fabric covered elevator construction
2 Elevator tab
3 Tailplane construction
4 Tailcone
5 Navigation light
6 Rudder hinge control
7 Rudder tab
8 Fabric covered rudder construction
9 Rear aerial post
10 Aerial cable
11 Rudder balance weight
12 Tailfin construction
13 Tailwheel shock absorber strut
14 Fixed tailwheel
15 Control cable access panel
16 Elevator control lever
17 Starboard elevator
18 Starboard tailplane
19 Fuselage fabric covering
20 Dorsal stringers
21 Upper longeron
22 Steel tube fuselage construction
23 Bottom longeron
24 Control cable runs
25 Trailing edge wing root fillet
26 First aid box
27 Gunner's compartment floor level
28 Spare ammunition drums
29 Pivoted gun mounting
30 Lewis Mk IIIA 0·303-in (7,7-mm) machine gun
31 Gun turret
32 Turret rotating mounting
33 Fuselage top decking
34 Emergency exit hatch
35 Port observation window
36 Parachute stowage
37 Flame floats
38 Cabin entry door
39 Bomb carrier and release gear
40 100-lb (45-kg) bomb
41 Flap hydraulic jack
42 Dinghy stowage
43 Engine nacelle rear fairing
44 Flap operating rod
45 Flap shroud construction
46 Starboard aileron
47 Aileron mass balance
48 Fabric covered metal aileron construction
49 Laminated spruce rear spar
50 Wing tip construction
51 Starboard navigation light
52 Spruce wing ribs
53 Laminated spruce front spar
54 Leading edge nose ribs
55 Fuel tank filler caps
56 Starboard wing fuel tanks, capacity 30 Imp gal (136 l) each, 35 Imp gal (159 l) later
57 Main undercarriage rear strut
58 Shock absorber leg struts
59 Starboard mainwheel
60 Mainwheel semi-housed, retracted position
61 Engine starter crank drive shaft
62 Exhaust collector pipe
63 Armstrong Siddeley Cheetah IX seven-cylinder radial engine
64 Cowling blister fairings
65 Fairey two-bladed metal propeller
66 Propeller hub attachments
67 Engine reduction gear casing



By the summer of 1940, Coastal Command's Ansons had certainly distinguished themselves, and none more so than the "faithful Annies" of No 500 Squadron based at Detling in Kent and thus in the forefront of the 1940 fighting. On 15 May Anson "MK-B" was patrolling over a minesweeper formation when the crew of a Heinkel 111 had the sauce to attempt to bomb the leisurely flying Anson, whose manoeuvrability neatly took it to safety. Nine Bf 109s over the English Channel on 1 June 1940 came across a formation of three Ansons. Two they quickly shot down, but the third fought its way home taking on the nine German fighters and, incredibly, survived ... but not until a Bf 109 had been shot down and two more damaged. Another fierce battle took place on 24 September 1940 when Anson "MK-R" set off to search for E-Boats, four of which were soon found. Before any attack upon them was possible a couple of Henschel Hs 126s engaged in inconclusive battle with the Anson. A few moments later three Bf 110s detached themselves from a large formation to see off the helpless victim. Their fire seriously injured both pilot and navigator and badly damaged the Anson, which nevertheless arrived home.

Enter the Beaufort

Failure of the Botha had left the field open for its competitor, the Bristol Beaufort. Bristol had submitted their Type 152 to Specification M.15/35 in April 1936. This had called for a torpedo-bomber able to achieve 220 mph (354 km/h) at 1,000 ft (305 m) and carry a 2,000-lb (908-kg) bomb load as well as an internally stowed torpedo. Then the Air Staff asked for the crew to be increased to four, placing the navigator in a nose compartment. This meant a raised pilot's cockpit behind which were the wireless operator and camera compartment, then a dorsal gun turret. These modifications brought the aircraft into line with Specification 10/36, its torpedo now being partly exposed.



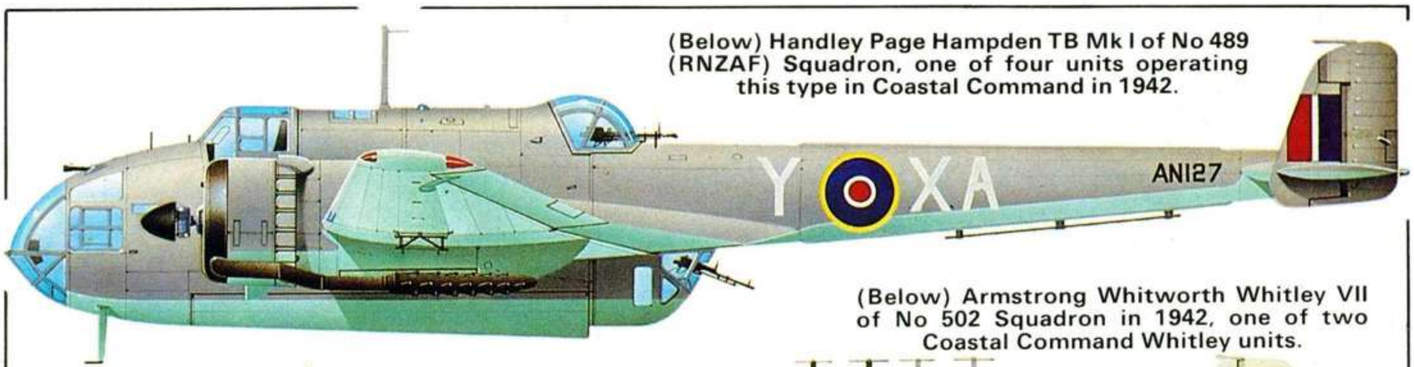
68 Engine bearer struts
69 Fireproof bulkhead
70 Oil tank, capacity 7 Imp gal (32 l)
71 Undercarriage actuator chain drive
72 Nacelle bearer attachments
73 Dinghy inflation bottle
74 Starboard wing root bomb bay
75 20-lb (9-kg) light bombs, four each side
76 Fuselage/rear spar attachment
77 Radio operator's seat
78 Aerial lead-in
79 D/F loop aerial
80 Cabin roof escape hatch
81 Radio equipment rack
82 Navigator's seat
83 Battery
84 Fuselage/front spar attachment
85 Chart table
86 Navigator's instrument panel
87 Cockpit roof glazing panels
88 Aerial mast
89 Port split trailing edge flap
90 Flap operating rods
91 Port aileron
92 Aileron mass balance
93 Plywood wing skinning
94 Port navigation light
95 Aileron cable control
96 Port wing fuel tanks
97 Port engine nacelle
98 Windscreen panels
99 Instrument panel shroud
100 Control column handwheel
101 Pilot's seat
102 Sliding cockpit side windows
103 Observer's tip-up seat
104 Fuel cock controls
105 Bomb fusing control lever
106 Engine throttle and mixture control levers
107 Back of instrument panel
108 Rudder pedals
109 Pilot's footboards
110 Pneumatic brake air reservoir
111 Fixed, forward-firing Vickers 0·303-in (7,7-mm) machine gun
112 Pilot's ring-and-bead gunsight
113 Aluminium skinned nose compartment construction
114 Observation window
115 Bomb aimer's prone position flooring
116 Pitot tubes
117 Bomb aimer's control panel
118 Drift sight
119 Bomb aiming windows
120 Searchlight
121 Port engine cowlings
122 Port Fairey metal propeller

Production aircraft were ordered in September 1936 and in December the design was named Beaufort. Bristol soon came to realise that their chosen Perseus power plant would never afford the aircraft its forecast performance, and in July 1937 their alternative choice of the Bristol Taurus was confirmed as acceptable by the Air Staff. Although this further delayed the new torpedo-bomber, a better aircraft resulted.

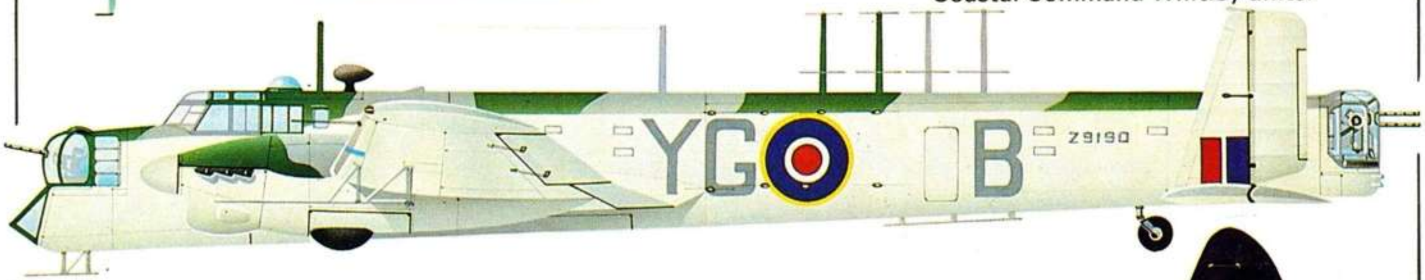
It was soon clear that the Taurus aircraft required a stronger airframe and additional fuel tankage for the more thirsty engines. Then came the forecast of a longer landing run as a result of Bristol's desire to retain the original wing layout, which meant higher wing loading. A combination of delays led to an initial order being for only 87 Beauforts, whereas Blackburn had some 300 Bothas on order by mid-1937.

