ROYAL AIR FORCE YEARBOOK 1982

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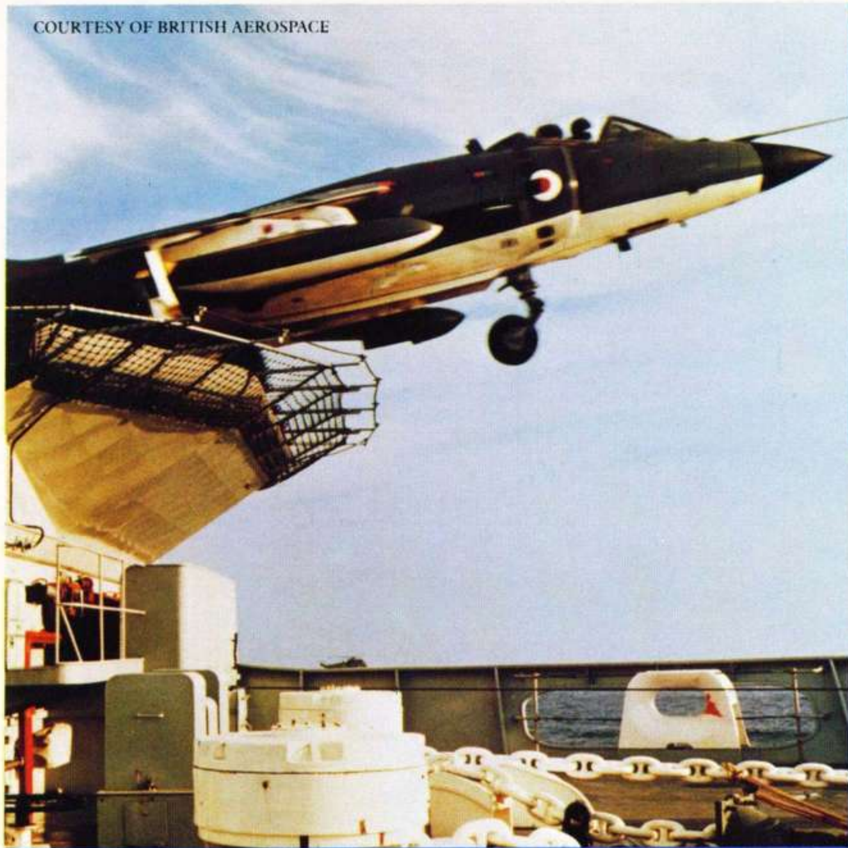

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ROYAL AIR FORCE YEARBOOK 1982

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

Michael Beetham

THE contribution which the Royal Air Force makes to the defence of our country and of the NATO Alliance will be significantly enhanced during the 1980s. This year, 1982, will be a particular milestone in our history since it will see the final disbandment of the V-Bomber Force and the formation of the first Tornado squadron. The V-Bombers have provided a central bulwark of our defences for more than 25 years — an era of which we can be justly proud and now sadly coming to an end. But Tornado, with its purpose-built low level all weather capability, is a worthy successor and seems destined to win as notable a place for itself in the affections of the RAF. And, in addition to Tornado, a whole new range of aircraft and weapons, covering all our major rôles, are due to enter the inventory. This will place great demands on the professionalism and dedication of our men and women, but they can be sustained by the knowledge of the vital importance of their task.

This Yearbook gives a taste of the extensive range of activities and achievements of the Royal Air Force, both past and present. I hope that as many readers as possible will take the opportunity to see us at first hand by attending the Battle of Britain "At Home" Days — at RAF Finningley and RAF Leuchars on 4 September and at RAF Abingdon and RAF St Athan on 18 September — and at some of the other displays and Open Days around Britain in which the Royal Air Force will be participating.

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The views expressed in RAF Yearbook 1982 are those of the authors alone and should not be taken as an expression of official policy.

RAF YEARBOOK 1982

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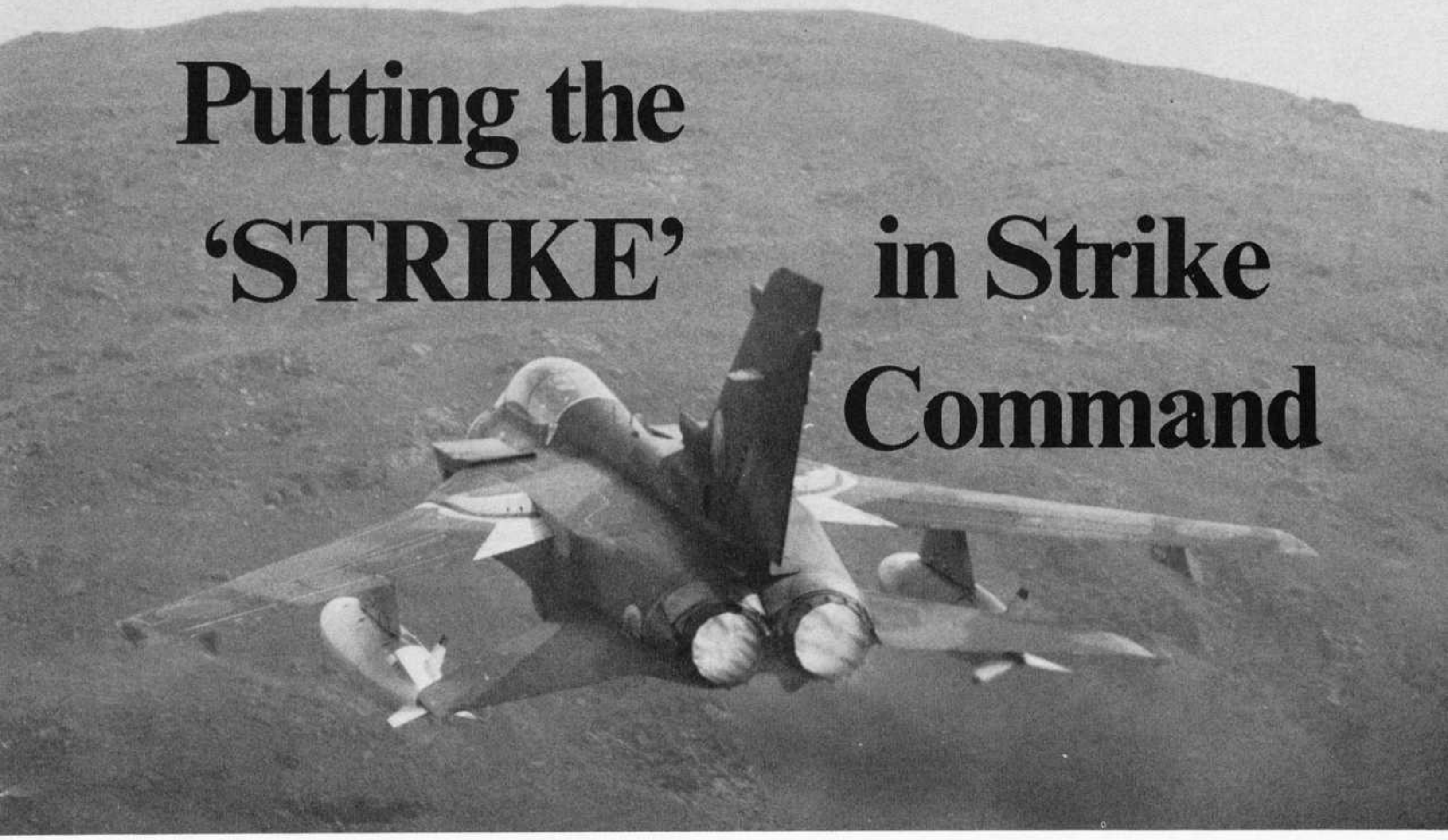


PAUL JACKSON DESCRIBES THE ACTIVITIES OF NO 1 GROUP, RAF

WHILST peace may be described as "the absence of war", such a desirable condition is seldom based on the absence of armed forces, for it is the prime peacetime function of armies, navies and air forces to preserve the *status quo* by diligent rehearsal of their ultimate — wartime — rôles. Such is the essence of deterrence; freedom is worth fighting for, but it is preferable that it should be defended before war becomes the sole remaining alternative to subjugation. Britain's strategic deterrent, the Polaris missile, has been in the care of its Senior Service for more than a decade, but powerful forces are also possessed by the RAF for medium- and short-range strike with conventional or nuclear weaponry against an aggressor on the march.

At home, the greater part of this offensive force is contained within Strike Command's No 1 Group — the last vestige of several such Groups which once formed the now-defunct Bomber Command. Tasked with the provision of strike/attack forces, reconnaissance, in-flight refuelling and manned target facilities, No 1 Group fields a wide cross-section of aircraft, ranging from the challenging new Tornado interdictor to the ageing, yet well-respected Canberra electronic warfare training aircraft, via such stalwarts as the Buccaneer, Victor, Nimrod and — in the twilight of its career as these words are written — Vulcan.

Raised on 1 May 1936 through redesignation of Central Area, Air Defence of Great Britain, No 1 Group provided the spearhead of Britain's contribution to the defence of free Europe when it transferred its Fairey Battles to France in August 1939, becoming HQ Advanced Air Striking Force in the process. The gallant sacrifice of the AASF whilst attempting to stem the *Wehrmacht* advance in May 1940 is reflected in the No 1 Group insignia of a black panther's head (a representation of the AASF code name, "Panther"), and its motto, "Swift to Attack". Re-established after the Battle of France, No 1 Group moved headquarters to Bawtry Hall near Doncaster in July 1941, and it is from this same converted country mansion that it is at present commanded by Air Vice-Marshal Michael W P Knight, CB, AFC, BA.

In 1951, the Group pioneered introduction to operational service of the world's first jet bomber, the Canberra, and later in the same decade it again achieved international distinction when the Vulcan became the largest delta-winged bomber to gain squadron status. The changes which the Group is now undergoing are no less profound than its earlier rounds of modernisation, and the next few years will see introduction of two new aircraft types, plus the partial or complete withdrawal of three models in the current inventory. During the interim period, RAF strike capability will be reduced substantially, but even when the Tornado is fully deployed, RAF Germany is to receive the major proportion of operational squadrons, and No 1 Group will not regain its previous supremacy as a long-range strategic force.

The Group's airfields are situated principally in East Anglia and Lincolnshire, several maintaining a long association with the former Bomber Command. In the rich farmlands of Suffolk, between Bury St Edmunds and Thetford, lies Honington, whilst in similar country a few miles south-east of King's Lynn, Marham is another station constructed on the pre-war pattern, but with greatly extended runways and dispersals. Just east of Huntingdon, in what is now Cambridgeshire, Wyton stands at the gateway to the Fenland. In the former county of Rutland rests RAF Cottesmore, the home of the unique Tri-national Tornado Training Establishment. To the north, high on the Lincoln Wolds, Scampton and Waddington straddle the Roman city of Lindum, and much farther still, the former naval air station at Lossiemouth is located on the bleak but picturesque shores of the Moray Firth. On the debit side one, or possibly both, of the Lincolnshire aerodromes will sever their ties with the Group.