Although the Beaufort was clearly second choice so far as the Air Staff was concerned, Bristol, with a fighter version of their Blenheim

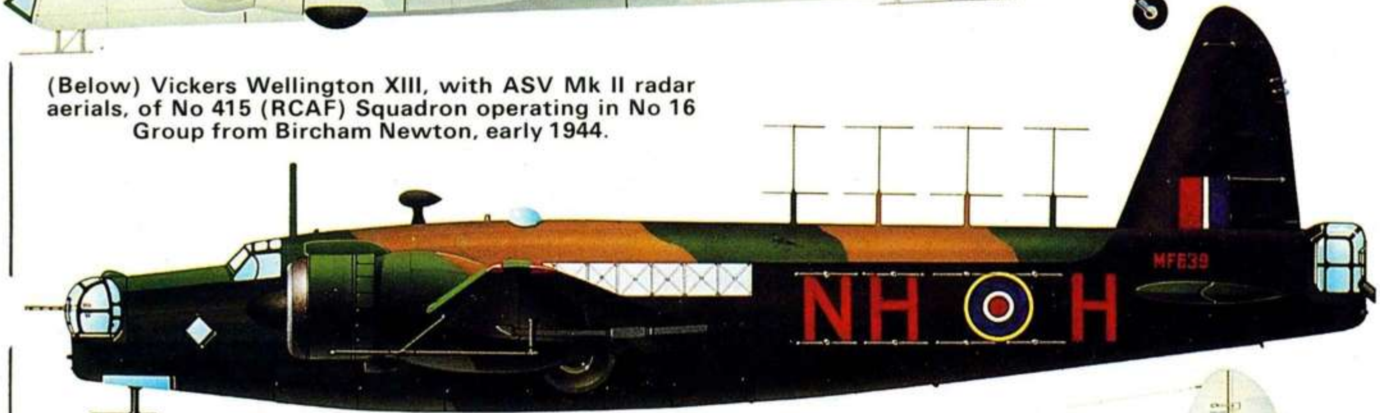
(Below) Handley Page Hampden TB Mk I of No 489 (RNZAF) Squadron, one of four units operating this type in Coastal Command in 1942.



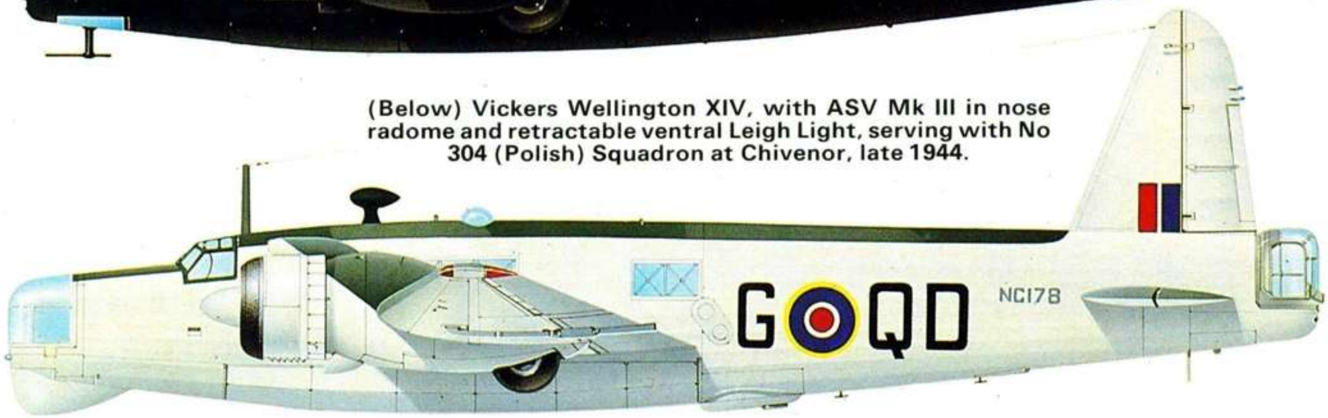
(Below) Armstrong Whitworth Whitley VII of No 502 Squadron in 1942, one of two Coastal Command Whitley units.



(Below) Vickers Wellington XIII, with ASV Mk II radar aerials, of No 415 (RCAF) Squadron operating in No 16 Group from Bircham Newton, early 1944.



(Below) Vickers Wellington XIV, with ASV Mk III in nose radome and retractable ventral Leigh Light, serving with No 304 (Polish) Squadron at Chivenor, late 1944.

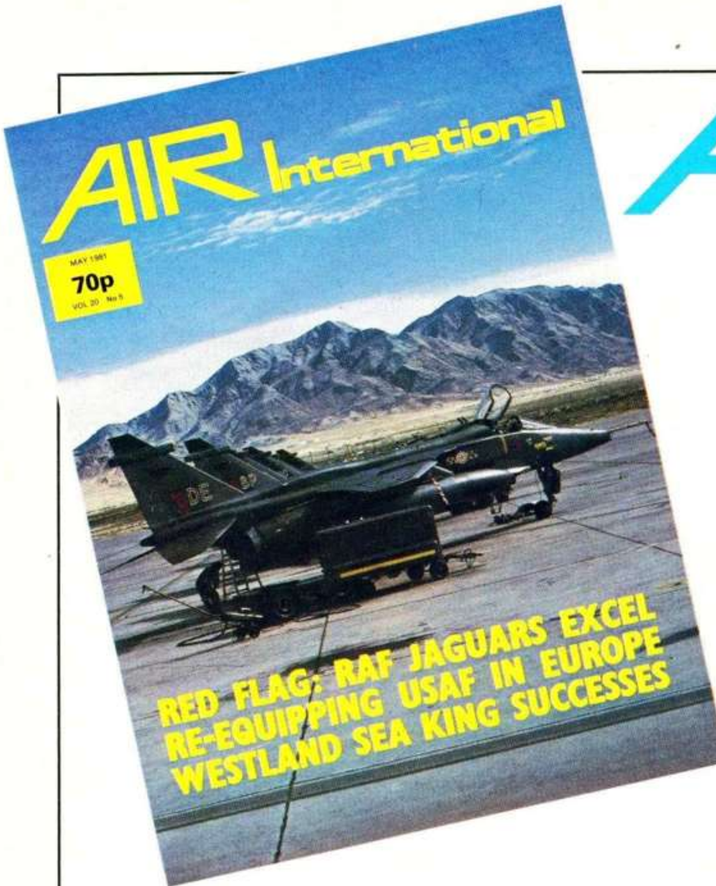


to hand, hit upon the exploitation of a cannon-armed fighter version of the Beaufort. By fitting a new fuselage to carry the cannon, and with machine guns installed in the wings, the company claimed that it could provide a fighter retaining the long duration of the Beaufort.

The company suggested this scheme to the Air Staff at the time of the Beaufort's first flight on 15 October 1938 — the first step in the process that would lead eventually to development of the Beaufighter. A somewhat complicated engine cooling system and the special cowlings had brought further delay to the Beaufort. Far East coastal strike forces had great need of new, longer range aircraft — the use of Vildebeests in Singapore as late as December 1941 has already been mentioned — and it was decided that the first 75 Beauforts must go to them. Engine cooling was therefore of considerable importance, but the problems now encountered by Bristol prohibited any tropical deployment of the aircraft for a considerable time. An assortment of troubles beset the Taurus engines, the only solution to which was to put early aircraft into temperate-zone service and re-engine them later.

At Thorney Island No 22 Squadron was, in November 1939, the first to receive Beauforts which thus, after all, had beaten the Botha into service. Teething problems were protracted, however, and it was 15 April 1940 before the first operational sorties were despatched, and then the loads were mines, not torpedoes. On 12/13 May 1940, Beauforts bombed Waalhaven, and nine Wick-based Beauforts attacked the *Scharnhorst* on 21 June 1940, two weeks before better Taurus engines became available. Torpedoes were first released from Beauforts in anger when No 22 Squadron attacked a convoy off Calais on 11 September 1940, but Beaufort operations from Britain increased slowly, still bedevilled by engine troubles. Probably the most famous attack was that by No 42 Squadron, which on 13 June 1941 torpedoed the *Lützow* off Norway. Certainly the most courageous was Fg Off Kenneth Campbell's torpedo attack on the *Gneisenau* in Brest on 6 April 1941. Attacking from 30 ft (9 m), his aircraft was shot down and he was posthumously awarded the Victoria Cross.