Vulcan valediction

Perhaps the saddest task which the Group is being called upon to perform this year is the disbandment of its Vulcan squadrons, thereby terminating a long and rewarding association begun with acceptance of the first Vulcan B Mk 1 in July 1956. Conceived in the immediate post-war years as a high-level strategic bomber, the Vulcan transitioned with ease to the rigours of low-altitude operation, armed with free-fall weapons or the Blue Steel stand-off bomb, whilst in more recent years it has constituted Britain's contribution to NATO's Long-Range Theatre Nuclear Forces, being the only RAF aircraft capable of low-level strike in all weathers. Vulcans will be remembered with affection for the impressive four-aircraft "scrambles" connected with their deterrent rôle and the almost unbelievable aerobatic agility demonstrated at air displays, but after 26 years the time has come for replacement.

Although capable of carrying 21 conventional 1,000-lb (454-kg)

Although the Buccaneer has suffered its share of problems recently, leading to a small but significant reduction in the inventory, this excellent strike aircraft is destined to serve with the RAF for another decade or so. The photographs above and at the foot of the page depict Buccaneers from RAF Lossiemouth. (Photos by Phillip Boyden and Geof Lee, BAe.)

bombs, the Vulcan has had as its primary rôle that of nuclear strike in the HI-LO-HI profile, and it is towards this task that training has been dedicated. For realistic practice of low-level flying, Vulcans have augmented European exercises by deployments to Goose Bay in Canada and Offutt AFB in the United States, where large expanses of sparsely-populated terrain offer realistic training with minimal restrictions. In peacetime, "low" means 300 ft (90 m) for experienced crews, or 1,000 ft (300 m) flying on instruments at night, although in an operational situation these heights would be reduced. Indeed, during "Red Flag" exercises in the USA, penetration at 200 ft (60 m) was not uncommon, this representing less than twice the wingspan of the Vulcan B Mk 2.

Crew experience and teamwork has been a vital factor in maintaining the Vulcan's effectiveness as a low level bomber, despite its ageing avionics systems. The main radar is none other than a modified version of the wartime H2S, which in conjunction with a terrain-avoidance radar added in a small nose radome during the late 1960s, provided data for "manual" contour-following. The Vulcan's navigation system was last updated a decade ago, when an HRS compass unit and a Decca Doppler augmented the Integrated Navigation System ("all pulleys and wheels" — definitely not to be confused with the modern meaning of INS: *Inertial* Navigation System). Soon after, additional ESM equipment was added in a distinctive fin-top fairing, to provide warning of pick-up by hostile radar. Lacking the advantages of microchip technology incorporated in today's military aircraft, Vulcan crews (comprising pilot, co-pilot, nav/radar, nav/plotter and air electronics officer) have nevertheless demonstrated a high degree of co-ordination in the achievement of creditable results in international bombing competitions, their honours including the prized Mathis Trophy at the USAF's "Giant Voice" tournament in 1974.

In addition to six Vulcan bomber squadrons, No 1 Group has also operated a unit dedicated to maritime radar reconnaissance. Based at Scampton, No 27 Squadron was equipped with Vulcan B Mk 2(MRR)s, differing in equipment from their compatriots. Incidentally, the B Mk 2(MRR)s retained gloss camouflage after the remainder of the fleet adopted matt colours with (from 1979 on some aircraft) dark grey and green finish on lower, as well as upper, surfaces.

Under original plans, Vulcan withdrawal was to have taken place in parallel with introduction of the Tornado, No 27 Squadron retaining its aircraft until the latter part of the decade. However, when the financial aspects of this scheme were fully examined, this proved impractical, and the decision was taken in 1981 to effect a much more rapid phase-out. Having flown an average of 5,500 hours per aircraft, the Vulcans were by that time approaching the end of their envisaged lifetime, and whilst capable of many more years of service after refurbishment, maintenance costs would have risen dramatically as inaccessible sealed-for-life components fell due for repair or replacement.

Scampton's Vulcans were the first to go, beginning with the training unit, No 230 OCU, which wound-down in August 1981. No 617 Squadron disbanded on the last day of that year, followed by No 35 in February 1982 and No 27 in March. The MRR rôle has been re-assigned to Nimrod MR Mk 2 squadrons, backed by satellite reconnaissance of shipping, and an effective if not totally dedicated service can still be provided. At Waddington, No IX Squadron disbanded in April 1982, leaving Nos 44, 50 and 101 to retire their aircraft during the next two months, and thereafter — for the first time since the prototype flew in August 1952 — Britain's skies have become devoid of the Vulcan's characteristic delta form.

Enter the Tornado

Unquestionably, the majestic Vulcan will be sorely missed by those associated with its long years of sterling service, but its very capable successor is now on the threshold of operational deployment, and No 1 Group is hard at work training the first Tornado GR Mk 1 crews. Honington is the hub of the Group's Tornado programme, following delivery of the initial aircraft to the Weapons Conversion Unit (TWCU) on 30 June 1981 and commencement of the first course in January 1982. Conversion to the aircraft itself is, of course, undertaken at the TTTE, Cottesmore, and Honington's function (explained in more detail elsewhere in this book) is to provide training in the use of the varied armament carried by this multi-rôle warplane.

Although it has been decided that the British and German Governments are to stretch out the Tornado production schedule for

The Panavia Tornado, scheduled to enter service with the RAF's first operational squadron this year, is replacing Vulcans in Strike Command, but not — at least until the early 1990s — Buccaneers. The Buccaneers in RAF Germany will be replaced by Tornadoes, however, making more aircraft available for the home-based squadrons. The photographs above and right show Tornado GR Mk 1s during the development phase of flight testing, concerned with weapons carriage and release, and the performance of the terrain-following and nav/attack system.

financial reasons, deliveries to the RAF had been running ahead of contract, placing no constraints on the training programme. Aircrew are pleased with the performance and serviceability of this sophisticated aircraft, and groundcrew — though still down on the learning curve — are encountering fewer problems than anticipated with their advanced equipment. As with all new aircraft, there have been some hiccups, certain components requiring a change sooner than anticipated and others performing normally after their predicted replacement time, but all concerned with the aircraft are convinced it is "a winner".

Several new weapons are in the pipeline for the Tornado, most of which will not be available until after it enters operational service. In addition to current weapons such as laser-guided and cluster bombs (CBUs), the much-needed JP233 airfield-denial store will become available within the next few years, followed by new anti-armour and anti-radar missiles produced to Air Staff Requirements 1227 and 1228 respectively. For the last-mentioned, BAe Dynamics is proposing the ALARM (Air-Launched Anti-Radiation Missile), backed by an alternative simpler submission, whilst Marconi is offering a missile based on the Sky Flash air-to-air missile (AAM) and the US is represented in the competition with the Texas Instruments AGM-88 HARM.

In more immediate prospect is the installation of a laser rangefinder beneath the Tornado's nose. Production aircraft with this fitment are now on the assembly line, whilst those in service will receive retrospective modification. Next year, Sky Shadow ECM (electronic countermeasures) pods will be available to aid penetration of defences and new AIM-9L Sidewinder AAMs will be supplied to Tornado users from the British share of European production. Though the latter weapon is immediately associated with air defence, it is a valuable asset to strike aircraft when they are confronted by hostile interceptors, for if the fighter pilot has to watch his six (tail) for a missile fired by his intended victim's wingman, his concentration may be sufficiently diverted for both Tornadoes to make good their escape.

As home of the TWCU, Honington will logically host the first operational Tornado unit (due to form later this year). Following a change of priorities, the squadron to gain this distinction will now be No IX and the hotly-favoured No 617 ("The Dam Busters") will not be re-established until the second squadron forms at Marham early in 1983. UK allocations for Tornado squadrons have yet to be finalised, so it is as yet uncertain whether a third strike unit will form at Marham. The UK-based Tornado force will be finally completed when a reconnaissance squadron is formed later in the present decade, with aircraft carrying new infra-red linescan equipment built to specifications issued to industry last year. (Whilst technically non-operational — having no "shadow" squadron number — the TWCU is capable of providing battle-ready aircraft crewed by instructors.)

A substantial infrastructure programme is being undertaken in parallel with the Tornado build-up, involving construction of hardened aircraft shelters (HASs) and headquarters at both operational bases. These are the first such installations to appear on RAF airfields outside Germany (except, of course, at the bases occupied by the USAF), the project also including HASs for Tornado F Mk 2 interceptors at the No 11 Group airfields. The first building at Honington was opened in November 1981.

Design of the new HAS shows that much has been learnt since RAF Germany's reinforced hangarettes were built. They are larger, and can hold a soundproof "management cabin" for crew briefing, and each is equipped with heating and a water supply for fire-fighting, plus the usual aircraft winch. Aircraft will operate from these HASs in both peace and war, thus ensuring the greatest possible security from surprise attack.

Management of the Tornado's introduction to service is a major task for No 1 Group, yet one which it is undertaking with obvious enthusiasm. The pioneering groundwork currently in hand will ensure a rapid and trouble-free re-equipment programme for RAF Germany, and go some way towards smoothing deployment of the Tornado F Mk 2 interceptor from 1985 onwards. Aircrew training for RAF Germany will continue to be a No 1 Group responsibility, resulting in a high workload for the TWCU. Only a small proportion of the Vulcan aircrew will transfer to Tornado. However, despite replacement of a five-man aircraft with a two-crew machine, there will be no redundancies among V-Bomber fliers, as their expertise is required in numerous other positions. Some navigators will transition to various fast jets and AEOs may be posted to Nimrod squadrons, whilst other personnel are to take up ground appointments, where staffing shortages have been evident since the late 1970s.

Buccaneer: forward to the 'nineties

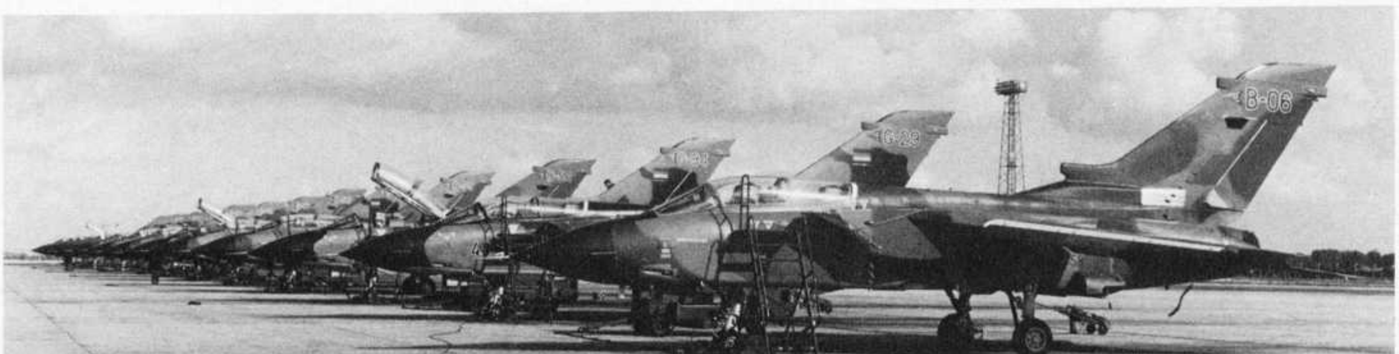
Though the Tornado will claim much of the limelight in this and future years, it must not be forgotten that it is partnered in the strike rôle by a still very capable aircraft of an earlier generation. Conceived originally for the Royal Navy, the Buccaneer entered service with the RAF in 1969 and currently equips two squadrons and an OCU in No 1 Group, plus two units of RAF Germany. The first British aircraft designed specifically for under-the-radar interdiction, it remains a valuable asset despite its ageing avionics, providing a stable platform at relatively high speeds for a variety of weapons. In fact, the three UK-based squadrons each specialise in the use of differing armament, although all are nuclear-capable if so required.

Southernmost of the Buccaneer bases is Honington, where No 208 Squadron is located alongside No 237 OCU, the latter providing 75-hour crew conversion courses. The OCU is additionally the sole user of the Buccaneer S Mk 2A (former naval aircraft lacking provision for the Martel air-to-surface missile), all other RAF Buccaneers being S Mk 2Bs with the Martel option. This weapon is not carried by No 208 Squadron, however, which is assigned to overland duties.

No 208 is declared to AFNORTH in NATO's chain of command, and its area of operation stretches from Denmark (the Baltic Approaches) to the northernmost areas of Norway. Typical targets for its attention would be selected airfields, medium to large battlefield formations, disembarking amphibious forces, ports, harbours and bridges, all of which would be attacked from low level with cluster or parachute-retarded bombs. The usual weapons fit for such operations would comprise up to six bombs in the rotating bomb-bay, and one beneath the wing, the remaining external hardpoints accommodating two fuel tanks and a Westinghouse AN/ALQ-101-10 jamming pod.

The squadron's "beat" encompasses wide variations in terrain, from flat, green Denmark to the ice-covered mountains and fjords of the Arctic Circle, and regular deployments are accordingly made to Norway for familiarisation. At home, the Buccaneers frequent the Southern Highlands of Scotland or the Welsh mountains, a typical two-hour sortie including practice at a weapons range, a simulated

By the beginning of 1982, the flow of crews trained to fly the Tornado was well-established through the Tri-national Tornado Training Unit at Cottesmore — where these aircraft were photographed on the flight line — and the next stage of training had begun, at the Tornado Weapons Conversion Unit at Honington — as described on pages 43-44.



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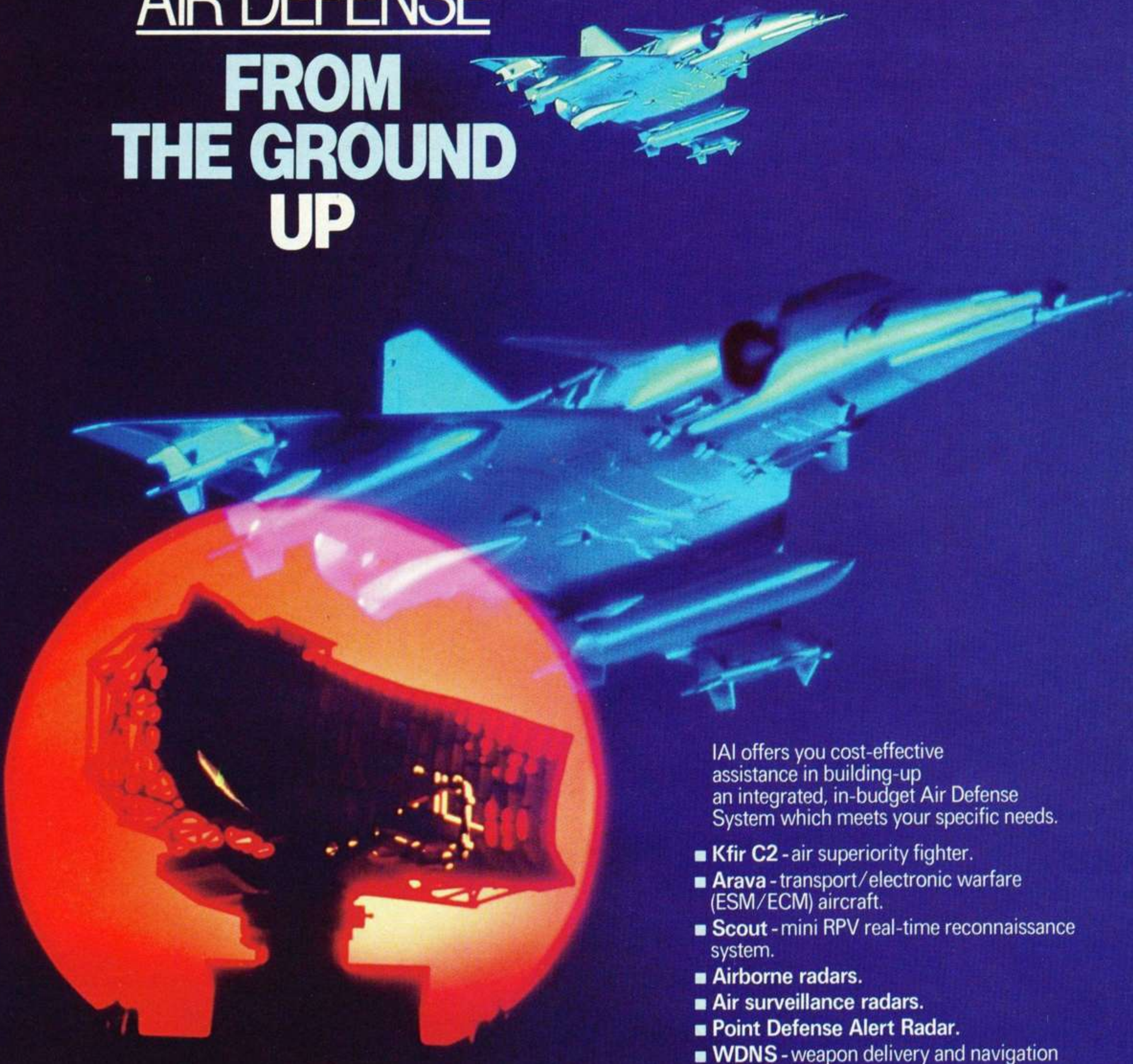

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attack on a random target (such as a disused airfield) and fighter affiliation — evasion tactics — with Phantoms or Lightnings of No 11 Group.

At Lossiemouth the Buccaneers of No 12 Squadron exercise in their maritime strike rôle in the Western Approaches and between Iceland and the Faroes, under NATO's Atlantic Command (SACLANT). Although the aircraft is the same, procedures differ greatly from the overland rôle. In both instances, crews work in close collaboration, but the overwater rôle sees aircraft flying a mission planned in detail beforehand and largely controlled by the navigator, while No 208 Squadron adopts more flexible tactics to accommodate unforeseeable changes in the land situation (such as mobile SAM sites or intercepting aircraft) and in this case, the operation is more demanding on the pilot.

Usually, the maritime target would be a surface action group (SAG) or a formation of amphibious landing craft. No 12 Squadron specialises in carrying Martel missiles and 1,000-lb (454-kg) bombs (using the Buccaneer's inbred toss-bombing capability). Both UK-based Buccaneer squadrons have been reduced in strength since the fleet was temporarily grounded for fatigue investigation in 1980.

Detailed examination of every RAF Buccaneer, in conjunction with repair where necessary, has left the aircraft structurally ready for many more years of service, and crew confidence is at its former level. Few aircraft can match the hard, low-level manoeuvring (up to 6 *g*) of which the Buccaneer is capable, and this is all to the good in view of the recent decision to retain the aircraft for maritime strike operations into the 1990s. However, for the Buccaneer to remain operationally effective throughout the decade, installation of an improved nav/attack and ECM system will be necessary. This will make the aircraft compatible with the British Aerospace Sea Eagle, the new stand-off sea-skimming missile that was ordered into production early this year, and will enable crews to counter improving enemy defences.

Operating in the maritime strike rôle with No 1 Group, the Buccaneers will in due course be modified to carry the British Aerospace Sea Eagle anti-shipping missile — shown here undergoing early flight testing on a trials Buccaneer.

Fuelling the fighters

The Tornado and Buccaneer represent the offensive element of No 1 Group for the rest of this decade and beyond, but other types of aircraft are employed for less well publicised, yet equally important, functions. It is in this respect that the Group provides a variety of services for other RAF units and, furthermore, for other branches of the armed forces.

In-flight refuelling is now an indispensable facet of air operations, extending the range of aircraft well beyond the limitations of their own fuel tanks. At Marham, Nos 55 and 57 Squadrons operate a fleet of Victor K Mk 2 airborne tankers which are more frequently to be found topping-up aircraft of other than No 1's own strike element.

Produced as a high-level strategic bomber (to the same specifications as the Vulcan), the Victor has been converted to its present rôle by the addition of extra fuel tankage in the bomb-bay and permanent fixture of the previously optional external wing tanks. In the cockpit, a large fuel management panel mounted between the two front seats enables the co-pilot to feed kerosene between no less than 32 separate tanks — vitally important to maintain the aircraft's centre of gravity as fuel is dispensed — whilst the navigator (radar) doubles as refuelling operator, controlling hoses and pumps and eyeing the receiving aircraft through a rearwards-pointing periscope. The remaining two "back seaters" also play their part in the fuel transfer process, the AEO with electrical, hydraulic and communications functions and the navigator (plotter) controlling the rendezvous.

Three fuel hoses are carried by the Victor, and in the case of fighter refuelling, the two outer-wing pods are normally employed, each being capable of transferring 150 Imp gal (682 l) per minute. For single, heavier aircraft, the hose drum unit (HDU) in the bomb-bay pumps 500 Imp gal (2 273 l) per min. Although fitted with three hoses, the Victor can accommodate only two aircraft at once (on the outboard positions) as there is insufficient wing room for a triple hook-up.

Victors regularly accompany overseas flights of RAF strike aircraft to the Mediterranean for weapons practice or North America for "Red Flag" and "Maple Flag" exercises, yet the majority of sorties are mounted at short notice, air defence Phantoms and Lightnings being the principal customers, followed by maritime strike Buccaneers, Jaguars and, only occasionally, Harriers. The Victor squadrons have also been involved in trials work with the Tornado, and have infrequently topped-up aircraft of the US Navy, whose refuelling system is compatible with British methods.

Most day-to-day flying is in conjunction with the training of other RAF units, but Nos 55 and 57 Squadrons also provide aircraft for immediate scramble in support of No 11 Group's QRA interceptors. Such operations are launched when Soviet intelligence-gathering aircraft enter British-controlled airspace, and as the fighters take-off to escort the intruder, so does their Victor mother-ship.