Shortage of long-duration fighters to patrol over coastal convoys — "trade protection duty" it was called — was readily apparent as soon as the war had broken out. To remedy this, Blenheim fighter squadrons were formed in Fighter Command in October 1939. Since their most useful employment was on convoy escort and maintaining an eye upon the then important North Sea "kipper fleet" of fishing boats, they were logically soon transferred to Coastal Command, No 254 Squadron going to Bircham Newton in January 1940 and Nos 235, 236 and 248 to North Coates in February 1940. These



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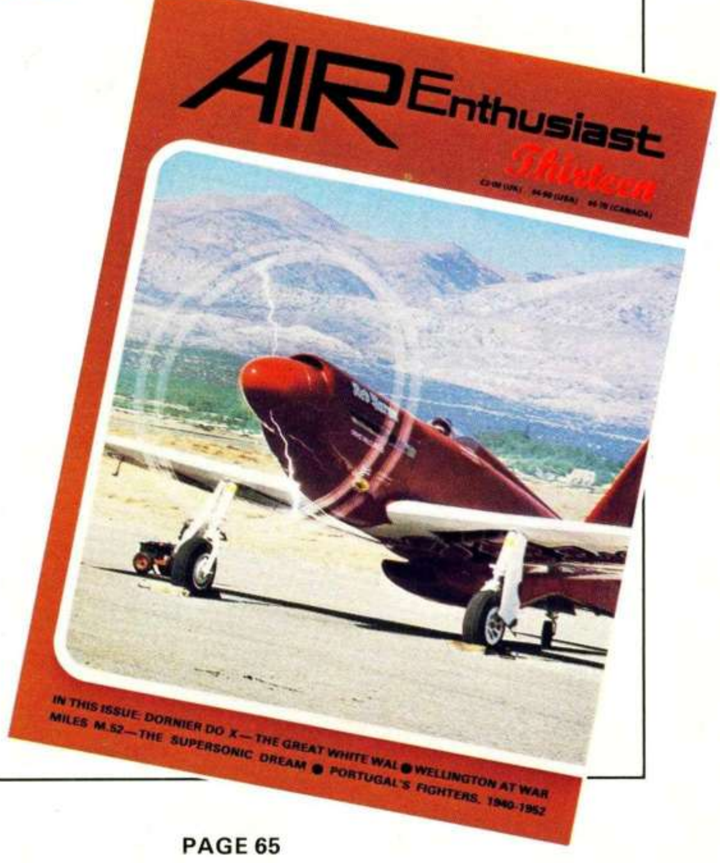
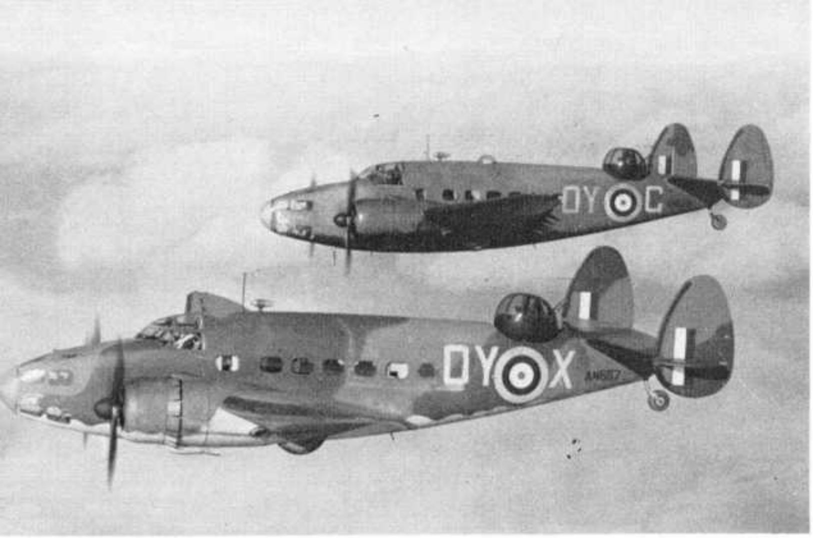




Lockheed Hudsons — shown here in the markings of No 48 Squadron — were ordered from the USA to help the RAF meet its expansion plans in 1938 and gave useful service for much of the wartime period (eventually as transports).

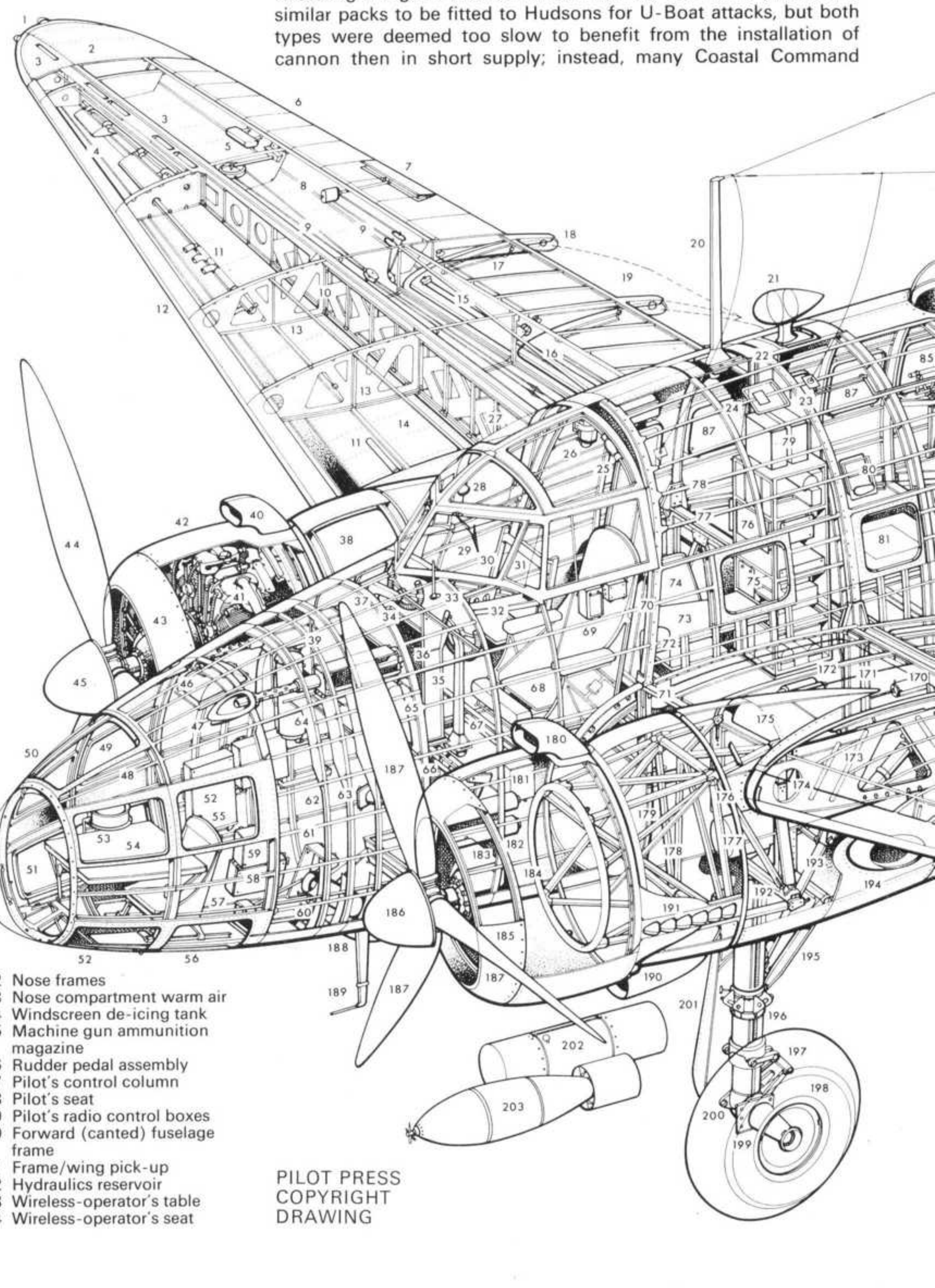
squadrons were equipped with Blenheim IVFs which each had four 0·303-in (7,7-mm) forward-firing machine guns in a belly tray. The range of these aircraft enabled them to take an active part in the Norwegian fighting in April 1940 and then to operate off Scandinavia.

Coastal Command's Blenheim force was further extended when Blenheim IV bombers of Nos 53 and 59 Squadrons, driven out of France, were assigned as GR squadrons to the Command. During the Battle of Britain, Blenheim fighters of Nos 235 and 236 Squadrons were very active over the English Channel and took part in a number of very fierce air battles as well as keeping an eye, most courageously, upon the Channel ports. Blenheim bombers and fighters served in considerable numbers in Coastal Command in 1941, particularly in an anti-shipping rôle in which they were supported by the Blenheim squadrons of No 2 Group, Bomber Command. The latter extended its sphere of anti-shipping raids to Malta, from where its crews operated with exceptional courage.