For safety reasons, refuelling fighters are closely monitored by radar and radio, but in an operational situation, silence is not only golden, but is also essential, and the fighters approach the Victor using lines painted on the undersurfaces as reference points and receive progress indications of the fuel transfer process from "traffic lights" mounted in each hose unit. By night the procedure is the same, floodlights illuminating the tanker's lower areas.

More than half the Victor's maximum take-off weight is fuel 55 tons (56 tonnes) compared with 51 tons (52 tonnes) for the rest of the aircraft — and the ability to shunt this from tank to tank is of value if a hose unit becomes unserviceable, when fighters must queue for the remaining available drogue. The entire fuel stock can be used by the Victor's engines or can be delivered to other aircraft (theoretically!), although more can be taken on board from another Victor via the nose-mounted refuelling probe. Fuel shunting is especially appreciated by Lightning pilots, as their aircraft do not take too kindly to cold fuel from the Victor's wing tanks, and warmer stock from the bomb-bay is preferred.

Victor crews are trained by No 232 OCU in courses lasting 55 hours for navigators, 60 for pilots and 75 for AEOs. To allow flexibility, the OCU's aircraft are pooled with the squadron aircraft and then lent back to the OCU. However, it is "allowed" to apply its


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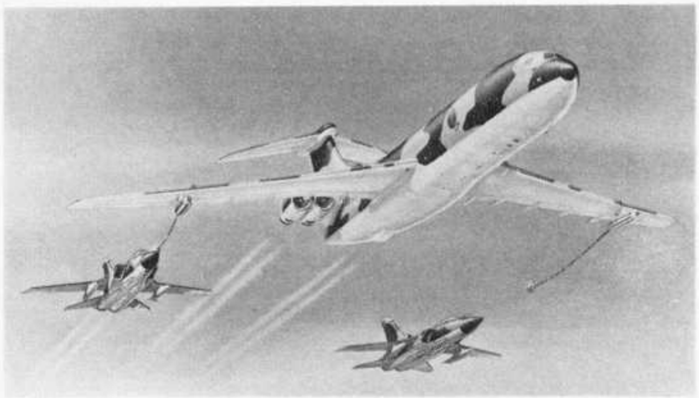


(Left) Victor K Mk 2 in-flight refuelling tankers of No 57 Squadron at RAF Marham — home base for the two Victor squadrons that make up the entire tanker Force in No 1 Group. Next year, the RAF should begin to put into service the VC10 tanker (artist's impression, right).

insignia to the Victor serialled XL232, which by happy coincidence shares the "232" with the number of the OCU.

From the foregoing, it is clear that fighter refuelling is a central element in the RAF's defensive and offensive planning, and it will therefore come as no surprise to learn that extension of FR capabilities are of high priority. Accordingly, No 1 Group is shortly to gain a third refuelling squadron equipped with five VC10 K Mk 2s and four Super VC10 K Mk 3s converted from surplus airline equipment by BAe at Filton, Bristol. The first aircraft (a K Mk 2) was flying again this year after a lengthy modification and refurbishing programme at Filton, including installation of five additional fuel tanks in the hold, a ventral HDU and two wing refuelling pods. It will be followed by three more K Mk 2s before the first K Mk 3 emerges, all aircraft having the uprated Conway 43 turbofans of the Super VC10.

For ease of maintenance, VC10 tankers will be based at Brize Norton alongside the VC10 C Mk 1 transports of No 38 Group. In common with the USAF's KC-10 Extender, they can carry ground equipment and personnel whilst undertaking their refuelling mission — a capability beyond that of a converted bomber such as the Victor.

In the longer term, a replacement must be found for the present AAR fleet, and in this connection it is significant that the RAF has recently purchased British Airways' entire holding of 14 Super VC10s. Three of these have been earmarked for breakdown and use as spares, the remainder currently standing in storage at Abingdon. There is plenty more airframe life in the Victor yet, so it is probable that the operational value of the first nine VC10 tanker conversions will be assessed in RAF usage before a decision is taken on the possible modification of the 11 reserves.

Born 1951 — still going strong

On 25 May 1951, Roland Beamont, English Electric's then chief test pilot, delivered the first Canberra B Mk 2 to an operational squadron in No 1 Group — No 101 at Binbrook. An almost unbelievable 31 years later, the Canberra was *still* in the front line of No 1 Group, although only just. This remarkable longevity is sufficient evidence of the Canberra's qualities in a broad spectrum of rôles, but from June of this year these are restricted to support duties, in which the aircraft will continue to operate until the end of the century.

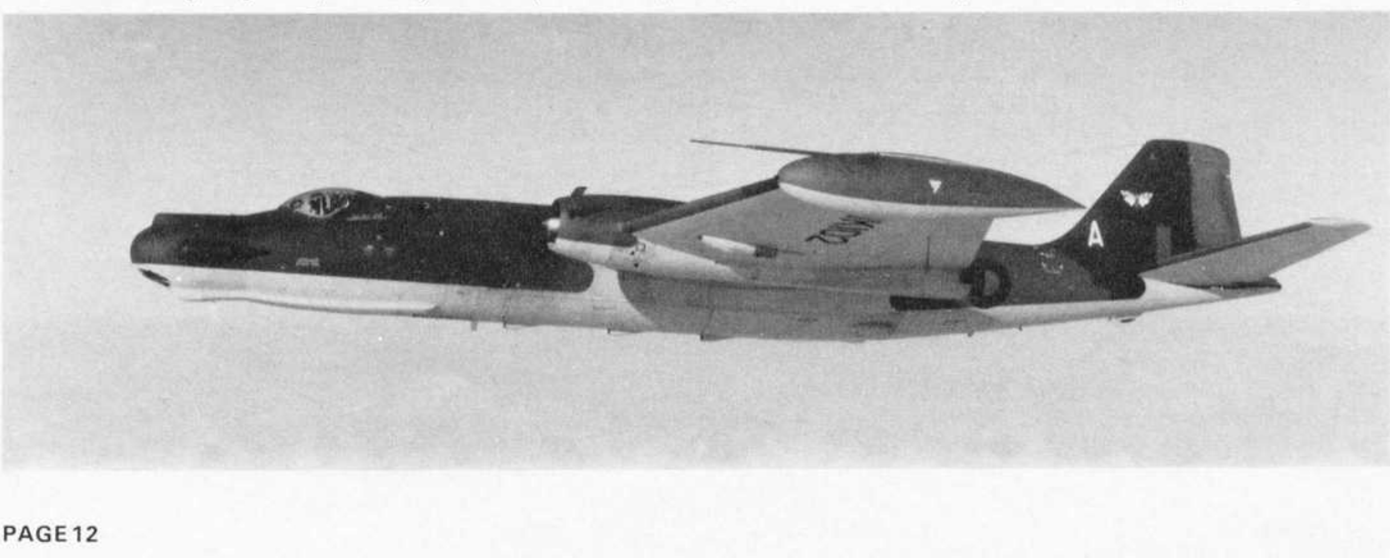
In its final days as a front-line aircraft, the Canberra has been employed for reconnaissance in both its PR Mk 7 and PR Mk 9 forms. No 13 Squadron at Wyton, flying the Mk 7, disbanded on 5 January 1982, whilst the Mk 9s of co-located No 39 Squadron were given a further five months before they too were to leave the operational scene. Readily distinguished by its broader wingspan and offset cockpit canopy (plus the recent addition of radar warning receivers in the tailcone and on the fin), the Mk 9 has not been entirely dismissed by the Service, for three aircraft — plus reserves — will be maintained as photographic survey platforms.

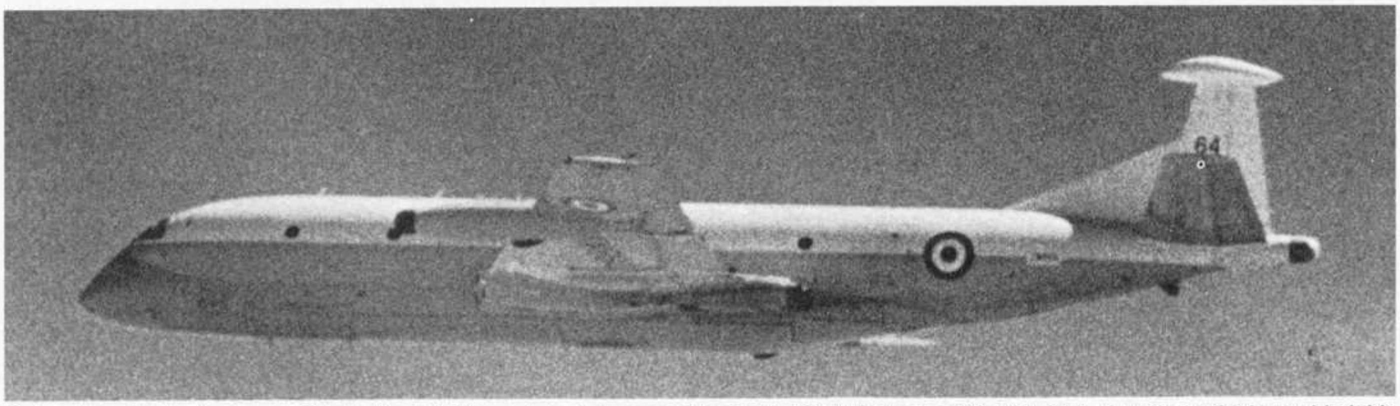
Wyton is now the exclusive home of the Canberra, all RAF aircraft of this type having recently come under the control of No 1 Group and being based at the Cambridgeshire airfield for ease of maintenance. In brief, their support rôle is the provision of aerial targets on which defensive units can practice their skills, but such is the diverse nature of this work that five distinct marks of Canberra are used. Those aircraft selected for continued service have been passing through BAe's works at Samlesbury, near Preston, since 1977, each emerging after almost two years' refurbishment as virtually new machines.

Easily the strangest-looking of these are the Canberra T Mk 17 electronic countermeasures aircraft of No 360 Squadron, a joint-Services unit which numbers Royal Navy personnel among its crews. It is of passing interest that No 360 is the RAF's youngest numbered squadron (it formed for the first time in September 1966), yet it flies the world's oldest airworthy Canberra: WD955 — born November 1951 and still going strong.

A large bulbous nose, studded with additional bulges, indicates that the Canberra 17 is equipped with an array of jamming devices

Although the RAF's inventory of Canberras is now running down, several variants will remain in service for some years yet, including (above) the TT Mk 18 target tug now operated by No 100 Squadron and (below) the T Mk 17 ECM target and trainer flown by No 360 Squadron.





Going about its business over the Baltic, this Nimrod was intercepted by Saab J 35D Drakens of the Swedish Air Force, which provided this photograph. It has been reported to be a Nimrod R Mk 1 of No 51 Squadron.

intended to confuse defensive radars. No 360 Squadron helps to test the vigilance of the UK's defences and to train airborne and ground radar operators to function in the face of the electronic interference which is now as much a facet of warfare as guns and explosives.

Early in January this year, Wyton became the base of No 100 Squadron transferred together with the Canberra OCU (No 231) from RAF Marham. The latter equipped with Canberras in December 1951 and still maintains a steady flow of crews for user squadrons with its fleet of B Mk 2s and dual-control T Mk 4s, as well as training civilian pilots to fly the Navy's Canberras at Yeovilton. Slight thinning of unit establishments in the past few months has made some amalgamation possible, with the result that No 7 Squadron (a former No 18 Group unit) disbanded at St Mawgan in Cornwall, and some of its aircraft were absorbed by No 100 last December.

Until recently, No 100 Squadron's equipment comprised Canberra 2s and a handful of E Mk 15s — the latter identified by an external aerial strung between the cockpit and the fin. Operating in conjunction with interceptor squadrons, No 100 supplies Mk 15s for high-level interception practice (up to 45,000 ft/13 720 m) and Mk 2s for the time-honoured task of banner-towing (down to 250 ft/76 m). The use of cannon in air defence has by no means been obviated by the missile, and the squadron's aircraft are regularly employed in pulling a target banner round the sky at the end of a 900-ft (275-m) cable for gunnery practice by fighter units. Whilst No 100 Squadron admits that it has never suffered a perforated Canberra in the course of its duties, light-hearted rivalry between squadrons prompts mention of the fact that targets occasionally return in an equally intact condition.

With absorption of No 7 Squadron, No 100 is now the operator of the RAF's Canberra TT Mk 18s. These specialised target tugs are equipped with a Flight Refuelling Ltd winch under each wing for the trailing of a Rushton target at considerable distances behind the aircraft (indeed, after a tight turn it is possible for the pilot to be confronted by his own target still travelling in the opposite direction!). The TT Mk 18 is flown principally in support of naval and Royal Artillery units. Before leaving Wyton, brief mention should be made of No 51 Squadron, equipped with Nimrod aircraft which are employed on radio/radar calibration duties.

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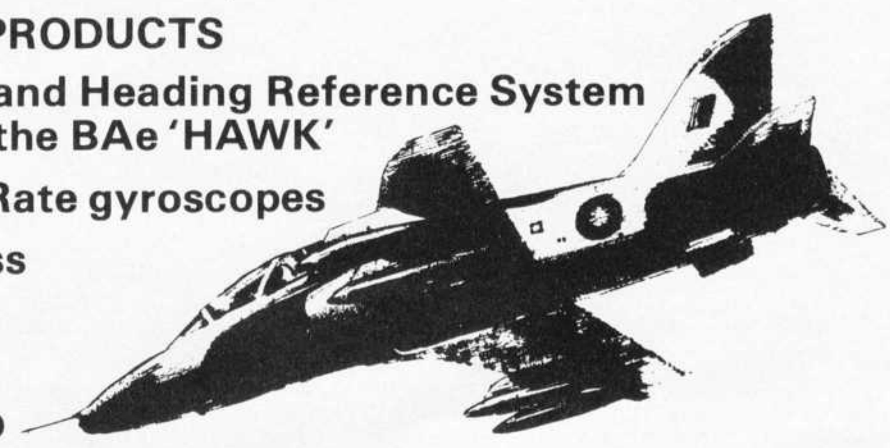

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As well as meeting the daily requirements of the RAF's operational squadrons, the in-flight refuelling tankers are often called upon to support the development and test flying of new types, such as the Tornado F Mk 2 shown here.

Now, as at no other time since 1940, No 1 Group is undergoing a period of fundamental re-organisation. Shorn of its Vulcans, and with the front-line Tornado force still in the process of building-up, the Group's overland bomber strength will be temporarily reduced. However, over the months ahead there is no doubt that advanced aircraft design and traditional RAF professionalism will be combined to re-establish the UK-based dual capable force relied upon both by ourselves and by our NATO allies.

As may be imagined, the rebuilding of No 1 Group's nuclear-capable strike force has found little favour in Moscow or among the well-organised ranks of the Peace Movement. From within the country, opposition has been voiced by those who appear to believe that possession of nuclear weapons by a democracy is a one-way ticket to Armageddon, whereas communism's invasion of other nations and its merciless decimation of their population is in no way provocative of war.

Re-armed with modern aircraft and new conventional weapons, No 1 Group will continue to provide a powerful and effective strike force for the defence of Britain and free Europe. Vladimir Ilyich Lenin once asserted that, "As an ultimate objective, 'peace' simply means communist world control"; No 1 Group has in mind an alternative path to "the absence of war". □

(Above) One of the Canberra E Mk 15s of No 100 Squadron, used for high-level interception practice with fighter squadrons. (Below) Soon after this edition of RAF Yearbook *is published, the Vulcan will have disappeared from service for ever. One of the last units to fly the type is No 101 Squadron, illustrated.*

V/STOL IN THE RAF

... Past, Present and Future

The history and future prospects of the British Aerospace Harrier, described by Roy Braybrook

THE ROYAL AIR FORCE has led the world in the use of V/STOL (vertical or short take-off and landing) aircraft, introducing its first such fighters in 1969, well ahead of any other service in either the West or the Communist Bloc. The Harrier family — still the Western world's only successful V/STOL aircraft — currently makes up well over ten per cent of the RAF combat strength. Of 120 single-seaters and 19 two-seaters ordered for the service, approximately 70 are now in operation. This figure is expected to stay roughly constant over the next few years, with newly-built aircraft making up for attrition.

In RAF Germany there are 36 Harriers with Nos 3 and 4 Sqn at Gütersloh, forming part of 2ATAF. Another 12 aircraft serve with No 1 Sqn at Wittering, where other Harriers make up No 233 OCU, both units being under the control of Strike Command. A detachment from No 1 Sqn is based in Belize, a defensive assignment that makes full use of the Harrier's go-anywhere capability and lack of need for diversion airfields.

The Harrier entered service with No 1 Sqn in April 1969, and by July of the following year the unit had received its full complement of 12 aircraft. Deliveries then switched to No 4 Sqn at Wildenrath in Germany, where No 20 Sqn also began conversion later that year, No 3 Sqn following suit early in 1972. Wildenrath is set well back, close to the Dutch border, however, where proper use could not have been made of the Harrier's quick-reaction close support capability. In 1977 the Harrier wing was therefore moved forward to Gütersloh, only approximately 75 miles (120 km) from the East German border. This significantly improved reaction times, although it was necessary to reorganise the wing into two larger squadrons (with No 20 then being reformed as a Jaguar unit at Brüggen) because of the lack of administrative accommodation for a third squadron.

The Harrier's rôle

All RAF Harriers are used in the offensive support rôle, ie, close air support (CAS), battlefield air interdiction (BAI), and tactical air reconnaissance (TAR). In the event of a European war, the Gütersloh squadrons would operate in support of the Northern Army Group (NORTHAG). At the present time this function would probably be limited to the support of the 1st British Corps, although these squadrons might in principle be required to switch their support to either of the adjacent corps, ie, the Germans to the north or the Belgians to the south. The Wittering squadron might be used to reinforce the Gütersloh units, although as part of AMF (Allied Command Europe Mobile Force) its deployment options are primarily on NATO's flanks, ie, Norway, Denmark, Italy, Greece and Turkey. In less desperate situations, No 1 Sqn could be deployed virtually anywhere in the world as part of No 38 Group.

If caught on the ground in their HAS (hardened aircraft shelters) by a surprise attack at the outbreak of war, the Harriers could continue operations from bomb-cratered runways, dispersing by V/STOL between sorties. Under this concept of operations, the Harriers would benefit from main base supplies and maintenance facilities, and from the defence provided by Rapier SAMs, automatic weapons and ground defence units of the RAF Regiment.

On the other hand, main base operations make the Harrier just as vulnerable as any conventional aircraft to nuclear, biological or

In addition to the front-line strength of 36 Harriers flown by Nos 3 and 4 Squadrons at RAF Gütersloh in Germany, No 1 Squadron maintains a 12-aircraft strength at RAF Wittering and is committed to supporting activities on NATO's flanks. Exercising in this rôle, Harriers from No 1 Squadron deployed to Denmark in "Amber Express" in 1981, and operated from the very effective "hides" constructed by No 38 Engineer Regiment from Ripon.

chemical (NBC) attack. Given some indication that war was about to break out, the Gütersloh aircraft and supporting vehicles would therefore move forward to pre-selected sites in wooded country (notably the Teutoburger Wald) and in urban areas. From these sites the Harriers would fly missions against Warsaw Pact armoured thrusts, and also attack in the areas 10-60 miles (16-96 km) behind the FEBA against enemy reserves and supply columns.

Judging by peacetime exercises, there would be six dispersed sites, each with around six aircraft, and a central logistics park. The two primary sites would be under the direct control of the squadron commanders, with flight commanders at each of the four sub-sites. Operating sites must offer concealment, but they must also have good road access for motor transport (approximately 400 of the 600 RAF vehicles and 440 of the 560 maintenance men at Gütersloh would move forward with the aircraft), and they must have clear, flat ground for STO. Grass fields of 1,300 ft (400 m) may suffice — the traditional test is to drive a Land-Rover across them at 40 mph (64 km/h) — but a straight stretch of secondary roadway is preferred.

In the initial stages at least, the two squadrons' 36 aircraft could generate around 200 sorties per day, with the pilots often staying in the cockpit throughout the 20-min turn-round for debrief and tasking by telebrief line. Each of the six operating sites would have limited facilities for servicing and repair of the aircraft, and sufficient fuel and armament for at least two days operations by six aircraft. However, in anything but the shortest war, the sites would be heavily dependent on the logistics park for fuel, weapons and spare parts. A typical spares pack for 10 aircraft for 14 days has been estimated to include 650 items (with one spare engine) and to weigh around seven tons.

Central Germany is a reasonably good area for dispersed operations, due to the abundance of trees and the highly developed road network, but the winters are harsh, and there is a serious risk of attacks by enemy agents or airborne forces. Attacks on the operating sites by aircraft are felt to be unlikely, although infra-red reconnaissance does pose some threat of site detection from the air. There would be no SAMs or anti-aircraft artillery at the sites on present planning, but each site would have an RAF Regiment detachment, and in war land-mines would be sown around the perimeter. Rather than defending the site by heavy firepower, the plan would be to relocate to a pre-selected alternate site, typically within 10 miles (16 km) to remain within easy reach of the logistics park. In exercises, it has been proved possible to vacate a site within one hour and have the new site operational within two or three hours of arrival.

Improved Harriers

Planning for a Harrier replacement began in the early 1970s with AST.396, a subsonic ground attack aircraft with equipment to facilitate operations in bad visibility. This concept developed into an ultra-STOL aircraft with the warload-radius of a Jaguar, that would replace both the Harrier and the Jaguar. It became an expensive project, and was finally abandoned in the light of the growing Soviet air-air threat and the mid-1975 European demonstrations of the F-16 lightweight fighter, which offered many of the capabilities required.