Coastal Command wanted heavier offensive armament in its Blenheim fighters, and trials were undertaken with two 20-mm Hispano cannon fitted into a new belly pack. Unheated, the cannon froze during test sorties, in addition to which there was no means of reloading the guns once airborne. Even so, Command pressed for similar packs to be fitted to Hudsons for U-Boat attacks, but both types were deemed too slow to benefit from the installation of cannon then in short supply; instead, many Coastal Command

Lockheed Hudson I Cutaway Drawing Key

1 Starboard navigation/identification lights
2 Starboard wingtip
3 De-icing slots
4 Internal vanes
5 Aileron internal mass balance
6 Starboard aileron
7 Aileron tab
8 Tab mechanism
9 Control cables
10 Wing main spar structure
11 De-icing tubes
12 Leading-edge de-icing boot
13 Main wing rib stations
14 Wing skinning
15 Flap control cables
16 Flap tracks
17 Flap cables/pulleys
18 Track fairings
19 Port flap (extended)
20 Aerial mast
21 D/F loop fairing
22 Support structure
23 Aerial lead-in
24 Cockpit cold air
25 Flight deck sun-blind frames
26 Windscreen wiper motor
27 Jettisonable canopy hatch
28 Console light
29 Windscreen wipers
30 Second-pilot's jump seat
31 Adjustable quarterlight
32 Windscreen frame support member
33 External gunsight
34 Second-pilot's (back-up) control column (cantilevered)
35 Central instrument console
36 Starboard nose compartment entry tunnel
37 Bulkhead
38 Starboard engine oil tank
39 Fixed forward-firing 0·303-in (7,7-mm) machine guns (two)
40 Carburettor intake
41 Wright R-1820-G102A radial engine
42 Starboard nacelle
43 Cowling nose ring
44 Three-blade propeller
45 Spinner
46 Nose compartment cold air
47 Machine gun muzzles
48 Nose structure
49 Roof glazing
50 Window frames
51 Nose cone
52 Navigator's side windows
53 Compass
54 Navigator's table
55 Navigator's (sliding) seat
56 Bomb-aimer's flat panels
57 Bomb-aimer's prone position
58 Bomb selector/switch panel
59 Navigator's instrument panel
60 Forward flare chute
61 Bombsight support
62 Nose frames
63 Nose compartment warm air
64 Windscreen de-icing tank
65 Machine gun ammunition magazine
66 Rudder pedal assembly
67 Pilot's control column
68 Pilot's seat
69 Pilot's radio control boxes
70 Forward (canted) fuselage frame
71 Frame/wing pick-up
72 Hydraulics reservoir
73 Wireless-operator's table
74 Wireless-operator's seat



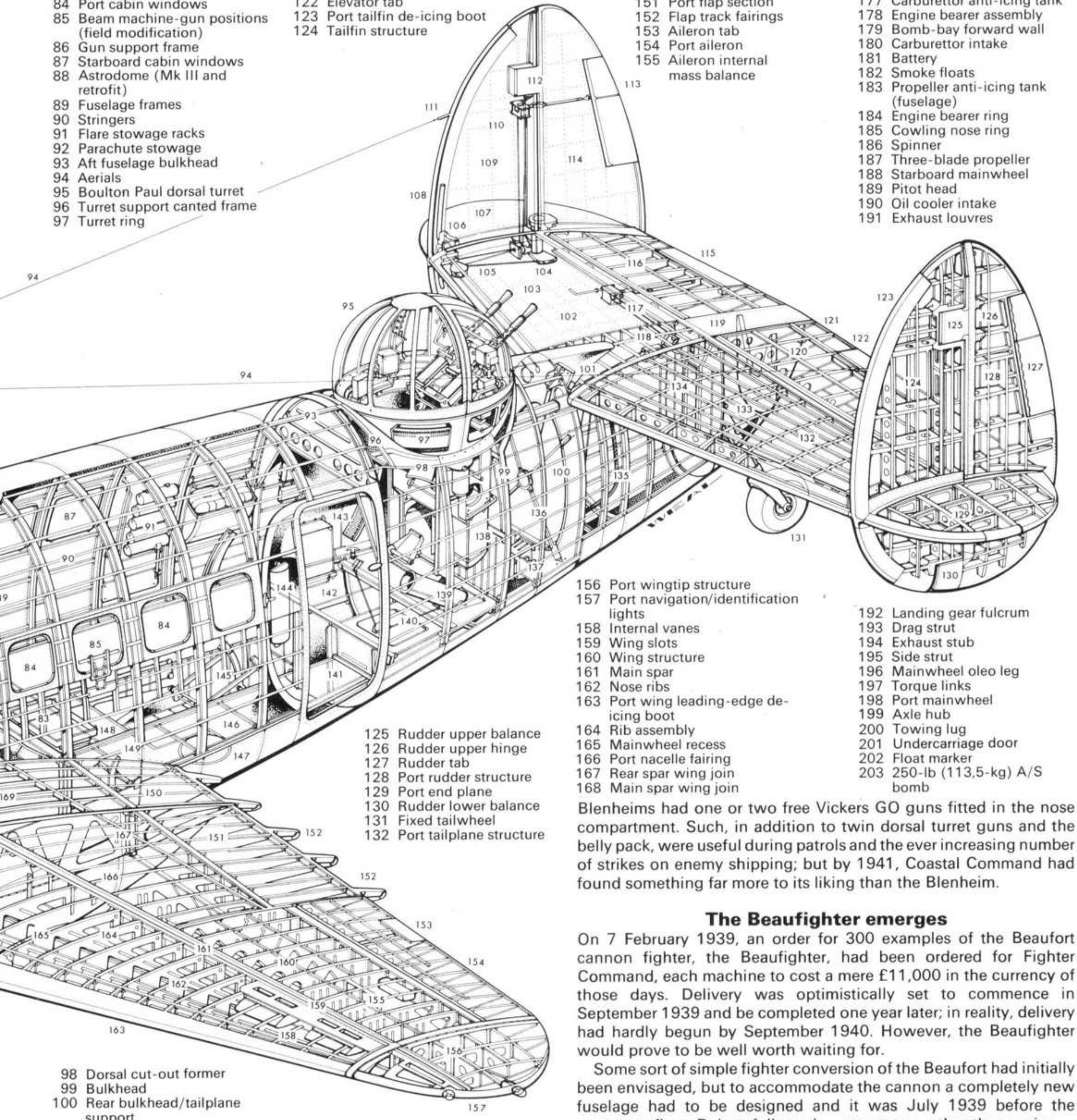
PILOT PRESS COPYRIGHT DRAWING

75 Transmitter
76 Receiver
77 Main spar centre-section carry-through
78 Spar/frame attachment
79 Wireless bay racks
80 Cabin cold air
81 Astrograph table/supply locker
82 Wing flaps actuating cylinder
83 Smoke-float stowage rack
84 Port cabin windows
85 Beam machine-gun positions (field modification)
86 Gun support frame
87 Starboard cabin windows
88 Astrodome (Mk III and retrofit)
89 Fuselage frames
90 Stringers
91 Flare stowage racks
92 Parachute stowage
93 Aft fuselage bulkhead
94 Aerials
95 Boulton Paul dorsal turret
96 Turret support canted frame
97 Turret ring

111 Aerial attachment
112 Rudder upper balance
113 Rudder tab
114 Starboard rudder
115 Elevator tab
116 Starboard elevator
117 Tab actuating linkage
118 Elevator control mechanism
119 Fixed centre-section
120 Tail navigation light
121 Port elevator
122 Elevator tab
123 Port tailfin de-icing boot
124 Tailfin structure

143 Ammunition feed/magazine
144 Dinghy release cylinder/hand lever
145 Tunnel (ventral) gun station (optional)
146 Cabin entry walkway (port)
147 Ventral camera port
148 Ventral gun well
149 Bomb-doors operating quadrant
150 Bomb-bay rear wall
151 Port flap section
152 Flap track fairings
153 Aileron tab
154 Port aileron
155 Aileron internal mass balance

169 Port wing aft fuel tank
170 Fuselage bomb-bay actuating cylinder
171 Port wing forward fuel tank
172 Control servos
173 Undercarriage retraction cylinder
174 Undercarriage support/attachment strut
175 Port engine oil tank bay
176 Engine support frame
177 Carburettor anti-icing tank
178 Engine bearer assembly
179 Bomb-bay forward wall
180 Carburettor intake
181 Battery
182 Smoke floats
183 Propeller anti-icing tank (fuselage)
184 Engine bearer ring
185 Cowling nose ring
186 Spinner
187 Three-blade propeller
188 Starboard mainwheel
189 Pitot head
190 Oil cooler intake
191 Exhaust louvres



156 Port wingtip structure
157 Port navigation/identification lights
158 Internal vanes
159 Wing slots
160 Wing structure
161 Main spar
162 Nose ribs
163 Port wing leading-edge de-icing boot
164 Rib assembly
165 Mainwheel recess
166 Port nacelle fairing
167 Rear spar wing join
168 Main spar wing join

192 Landing gear fulcrum
193 Drag strut
194 Exhaust stub
195 Side strut
196 Mainwheel oleo leg
197 Torque links
198 Port mainwheel
199 Axle hub
200 Towing lug
201 Undercarriage door
202 Float marker
203 250-lb (113,5-kg) A/S bomb

125 Rudder upper balance
126 Rudder upper hinge
127 Rudder tab
128 Port rudder structure
129 Port end plane
130 Rudder lower balance
131 Fixed tailwheel
132 Port tailplane structure

98 Dorsal cut-out former
99 Bulkhead
100 Rear bulkhead/tailplane support
101 Tail surface control linkage
102 Starboard tailplane
103 Twin 0·303-in (7,7-mm) machine guns
104 Rudder control quadrant
105 Cable linkage
106 De-icing tube
107 Starboard end plane
108 Tailfin de-icing boot
109 Tailfin skinning
110 Rudder tab actuator

133 Tailwheel shock-absorber leg
134 Tailplane support bulkhead
135 Warm air conduit
136 Bulkhead cover plate
137 Control pulley quadrant
138 Turret mechanism/support
139 Aft flare tube
140 Toilet location
141 Step
142 Entry door (jettisonable dinghy housing)