It was superseded by AST.403, which was still a Harrier-Jaguar replacement, but accepted a more relaxed approach to STOL in order to achieve a secondary air combat capability roughly comparable to that of the F-18. However, subsequent talks with France and Germany on the possibility of joint development of an aircraft in this category (the European Combat Aircraft) showed that these prospective partners had no interest in the use of jet lift for STO-VL. In consequence, AST.403 evolved as purely a Jaguar successor, and AST.409 was drafted as a programme to improve and extend the life of the Harrier GR Mk 3, rather than as a new (and consequently collaborative) replacement aircraft.

The original AST.409 concept was a Harrier GR Mk 3 retrofitted with a big "tin" wing of very advanced aerodynamic design, giving improved STO and turning performance, plus two extra pylon positions to allow the carriage of Sidewinders for self-defence, increased internal fuel to eliminate the routine use of drop tanks, decreased outrigger track to facilitate road operations, an avionics update and airframe improvements to take the aircraft to the turn of the century.

Two main factors led to this concept being abandoned. Firstly, the increasing Warsaw Pact threat led to a demand for more major improvements. Secondly, it became clear from studies made by

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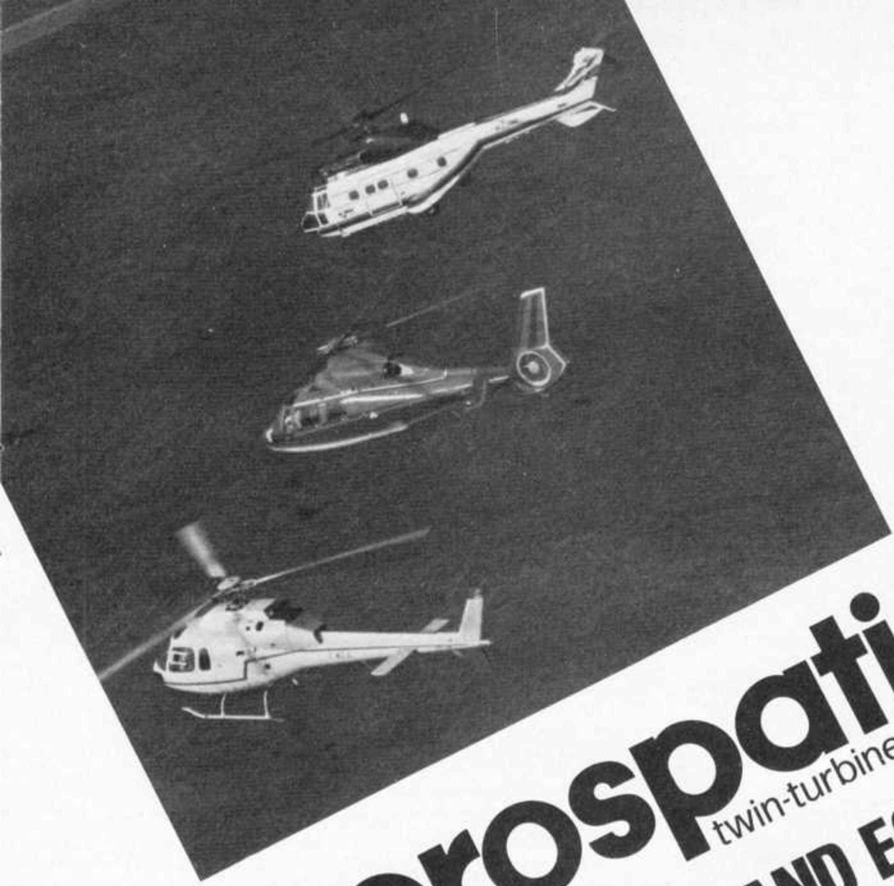

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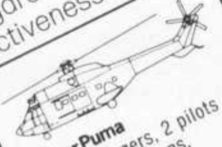

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The Harrier GR Mk 3 is at present the standard operational version of the V/STOL aircraft in the RAF, this being a progressively developed variant of the original single-seater, with uprated engine, fin-mounted ECM and nose-mounted laser ranging and target marking systems.

British Aerospace that the time taken to retrofit each big wing would have resulted in a serious depletion of front-line numbers. In addition, it was evident that (in addition to the attrition batch of 24 Harrier GR Mk 3s currently being built) the RAF would have to purchase a top-up batch, since there will not be enough GR Mk 3s and T Mk 4s to form three squadrons and an OCU at the end of this decade.

It was therefore decided that AST.409 should be revised to define a new-build aircraft that would replace the GR Mk 3s of the two squadrons "at the sharp end" in Germany, all GR Mk 3s then being concentrated at Wittering, where extensive improvements would be introduced to enhance their capability and keep these aircraft in

During 1981, plans were finally confirmed for the acquisition by the RAF of a modernised version of the Harrier, to be designated the GR Mk 5. This will be a British production variant of the McDonnell Douglas/BAe AV-8B, the first production example of which flew on 5 November 1981 and is illustrated here.

operation to about the turn of the century. In addition, further Harrier T Mk 4s will be required by the RAF (the US Marine Corps has also formally stated that it will need further two-seat Harriers), although the precise number will depend on attrition, which has so far proved very low.

Exactly what changes will be made to Wittering's GR Mk 3s (which could peak at around 50 aircraft) has yet to be determined. Studies are in progress, and decisions will be made in 1982-83.

All that can be said is that the options could clearly include:

— modifications to the structure for improved fatigue life;

— installation of the same Pegasus as that fitted in the GR Mk 5 described below;

— two extra pylons for Sidewinders (possibly on the wingtips or over the wing);

— small wing leading edge root extensions (LERX) to improve manoeuvrability;

— enlarged drop tanks (the BAe Hawk demonstrator was ferried to America in 1981 using lengthened drop tanks);

— a nav-attack system update, possibly in line with that of the Jaguar;

— ECM fit, external or internal;

— provision for an improved anti-armour weapon (as suggested by the now-defunct AST.1227);

— reliability improvements to reduce life-cycle costs.

The Harrier II

As most readers will already be aware, the new-build AST.409 aircraft will be a slightly-modified McDonnell Douglas AV-8B Harrier II, which will be known in the RAF as the Harrier GR Mk 5. The service is to have 60 GR Mk 5s, including two full-scale development (FSD) aircraft for weapon system certification. The first of these FSD aircraft will fly early in 1984 and production deliveries will begin from the British Aerospace assembly line in mid-1986. Most GR Mk 5s will go to Gütersloh, although a few will be based with the Wittering OCU, and one or two others will be retained in the UK for trials installations.

The AV-8B has been derived from the British Aerospace AV-8A (a simply-equipped version of the GR Mk 3) to meet US Marine Corps needs for a V/STOL close support aircraft of improved warload-radius performance, to replace both the AV-8A and the older, quite conventional A-4 Skyhawk. The USMC will have 340 AV-8Bs on present plans, including six FSD aircraft, the first of which made its first hover at the McDonnell Douglas plant on 5 November last. Deliveries will begin in 1983, and the first AV-8B squadron will be operational by June 1985. By 1989 the type will have replaced all three USMC AV-8A and five A-4 squadrons.

The basic aim in the design of the AV-8B was to achieve a major improvement in STO performance, lifting a far heavier aircraft weight from a given ground roll, and thus doubling either warload or radius of action. All previous Harrier developments in this direction had been done by increasing the thrust of the Rolls-Royce Pegasus engine, from 19,000 lb (6 617 kg) for the Peg 6 (Mk 101) in the GR Mk 1 to 21,500 lb (9 750 kg) for the Peg 11 (Mk 103) in the GR Mk 3. This had become an increasingly costly exercise as the Pegasus approached the limit of its potential, so McAir (McDonnell Aircraft — the St Louis division of the parent McDonnell Douglas Corporation) decided to improve STO performance by other means, using engine modifications to extend life and reduce operating costs, rather than to increase thrust.

Firstly, the wing was increased in area from the Harrier's 201 sq ft (18,7 m^2) to 230 sq ft (21,4 m^2), a nominal figure that is far less than the full gross area with trailing edge kink and LERX. Secondly, the Harrier's plain flaps were replaced by large, single-slotted flaps that were designed to have their lift boosted by the pumping action of the engine's rear nozzles. Thirdly, the air intakes were redesigned to give a greater throat area, with a double row of suction-relief doors. In addition, VTO performance was improved by the use of larger strakes under the fuselage and a retractable cross-dam to increase the ground cushion effect and minimise the recirculation of hot gases to the intakes. Previously, no Harrier operator had specified a VTO mission, but for this new variant the USMC plans a VTO deck-launch intercept.

A supercritical aerofoil was adopted, with the aim of minimising the drag penalty of the larger wing, while allowing a much thicker section, which in turn would increase fuel volume. The result is a significant increase in internal fuel: from 5,056 lb (2 293 kg) on the Harrier to 7,500 lb (3 400 kg) on the AV-8B.

To minimise the weight penalty of the larger wing, its main structure is constructed of carbon fibre composite material, which is estimated to save 330 lb (150 kg) relative to an equivalent metal wing. Carbon fibre is also used for the flaps, ailerons, tailplane, rudder, the engine access panels in the upper fuselage, the outrigger fairings, ventral strakes and the new front fuselage. This material forms a total of 1,317 lb (597 kg) of the structure weight, ie, approximately 26 per cent, which is a higher proportion than in any other military aircraft.

The front fuselage has been redesigned to raise the pilot by 10·5 in (26,7 m), giving much improved rear view and more space for equipment. Balancing this extra equipment in the nose, the rear fuselage is extended by 18 in (45,7 cm). The outrigger track is reduced from 22 ft (6,7 m) to 17 ft (5,2 m), while the wing-mounted reaction controls are moved out to the tips, giving improved roll power. Two extra pylons are fitted, giving a total of seven.

As indicated earlier, the existing engine rating is retained, but the engine is modified to improve its life and reduce operating costs. Starting from the "navalised" Pegasus Mk 104 of the Sea Harrier (with improved anti-corrosion characteristics) the AV-8B's Pegasus 11-21E Mk 105, which will be known to the USMC as the F402-RR-405, has minor changes to smooth the airflow to the HP compressor and improve turbine cooling. These modifications are expected to reduce failure rate by around 35 per cent, halve maintenance manpower needs, save fuel costing £10,000 per engine each year, and improve engine life by a quarter, taking overhauls to 1,000 hours with a hot-end inspection at the half-way point.

The new avionics

In USMC service, the AV-8B will have a Litton ASN-130 inertial navigator, Smiths HUD, pod-mounted advanced self-protection jamming (ASPJ) system, all-weather landing system (AWLS) and a Hughes angle-rate bombing system (ARBS). Whereas the Harrier GR Mk 3 measures the distance to the target by laser, the ARBS will calculate this distance from outputs (depression angle and spin rate) of a set of optics locked on to the target. The optics combine laser- and TV-trackers, the former system being used day/night against a target laser-designated by friendly troops or another aircraft, while TV-tracking is used in daylight against an unmarked target selected by the pilot. In principle this is a more complex way to solve the weapon release equation than laser ranging, but it avoids the latter's peacetime training restrictions and the possibility of jamming in wartime.