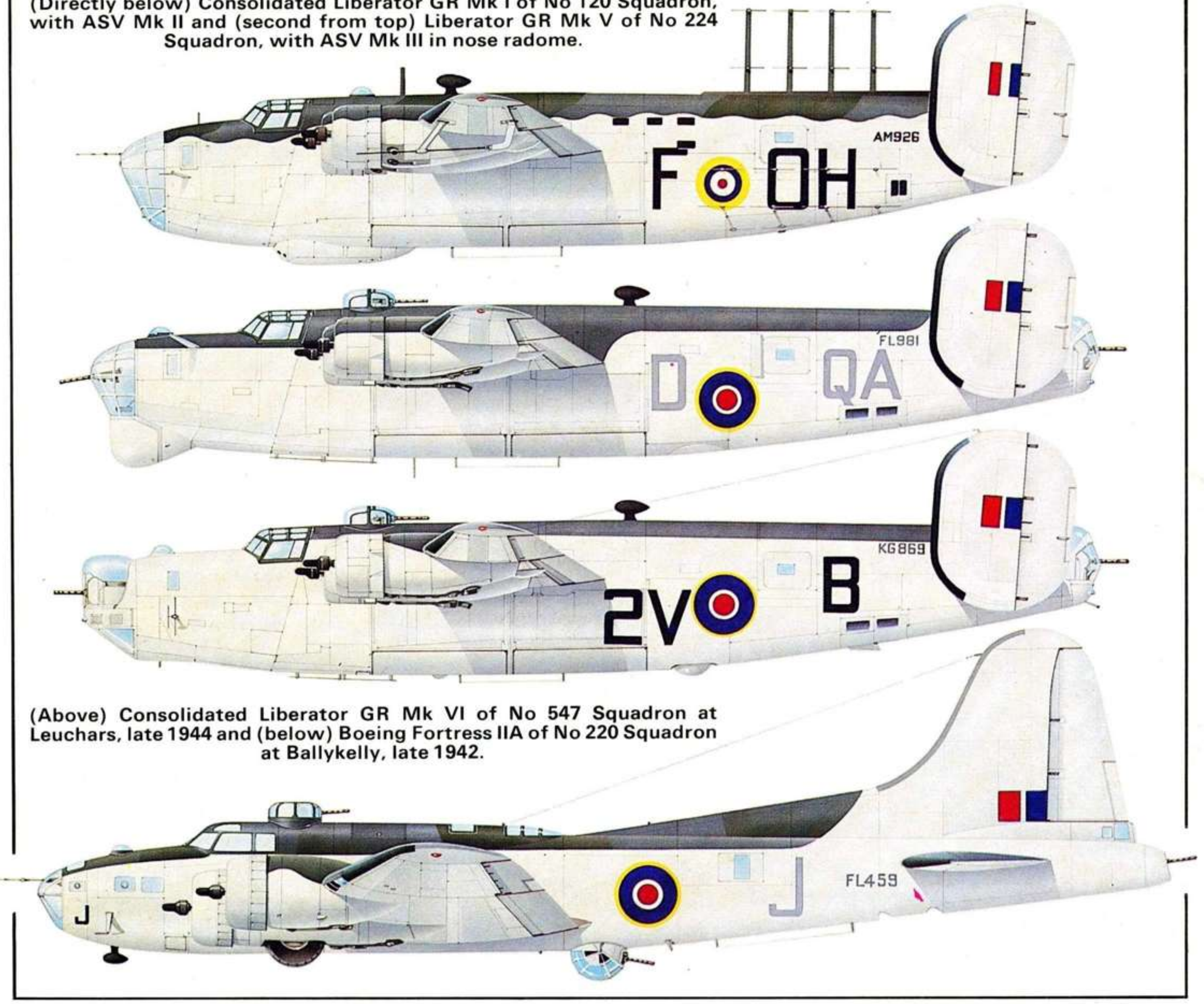
Blenheims had one or two free Vickers GO guns fitted in the nose compartment. Such, in addition to twin dorsal turret guns and the belly pack, were useful during patrols and the ever increasing number of strikes on enemy shipping; but by 1941, Coastal Command had found something far more to its liking than the Blenheim.

The Beaufighter emerges

On 7 February 1939, an order for 300 examples of the Beaufort cannon fighter, the Beaufighter, had been ordered for Fighter Command, each machine to cost a mere £11,000 in the currency of those days. Delivery was optimistically set to commence in September 1939 and be completed one year later; in reality, delivery had hardly begun by September 1940. However, the Beaufighter would prove to be well worth waiting for.

Some sort of simple fighter conversion of the Beaufort had initially been envisaged, but to accommodate the cannon a completely new fuselage had to be designed and it was July 1939 before the prototype flew. Delays followed — numerous rather than major — but then came the serious news that the planned Hercules VI engines would not be available in time. A top speed of about 370 mph (595 km/h) had been forecast for the Beaufighter, whereas with Hercules IIs and IIIs running on only 87 octane fuel the top speed fell to a mere 335 mph (539 km/h). To some extent this was counteracted by the aircraft's capacious fuselage, into which heavy AI radar could easily be fitted. Good duration was retained from the Beaufort, but there was relatively little common to both aircraft. Four cannon and six

(Directly below) Consolidated Liberator GR Mk I of No 120 Squadron, with ASV Mk II and (second from top) Liberator GR Mk V of No 224 Squadron, with ASV Mk III in nose radome.



(Above) Consolidated Liberator GR Mk VI of No 547 Squadron at Leuchars, late 1944 and (below) Boeing Fortress IIA of No 220 Squadron at Ballykelly, late 1942.

machine guns, plus the good range, attracted Coastal Command's attention to the Beaufighter in March 1940. Three rôles suggested themselves — anti-shipping, anti-E-Boat and trade protection. Coastal Command likened their idea for the Beaufighter to a "policeman on the beat", and pleaded for it to carry a crew of three and a dorsal turret. A mock-up of a maritime variant was ready by November 1940 and soon Beaufighters were being built with dual Coastal and Fighter Command fittings, until production arrangements were fully worked out. Delivery of the first Coastal Mk Ic came in February 1941, when No 252 Squadron equipped. In May, that squadron moved to the Middle East but home-based Nos 143, 236 and 248 Squadrons had Beaufighters in its place by August 1941. Most were long-range fighters, their wing guns having been replaced by additional fuel tanks.

Meanwhile the Hudson force, 150 strong in mid-1941, was waging an intensive anti-shipping campaign. Hudsons and an equivalent number of Blenheims formed two-thirds of the entire Coastal Command strength, which then included about 60 Beauforts. Five stations in the Command each held 60 torpedoes for them, the entire reserve amounting to 75 torpedoes; with 560 torpedoes being built between March and December 1941, production steadily rose thereafter to nearly 100 a month.

Hudson IIs began arriving in September 1940, then Mk IIIs with increased engine power, additional guns and greater fuel load in the Spring of 1941. Squadrons soon received Mk Vs, in which Pratt & Whitney Wasp engines were replaced by Wright Cyclones. In mid-1942, the 220-strong Hudson force represented 37 per cent of Command strength, and Hudsons had come to hold some notable "firsts", with the crew of a No 224 Squadron aircraft, on 8 September 1939, claiming to be the first in the RAF to shoot down an enemy aircraft, a Do 18 off Jutland; on 27 August 1941 the crew of a No 269 Squadron Hudson captured U-Boat U-570. More important, it was a Hudson that in January 1940 was the first Coastal Command aircraft to carry ASV (Air-to-Surface Vessel) radar.

Ansons were finally retired from GR duty at Skitten as 1941 ended, and there were then nine Hudson squadrons operational. Also on strength were 120 Blenheims in six squadrons, 80 Beauforts in four squadrons with two more forming, but a mere 20 Beaufighters of No 248 Squadron, because an improved version was being prepared. Enemy surface raiders had taken second place to U-Boats and to help combat them Coastal Command turned to the ageing Whitley, examples of which had reinforced it in 1939 on detachment from Bomber Command. It seemed suitable for long duration ocean patrol and the first Whitley Vs entered Coastal squadrons in September 1940. By mid-1941 two squadrons were operating, from Limavady and Wick, and their effectiveness greatly improved when the ASV equipped Whitley VII entered service in August 1941. Some 64 of the latter were built by March 1942 and a further 70 were ordered to maintain Whitleys in service for another six months. No 502 Squadron was first to use ASV Mk II-equipped Whitleys, one of which (Z9190) on 30 November 1941 made the first ASV kill by sinking U-206 in Biscay.

Wellington Ics (retitled GR Mk VIII in Coastal guise) had been with No 221 Squadron of Coastal Command since December 1940, and acquired ASV in 1941. Faster than the Whitley, the Wellington had good endurance, was better armed and had ample development potential. A torpedo-bomber variant was soon produced and used in the Middle East whilst GR variants saw home service. The other ageing bomber available to the Command was the Handley-Page Hampden, whose builders, eager to extend its life, converted — in only six weeks — one to carry a tight-fitting Mk XII torpedo in late 1941. Relief greeted its proven value after only two weeks of trials and then Handley-Page caused considerable amazement by converting 24 Hampdens into torpedo-bombers in another fortnight! About 150 were eventually converted, half of them fitted with ASV radar. Four squadrons operated the Hampdens between January 1942 and late 1943, thus filling a gap at a time when Beauforts were in very short supply, but the Hampden's large wing area made it an easy gunner's target and, lacking manoeuvrability, it was at best an interim aircraft whose life was extended while better things were developed.