The AV-8B cockpit is vastly different from that of the Harrier, introducing a push-button up-front control (UFC) panel for essential communications, navigation, identification and weapons control functions, plus a digital engine display and a TV-type multi-purpose display (MPD) for ARBS and Maverick pictures, radar warning, navigation information, stores management and checklists. In line with McAir experience on the F-15 and F-18, there is a complete array of combat switches on the control column and throttle, allowing the pilot to make inputs for radar warning, weapon modes, armament selection, ARBS, manoeuvre flap and stability augmentation (in addition to firing the gun and releasing ordnance), without moving his hands from the flying controls. It may be noted that the gun represents another change from Harrier practice in that the two 30-mm Aden cannon are replaced by a single General Electric GAU-12 25-mm Gatling-type gun. This will combine a high rate of fire with very high muzzle velocity, giving better accuracy and longer range.

Any aircraft that has been in service for 12 years reveals a host of features that could have been better designed from a groundcrew viewpoint, and the Harrier is no exception to this rule. Current UK defence economies have so far ruled out the correction of these faults on the GR Mk 3, but most will be rectified on the AV-8B. The reliability and serviceability of the new aircraft will doubtless be seen by many as the result of American know-how, but the transformation actually owes a great deal to inputs from the RAF and British Aerospace.

Initial testing of the AV-8B concept was helped by using two converted AV-8As fitted with large metal wings. The first of these YAV-8Bs (serial 158394) flew on 9 November 1978 and immediately showed a vast improvement in V/STOL performance,

All three squadrons of Harriers in the RAF include in their inventories a pair of two-seat Harrier T Mk 4s, although only the examples based in Germany have the LRMTS in the nose, as illustrated below. They are based, like the single-seat GR Mk 3s above right, at RAF Gütersloh.

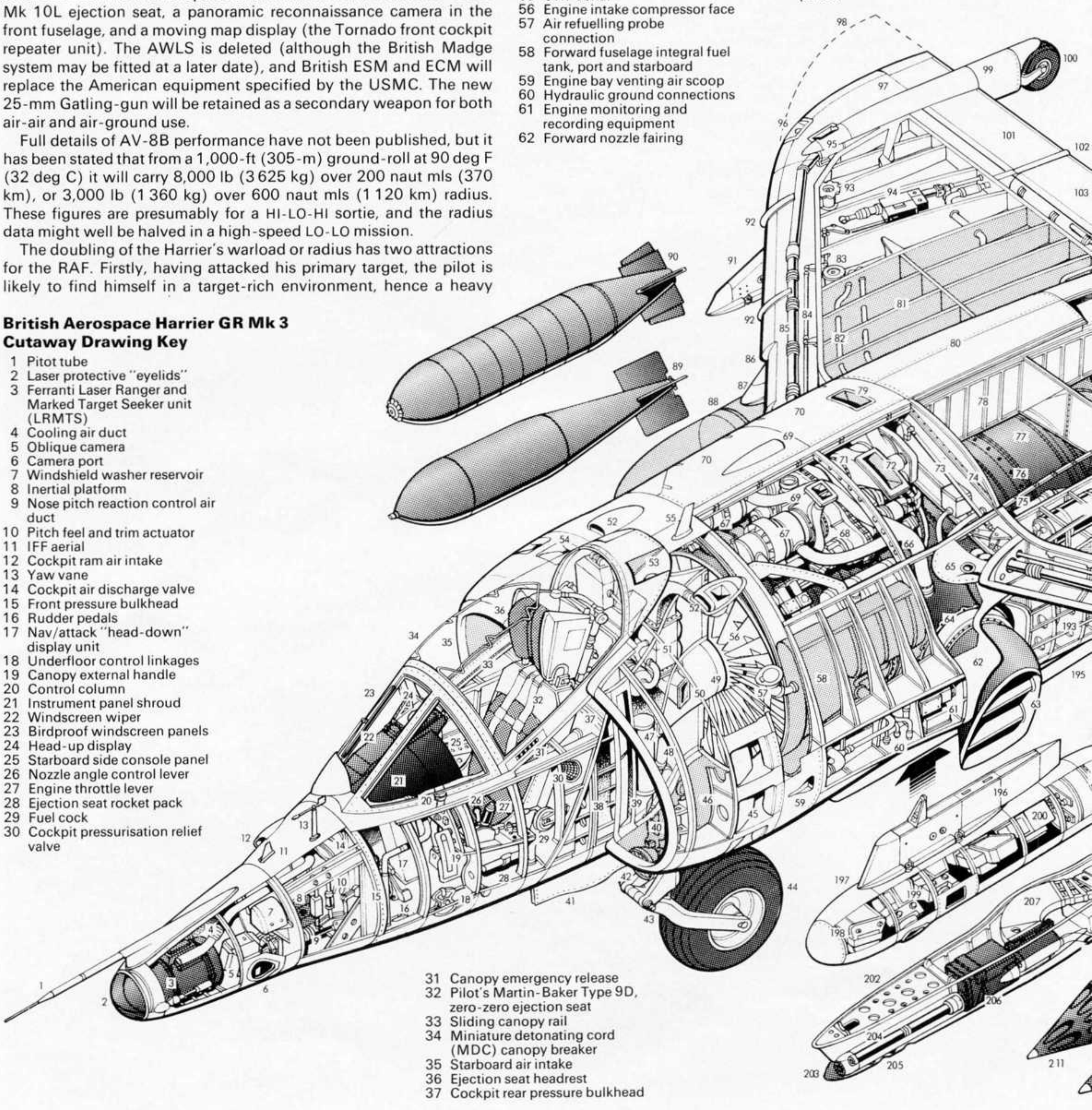
but a severe drop in level flight speed relative to the GR Mk 3, and considerably less turning performance than the RAF hoped to achieve. To reduce the drag penalty, which is mainly the result of the concave profile toward the rear of the wing undersurface, the wing-body fillet was enlarged and the inboard pylon extended aft. The intake cowl was also reshaped. As a result of these changes, McAir now claims a maximum level speed of M=0·88 at sea level, which at around 582 kt (1 078 km/h) is not much slower than a clean GR Mk 3.

In order to improve turning performance, a LERX designed by British Aerospace was tested on a YAV-8B, but the resulting decrease in longitudinal stability was unacceptable for one USMC store configuration. A smaller LERX has now been tested in the wind tunnel, and was expected to have flown as this journal went to press. There was every indication that this will prove satisfactory for both the USMC and RAF.

The Harrier GR Mk 5 version of the AV-8B will have a strengthened windscreen, intake lips and wing leading edge to reduce losses due to birdstrikes in low level operations. It will also have a Martin-Baker Mk 10L ejection seat, a panoramic reconnaissance camera in the front fuselage, and a moving map display (the Tornado front cockpit repeater unit). The AWLS is deleted (although the British Madge system may be fitted at a later date), and British ESM and ECM will replace the American equipment specified by the USMC. The new 25-mm Gatling-gun will be retained as a secondary weapon for both air-air and air-ground use.

Full details of AV-8B performance have not been published, but it has been stated that from a 1,000-ft (305-m) ground-roll at 90 deg F (32 deg C) it will carry 8,000 lb (3 625 kg) over 200 naut mls (370 km), or 3,000 lb (1 360 kg) over 600 naut mls (1 120 km) radius. These figures are presumably for a HI-LO-HI sortie, and the radius data might well be halved in a high-speed LO-LO mission.

The doubling of the Harrier's warload or radius has two attractions for the RAF. Firstly, having attacked his primary target, the pilot is likely to find himself in a target-rich environment, hence a heavy



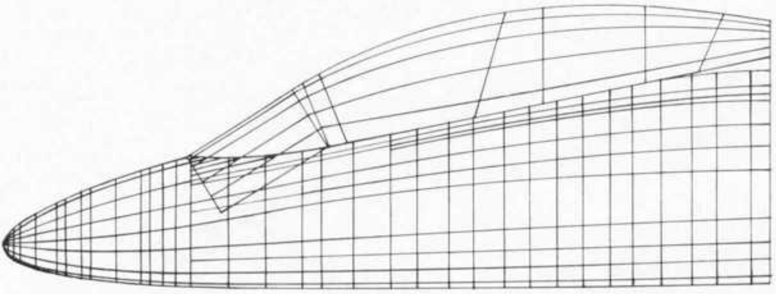
British Aerospace Harrier GR Mk 3 Cutaway Drawing Key

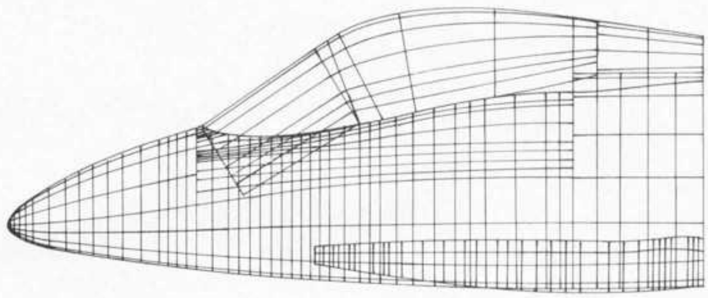
1 Pitot tube
2 Laser protective "eyelids"
3 Ferranti Laser Ranger and Marked Target Seeker unit (LRMTS)
4 Cooling air duct
5 Oblique camera
6 Camera port
7 Windshield washer reservoir
8 Inertial platform
9 Nose pitch reaction control air duct
10 Pitch feel and trim actuator
11 IFF aerial
12 Cockpit ram air intake
13 Yaw vane
14 Cockpit air discharge valve
15 Front pressure bulkhead
16 Rudder pedals
17 Nav/attack "head-down" display unit
18 Underfloor control linkages
19 Canopy external handle
20 Control column
21 Instrument panel shroud
22 Windscreen wiper
23 Birdproof windscreen panels
24 Head-up display
25 Starboard side console panel
26 Nozzle angle control lever
27 Engine throttle lever
28 Ejection seat rocket pack
29 Fuel cock
30 Cockpit pressurisation relief valve
31 Canopy emergency release
32 Pilot's Martin-Baker Type 9D, zero-zero ejection seat
33 Sliding canopy rail
34 Miniature detonating cord (MDC) canopy breaker
35 Starboard air intake
36 Ejection seat headrest
37 Cockpit rear pressure bulkhead
38 Nose undercarriage wheel well
39 Boundary layer bleed air duct
40 Port air intake
41 Pre-closing nosewheel door
42 Landing/taxying lamp
43 Nosewheel forks
44 Nosewheel
45 Supplementary air intake doors (fully floating)
46 Intake ducting
47 Hydraulic accumulator
48 Nosewheel retraction jack
49 Intake centre-body
50 Ram air discharge to engine intake
51 Cockpit air conditioning plant
52 Air conditioning system ram air intakes
53 Boundary layer bleed air discharge ducts
54 Starboard supplementary air intake doors
55 UHF aerial
56 Engine intake compressor face
57 Air refuelling probe connection
58 Forward fuselage integral fuel tank, port and starboard
59 Engine bay venting air scoop
60 Hydraulic ground connections
61 Engine monitoring and recording equipment
62 Forward nozzle fairing
63 Fan air (cold stream) swivelling nozzle
64 Nozzle bearing
65 Venting air intake
66 Alternator cooling air ducts
67 Twin alternators
68 Engine accessory gearbox
69 Alternator cooling air exhausts
70 Engine bay access doors
71 Gas turbine starter/Auxiliary power unit, GTS/APU
72 APU exhaust duct
73 Aileron control rods
74 Wing front spar carry-through
75 Nozzle bearing cooling air duct
76 Engine turbine section
77 Rolls-Royce Pegasus Mk 103 vectored thrust turbofan engine
78 Wing panel centreline joint rib
79 APU intake
80 Wing centre-section fairing panels