A far more agile type was needed. Pratt & Whitney Wasps, the supply of which was limited, did little to boost the Beaufort, in its Mk II version. Then, again almost by chance, Bristol hit upon the idea of a Beaufighter VI carrying a torpedo. The first Mk VIc (Hercules VI) entered service in April 1942 with No 235 Squadron, just as Bristol in a week converted a Mk VI to carry a torpedo below its belly. Wind tunnel tests indicated a speed loss of only about 8 mph (12 km/h) and a range of 1,700 miles (2 735 km). After dropping its torpedo, the Beaufighter could again become a long range strike fighter — very useful for Coastal Command — but the Air Staff, surprisingly, turned down the idea. Poor crew accommodation, lack of rear defence, stability problems, all these and other criticisms were levelled against the idea, added to which, it was claimed, the Beaufighter would not be able to fly slowly enough to drop a torpedo.

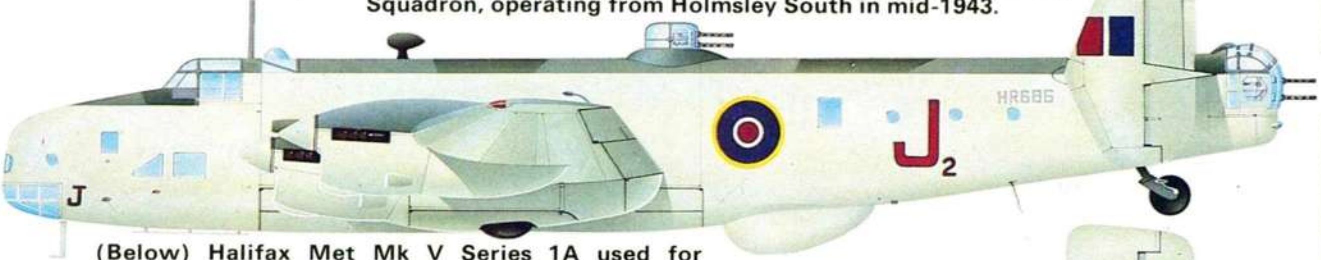
Bristol quickly sought out the C-in-C Coastal Command, who immediately warmed to the idea and succeeded in getting the Air Staff to change its collective mind. The Beaufighter went ahead, carrying an 18-in (45,7-cm) torpedo, and an order for 15 Interim Torpedo Fighter Mk VIcs was placed. Another 60 were ordered in August 1942 and a variant fitted with ASV Mk II was in prototype form by September 1942, at the same time that rocket projectile firing tests and bombing tests were also being arranged. All these items formed part of the armoury of the Beaufighter TF Mk X, in which Hercules XVII engines were fitted, to give their best performance at a lower level than the Hercules VIs. Other modifications included a stronger undercarriage, long range tanks in lieu of wing guns, Coastal's oft-wished-for rear gun, and airbrakes — which proved a constant problem but were necessary to slow the aircraft for torpedo dropping.

Arrival of the new family of Beaufighters released most of the Hudsons for anti-submarine duty late 1942 in connection with Operation *Torch*, the Allied landings in North Africa. During 1943, Beaufighter strike wings worked up with a multiplicity of weapons, and for the last two years of the war played a most valuable part in the offensive against enemy shipping both at home and overseas. To a limited extent they were replaced in 1944 by Mosquito FB Mk VIs, but the latter never carried torpedoes into action. By the end of 1943, one-third of the Coastal Command force flew Beaufighters, including a few Mk XIcs (Mk VIs with low altitude rated Hercules XVII engines) as well as the TF Mk Xs and Mk VIcs.

The VLR force

From mid-1941, No 120 Squadron had been using Consolidated Liberator Is for deep ocean patrol. By January 1942 five of these had been converted into Very Long Range aircraft whose range was

(Below) Handley Page Halifax GR Mk II Srs 1 (Special) of No 502 Squadron, operating from Holmsley South in mid-1943.



(Below) Halifax Met Mk V Series 1A used for meteorological reconnaissance, No 518 Squadron, Tiree, 1944.

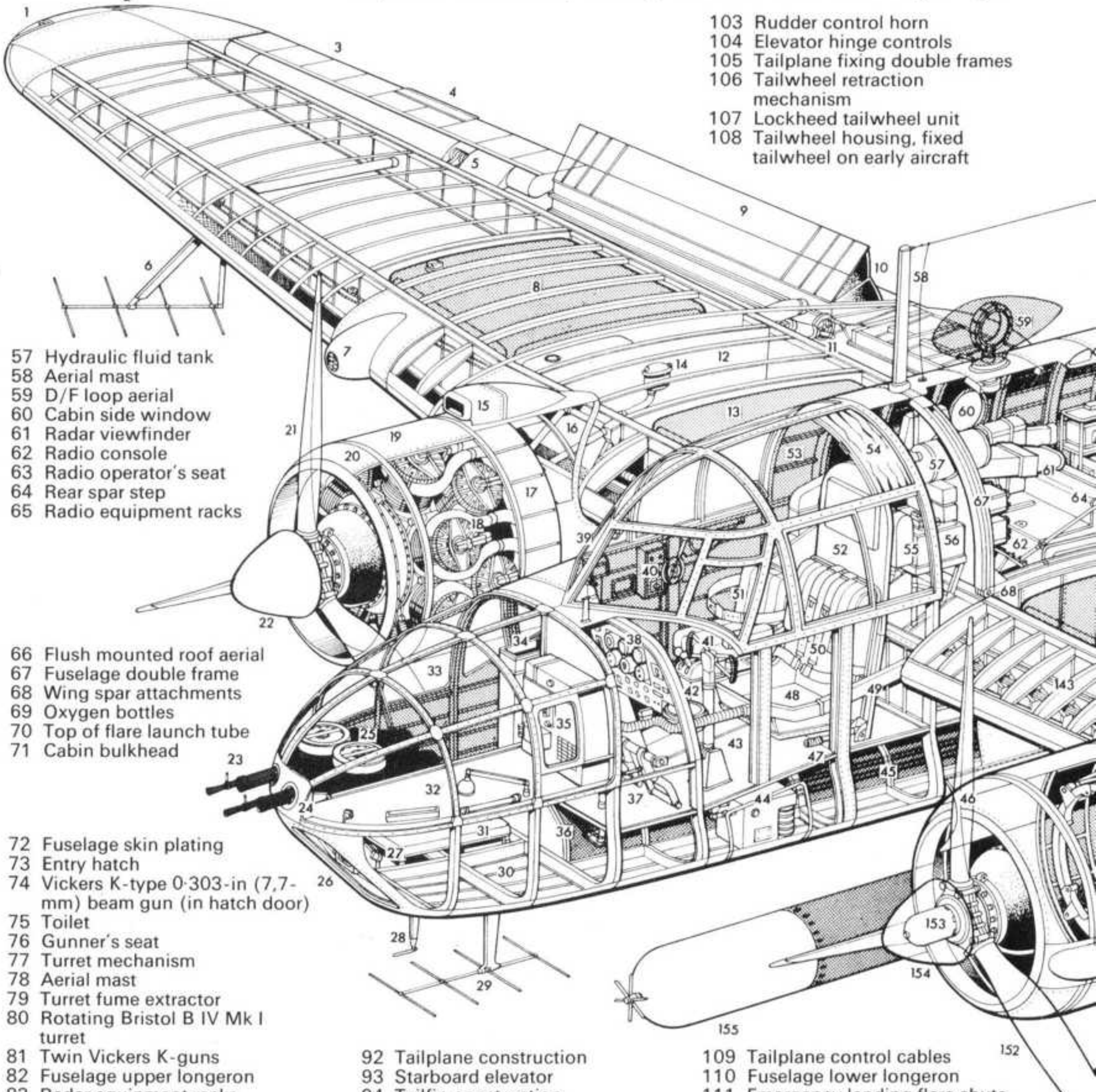
(Below) Vickers Warwick GR Mk V, with ASV Mk II radome forward and retractable Leigh Light aft, in service with No 179 Squadron at St Eval from November 1944 to mid-1946.

2,400 miles (3 860 km), and these were supplemented in the summer of 1942 by squadrons of Liberator IIIs, all for general maritime duties far out over the Atlantic. When the VLR Mk V entered service in April 1943, control of the Atlantic was gradually passing into Allied hands. Such was the range of the Liberators that one, after an 18-hour patrol from Iceland, landed at Goose Bay. There were six Liberator squadrons functioning by July 1943, two more with Fortress IIs and only No 269 Squadron was left using Hudsons. In March 1944, the first nose-turretted Liberator GR Mk VIs were received some of which, with Halifaxes in service with two other Coastal squadrons, operated as strike aircraft off Denmark in the closing weeks of the war.

Wellingtons proved just as successful in their GR/strike rôles, five squadrons being in use at the start of 1943. It was essential that U-Boats could be attacked at any time, especially when they surfaced at night to re-charge batteries. Using radar to locate them and flares to illuminate them was tried, but this allowed the submarine to dive before a depth charge attack was possible. A far more original idea was conceived in 1940 by Sqn Ldr H de V Leigh at HQ Coastal Command: radar would be used to locate the submarine, he proposed, which would then be illuminated using a high candlepower searchlight carried in the aircraft making the attack. After lengthy mistrust of the idea, No 1417 Flight at Chivenor experimented with Leigh Lights fitted to its Wellington VIIIs in 1941 and on 3 June 1942 No 172 Squadron, formed from this Flight, commenced Biscay night patrols and secured 25 per cent of all U-Boat night sightings during the first month of operations. It moved to Wick in August, where a second squadron then formed, releasing No 172 for further Biscay operations. U-Boats were now forced to surface much farther out to sea, thus much reducing their patrol effectiveness, although later the ability of their crews to become aware of ASV radar operations, and eventually the *Schnorkel* device, reduced the effectiveness of airborne searchlights. At their peak of value, between March and May 1943, 15 U-Boats out of 25 illuminated by Leigh Light were attacked with depth charges.

By August 1943 Coastal Command had six Wellington squadrons, four flying the Mk XII (Hercules VI) and Mk XIV (Hercules XVII) variants with Leigh Lights. Wellington GR XIIIs, equipped with ASV Mk II, were available for daylight operations and for night flare dropping and bombing attacks on shipping and E-Boats in sorties from Manston and Bircham Newton in 1944-45. By June 1944, three more Coastal Command squadrons were flying Leigh Light Wellingtons, and airborne searchlights were also carried under the wings of Liberators, slipped onto racks for a simpler installation than the Wellington's retractable belly-mounted light. Smaller versions of the Leigh Light, known as "Pumpkins", were developed for use on other aircraft, but their 3,500,000-candlepower and 1,600-yd (1 463-m) range fell well below the 15,000,000/20,000,000 cp of the standard lamp fitted to Liberators and Wellington XIVs, with a range of up to a mile (1,6 km).

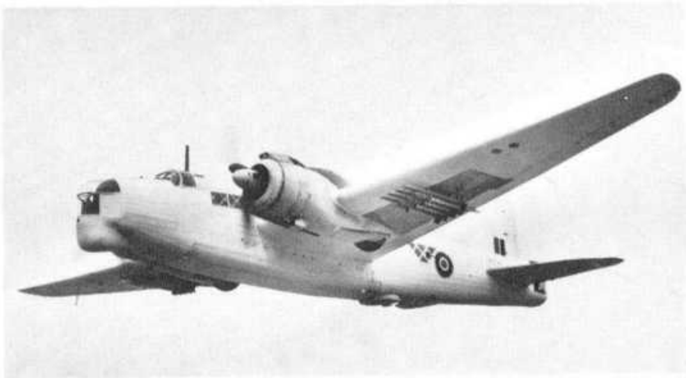
The general performance of maritime reconnaissance aircraft had improved enormously during the war. A loaded Leigh Light-



Bristol Beaufort I Cutaway Drawing Key

1 Starboard navigation light
2 Formation keeping light
3 Starboard aileron, fabric covered
4 Aileron tab
5 Aileron hinge control
6 Starboard ASV Mk II radar aerial
7 Oil cooler intake
8 Starboard outboard fuel tank
9 Pneumatic dive brake (few aircraft only) open
10 Dive brake operating bellows
11 Flap hydraulic jack
12 Starboard undercarriage wheel bay
13 Inboard fuel tank
14 Fuel vent
15 Carburettor air intake
16 Engine bearer struts
17 Cooling air outlet gills
18 Bristol Taurus VI 14-cylinder sleeve-valve radial engine
19 Engine cowlings
20 Exhaust collector ring
21 de Havilland three-bladed propeller
22 Spinner
23 Twin Vickers K-type 0·303-in (7,7-mm) nose guns on gimbal mounts
24 Windproof sealing apertures
25 Ammunition drums
26 Bomb aiming windows
27 Bomb sight
28 Pitot tube
29 Nose ASV Mk II radar aerial
30 Nose compartment construction
31 Bomb aiming prone position
32 Navigator's chart table
33 Nose glazing
34 Chart case
35 Navigator's instrument panel
36 Forward end of semi-recessed torpedo housing
37 Rudder pedals
38 Pilot's instrument panel
39 Windscreen panels
40 Pilot's fixed gun sight
41 Control column
42 Compass
43 Pilot's floor
44 Autopilot controller
45 Control cable runs
46 Bomb doors
47 Seat adjusting lever
48 Pilot's seat
49 Heater air duct
50 Safety harness
51 Navigator's seat
52 Pilot's armoured backplate
53 Cockpit roof escape hatch
54 Sliding sun blind
55 Parachute stowage
56 Radio equipment
57 Hydraulic fluid tank
58 Aerial mast
59 D/F loop aerial
60 Cabin side window
61 Radar viewfinder
62 Radio console
63 Radio operator's seat
64 Rear spar step
65 Radio equipment racks
66 Flush mounted roof aerial
67 Fuselage double frame
68 Wing spar attachments
69 Oxygen bottles
70 Top of flare launch tube
71 Cabin bulkhead
72 Fuselage skin plating
73 Entry hatch
74 Vickers K-type 0·303-in (7,7-mm) beam gun (in hatch door)
75 Toilet
76 Gunner's seat
77 Turret mechanism
78 Aerial mast
79 Turret fume extractor
80 Rotating Bristol B IV Mk I turret
81 Twin Vickers K-guns
82 Fuselage upper longeron
83 Radar equipment racks
84 Fuselage frame construction
85 Dive brake de-icing fluid tank
86 Carburettor de-icing tank
87 Vertical control cable shaft
88 Rear fuselage joint frame
89 Dust proof fabric bulkhead
90 Fin root fairing
91 Fin spar attachment
92 Tailplane construction
93 Starboard elevator
94 Tailfin construction
95 Aerial cable
96 Rudder balance weight
97 Rudder construction
98 Tail navigation lights
99 Rudder tab
100 Elevator tab
101 Port elevator
102 Port tailplane
103 Rudder control horn
104 Elevator hinge controls
105 Tailplane fixing double frames
106 Tailwheel retraction mechanism
107 Lockheed tailwheel unit
108 Tailwheel housing, fixed tailwheel on early aircraft
109 Tailplane control cables
110 Fuselage lower longeron
111 Emergency landing flare chute
112 Ballast weights
113 Walkway
114 Turret rotating jack
115 Wing root trailing edge fillet
116 Inboard split flap
117 Dinghy stowage
118 Inflation bottle
119 Airflow deflectors

equipped Liberator V, of which 21 were available to the Command by December 1943, had a range when loaded of just short of 2,000 miles (3 200 km), compared with the Anson's 800-ml (1 287-km) range with a load of small, largely ineffective bombs. Liberator Vs in the strike rôle with Nos 59 and 547 Squadrons even carried rocket projectiles for some operations.

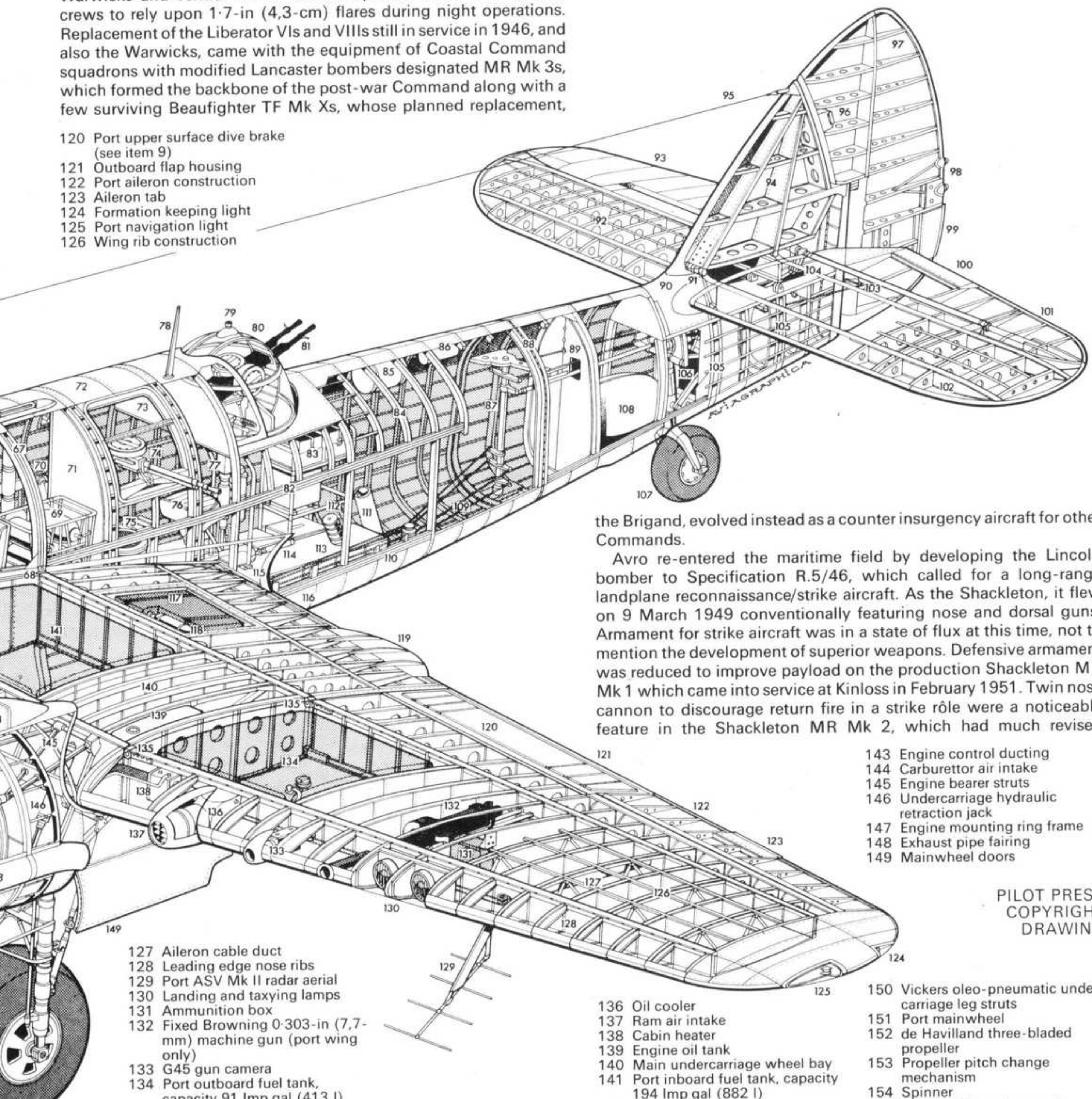


Wartime exigencies led to the adoption by Coastal Command of torpedo-carrying versions of several of Bomber Command's basic types, including the Wellington (GR Mk XIV illustrated), Hampden, Whitley and Halifax.

Post-war re-equipment

March 1944 brought the decision that all Coastal Command Liberators should be able to carry airborne searchlights and completely replace Wellingtons, but the end of the war witnessed nearly all of the Liberators being rapidly transferred for trooping duty in Transport Command, and those remaining with Coastal in any case had limited life due to the end of Lend Lease. A scheme to use Bristol Buckingham bombers as GR aircraft was dropped in favour of going ahead with the use of Leigh Light-equipped Vickers Warwick GR Mk Vs, seven squadrons of which had been planned. In the event, numbers were reduced, Leigh Lights were removed from the Warwicks and ventral FN 77 turrets replaced them, leaving their crews to rely upon 1·7-in (4,3-cm) flares during night operations. Replacement of the Liberator VIs and VIIIs still in service in 1946, and also the Warwicks, came with the equipment of Coastal Command squadrons with modified Lancaster bombers designated MR Mk 3s, which formed the backbone of the post-war Command along with a few surviving Beaufighter TF Mk Xs, whose planned replacement, the Brigand, evolved instead as a counter insurgency aircraft for other Commands.

Avro re-entered the maritime field by developing the Lincoln bomber to Specification R.5/46, which called for a long-range landplane reconnaissance/strike aircraft. As the Shackleton, it flew on 9 March 1949 conventionally featuring nose and dorsal guns. Armament for strike aircraft was in a state of flux at this time, not to mention the development of superior weapons. Defensive armament was reduced to improve payload on the production Shackleton MR Mk 1 which came into service at Kinloss in February 1951. Twin nose cannon to discourage return fire in a strike rôle were a noticeable feature in the Shackleton MR Mk 2, which had much revised



120 Port upper surface dive brake (see item 9)
121 Outboard flap housing
122 Port aileron construction
123 Aileron tab
124 Formation keeping light
125 Port navigation light
126 Wing rib construction
127 Aileron cable duct
128 Leading edge nose ribs
129 Port ASV Mk II radar aerial
130 Landing and taxying lamps
131 Ammunition box
132 Fixed Browning 0·303-in (7,7-mm) machine gun (port wing only)
133 G45 gun camera
134 Port outboard fuel tank, capacity 91 Imp gal (413 l)
135 Outer wing panel spar joints
136 Oil cooler
137 Ram air intake
138 Cabin heater
139 Engine oil tank
140 Main undercarriage wheel bay
141 Port inboard fuel tank, capacity 194 Imp gal (882 l)
142 Filler cap
143 Engine control ducting
144 Carburettor air intake
145 Engine bearer struts
146 Undercarriage hydraulic retraction jack
147 Engine mounting ring frame
148 Exhaust pipe fairing
149 Mainwheel doors
150 Vickers oleo-pneumatic undercarriage leg struts
151 Port mainwheel
152 de Havilland three-bladed propeller
153 Propeller pitch change mechanism
154 Spinner
155 18-in (45,7-cm) torpedo

(Below) Avro Shackleton GR Mk 1 of No 120 Squadron at Aldergrove, after adoption of the overall grey finish in succession to the predominantly white finish.

(Below) Hawker Siddeley Shackleton MR Mk 3 of No 201 Squadron, with which this variant operated at St Mawgan from October 1958 until October 1970.

Descended from the Avro Lancaster — which itself served with Coastal Command — the Shackleton has now been superseded in the maritime patrol rôle, illustrated by this MR Mk 3 of No 206 Squadron, but is still in service for airborne early warning with No 8 Squadron.

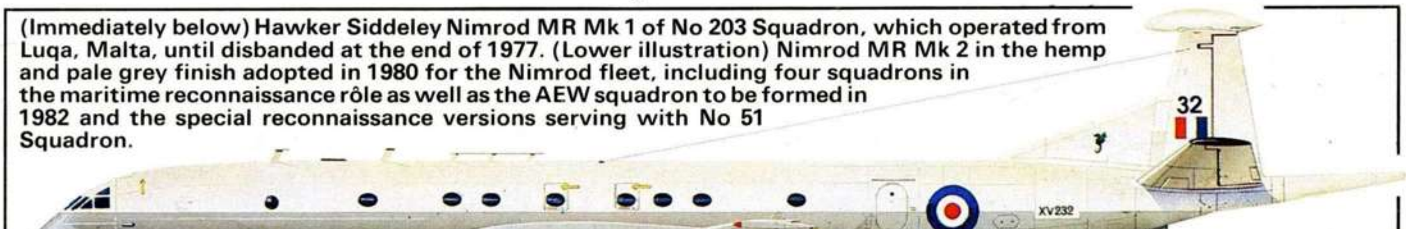
equipment at a time when fast strides in electronics were being made. The Mk 2 first flew on 17 June 1952 and already a further version, the Shackleton MR Mk 3, was being prepared. Nosewheel undercarriage, wing tip fuel tanks, modified cockpit canopy giving a better view and a revised internal layout — not to mention further up-dating of the electronics — were all apparent when the aircraft first flew in 1955, and the ability to remain airborne for 24 hours, without the use of flight refuelling which had earlier been considered, was in due course demonstrated.

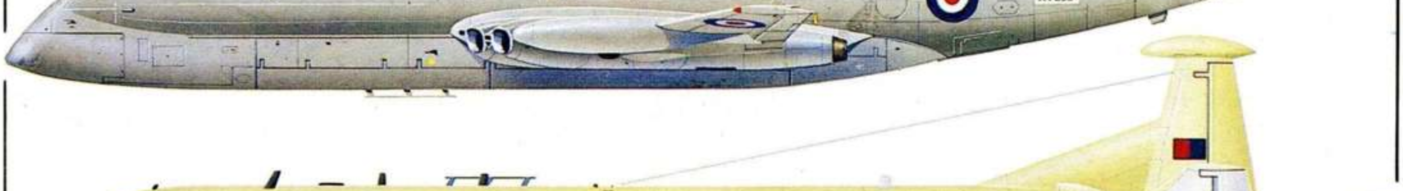
Anti-shipping operations are now assigned to part of the RAF's Buccaneer force, leaving the current Nimrods for ocean patrol and attack far out to sea. Numerous attempts had been made to adapt airliner designs for maritime duty in order to replace the Shackleton. Eventually it was the de Havilland Comet, the world's first jet airliner, that lent much of its beautiful form to the Nimrod, the world's first pure jet maritime patrol aircraft and probably its most advanced.

Far removed indeed is the Nimrod from the Vildebeest, whose torpedo-dropping rôle it maintains. The Nimrod's speed to station, not to mention its range, its high level of sophistication and the vast area of surveillance which it is able to achieve, would surely leave the crew of a Vildebeest speechless. Perhaps most of all they would marvel at a level of comfort which they could but dream of.

The oceans often present scenes of exotic grandeur and expansive beauty which are coupled with the ability to turn bitter and dangerous with great rapidity. Coastal Command, and now its successor No 18 Group, have faced and still face an exacting task over vast and hazardous areas. Their equipment needs to be the finest that can be afforded, and in ample supply. It guards our very existence — and we neglect it at our peril. □

(Immediately below) Hawker Siddeley Nimrod MR Mk 1 of No 203 Squadron, which operated from Luqa, Malta, until disbanded at the end of 1977. (Lower illustration) Nimrod MR Mk 2 in the hemp and pale grey finish adopted in 1980 for the Nimrod fleet, including four squadrons in the maritime reconnaissance rôle as well as the AEW squadron to be formed in 1982 and the special reconnaissance versions serving with No 51 Squadron.





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