81 Starboard wing integral fuel tank, total internal fuel capacity 630 Imp gal (2 865 l)
82 Fuel system piping
83 Pylon attachment hardpoint
84 Aileron control rod
85 Reaction control air duct
86 Leading-edge dog-tooth
87 Starboard inner stores pylon
88 Jettisonable combat fuel tank, capacity 100 Imp gal (454 l)
89 1,000-lb (454-kg) HE bomb
90 BL.755 600-lb (272-kg) cluster bomb
91 Starboard outer stores pylon
92 Wing fences
93 Outer pylon hardpoint
94 Aileron hydraulic power control unit
95 Roll control reaction air valve
96 Starboard navigation light
97 Wing tip fairing
98 Profile of extended-span ferry tip
99 Starboard outrigger fairing
100 Outrigger wheel retracted position
101 Starboard aileron
102 Fuel jettison pipe
103 Starboard plain flap
104 Trailing edge root fairing
105 Water-methanol filler cap
106 Anti-collision light
107 Water-methanol injection system tank
108 Fire extinguisher bottle
109 Flap hydraulic jack
110 Fuel contents transmitters
111 Rear fuselage integral fuel tank
112 Ram air turbine housing
113 Turbine doors
114 Emergency ram air turbine (extended position)
115 Rear fuselage frames
116 Ram air turbine jack
117 Cooling air ram air intake
118 HF tuner
119 HF notch aerial
120 Rudder control rod linkages
121 Starboard all-moving tailplane
122 Temperature sensor
123 Tailfin construction
124 Forward radar warning receiver
125 VHF aerial
126 Fin tip aerial fairing
127 Rudder upper hinge
128 Honeycomb rudder construction
129 Rudder trim jack
130 Rudder tab
131 Tail reaction control air ducting
132 Yaw control port
133 Aft radar warning receiver
134 Rear position light
135 Pitch reaction control valve
136 Tailplane honeycomb trailing edge
137 Extended tailplane tip
138 Tailplane construction
139 Tail bumper
140 IFF notch aerial
141 Tailplane sealing plate
142 Fin spar attachment
143 Tailplane centre section carry-through
144 All-moving tailplane control jack
145 Ram air exhaust duct
146 UHF standby aerial
147 Equipment air conditioning plant
148 Ground power supply socket
149 Twin batteries
150 Ventral equipment bay access door
151 Radio and electronics equipment racks
152 Electronics bay access door
153 Ventral airbrake
154 Airbrake hydraulic jack
155 Nitrogen pressurising bottles for hydraulic system
156 Flap drive torque shaft
157 Rear spar/fuselage attachment joint
158 Nozzle blast shield
159 Rear (hot stream) swivelling exhaust nozzle
160 Wing rear spar
161 Port flap honeycomb construction
162 Fuel jettison valve
163 Fuel jettison pipe
164 Aileron honeycomb construction
165 Outrigger wheel fairing
166 Wing tip fairing
167 Profile of extended ferry tip
168 Hydraulic retraction jack
169 Shock absorber leg strut
170 Port outrigger wheel
171 Torque scissor links
172 Outrigger wheel leg fairings
173 Port navigation light
174 Roll control reaction valve
175 Wing rib construction
176 Outer pylon hardpoint
177 Machined wing skin/stringer panel
178 Aileron power control unit
179 Front spar
180 Leading-edge nose ribs
181 Reaction control air ducting
182 Port outer stores pylon
183 Leading-edge fences
184 Twin mainwheels
185 Port inner stores pylon
186 Fuel and air connections to pylon
187 Inboard pylon hardpoint
188 Port wing fuel tank end rib
189 Pressure refuelling connection
190 Wing bottom skin panel/fuselage attachment joint
191 No 1 hydraulic system reservoir (No 2 to starboard)
192 Centre fuselage integral fuel tank, port and starboard
193 Nozzle fairing construction
194 Leading-edge dog-tooth
195 Cushion augmentation strake (fitted in place of gun pod)
196 Centreline stores pylon
197 Reconnaissance pod
198 Forward F.135 camera
199 Port F.95 Mk 7 oblique cameras
200 Starboard F.95 Mk 7 oblique cameras
201 Signal data converter (SDC) unit
202 Cannon pod
203 Frangible nose cap
204 Cannon barrel
205 Blast suppression ports
206 Aden 30-mm revolver-type cannon
207 Ammunition feed chute
208 Link ejector chute
209 Ammunition box, 100 rounds
210 ML twin stores carrier
211 Matra 155 rocket launchers, 18 x 68-mm rockets
212 Matra 116M rocket launcher, 19 x 68-mm rockets
213 LEPUS flare
214 Twin light stores carrier
215 28-lb (12,70-kg) practice bombs

Which MB·339 do you think you would need ?

Pubbliaermacchi 81





The MB-339A two seater or the single seater "Veltro 2"?
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warload will enable him to inflict more losses on the enemy without any significant effect on his own chances of survival. Secondly, the doubling of radius will considerably enhance the usefulness of the Harrier in supporting the two flanking corps from existing bases and operating sites.

Although McAir is the prime contractor for the AV-8B, the GR Mk 5s for the RAF will be assembled in the UK by British Aerospace, which company will perform approximately 40 per cent of the airframe work on AV-8Bs for the RAF and USMC, and 25 per cent of the work on aircraft sold to third countries. Rolls-Royce remains prime contractor for all Pegasus engines, although up to 25 per cent of the value of engines for the USMC may be represented by work done by Pratt & Whitney. British Aerospace is to manufacture the centre and rear fuselages complete with systems, the centre-line pylons, reaction control systems, and the fins and rudders. In addition to assembling RAF GR Mk 5s, the company will also make the tailplanes of these aircraft.

Beyond the Harrier 5

The Harrier GR Mk 5 is expected to remain in service until at least the end of the century, but preliminary thought is already being given to a possible follow-on V/STOL generation. Studies are in progress on AST.410, aimed at examining the need for (and cost of) STO-VL offensive support aircraft in four speed categories: subsonic, transonic, low supersonic, and high supersonic. The outcome cannot be predicted, but it is clear that a secondary rôle such as battlefield air superiority would favour supersonic capability, and that the development of a brand-new STO-VL aircraft will depend on collaboration with another country. At present the only likely partner is America, which may well favour supersonics.

Having developed various types of V/STOL powerplant, Rolls-Royce now advocates only the single-engined vectored-thrust concept, having found in studies a 20 per cent life-cycle penalty for lift-engine aircraft. However, the company favours three-nozzle arrangements for a supersonic fighter, for simplicity, lightness and easier installation. Rolls-Royce would like to see a low-cost transonic technology demonstrator funded on the basis of a modified Harrier and Pegasus.

British Aerospace at Warton appears to feel that the improvement in engine reliability since the advent of the Harrier concept in the late 1950s justifies a fresh look at ideas that would have been unacceptable at that time, such as a pair of tilting, wing-mounted engines. The Kingston division still believes in the single vectored-thrust engine, although two-, three- and four-nozzle arrangements are being studied. The Rolls-Royce idea of a transonic V/STOL demonstrator is criticised as an undesirably slow way to progress, relative to a "pre-prototype" phase using an airframe of roughly the final form, even if not equipped with the definitive engine.

At this stage, the key question is perhaps not how best to achieve a supersonic V/STOL aircraft, but whether V/STOL itself is worthwhile. The critical factor is how the user judges that his enemy's offensive counter-air campaign will be waged. If airfield bombing leaves perhaps 1,600 ft (500 m) of runway usable, it can be argued that there is no real need for V/STOL. However, if conflict breaks out and the only ground run available is substantially less than this distance, the air force without V/STOL aircraft has lost the war. The case for V/STOL aircraft is that, however powerful your opponent and whatever effort he allocates to destroying your airfields, you *know* he can't stop you flying! □

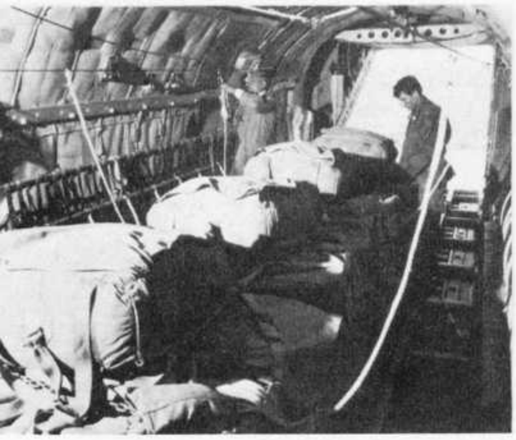
LOOSELY SPEAKING

In spite of a campaign against the danger of leaving loose objects in aircraft cockpits, human frailty sometimes prevails. Such had been the case when a pilot landed a Bulldog trainer after some solo aerobatics and angrily reported "There's something loose in the back!" A search revealed no less than a book, a copy of "The Intimate Adventures of Moll Flanders". As the sergeant said, "You can't get much looser than that, sir!"

* * *

A young airman came out of the station library with a book called "HOW to HUG". When he opened it he found, alas, that it was Part 8 of the Encyclopaedia Britannica.

our trail in the sky



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Keeping the Bear at Bay

Fundamental to any nation's air defence requirements is the need to monitor all air traffic so that any irregular aircraft movements can be highlighted. So far as Britain's defence needs are concerned, this monitoring is achieved by the air and ground based radar systems of the UK and NATO, closely co-ordinated with Civil Air Traffic authorities, and interlinked by comprehensive data analysis and communications systems. If an aircraft is picked up by the air defence sensors and cannot be identified by routine means it must then be visually identified to establish its bona fides — a task fulfilled by the RAF by scrambling a Quick Reaction Alert (Interceptor) or QRA(I) aircraft to intercept the unknown aircraft. Once or twice in a year such a scramble may result from a fault in the air traffic notification system, but most of the unknown tracks appear over the South Norwegian Seas, north of the Faroes, and are intercepted by a Phantom or Lightning fighter, supported by airborne refuelling often many miles out to sea. These unknown tracks, accounting for as many as six scrambles a week last year, invariably turn out to be Russian military aircraft going about their lawful business over international waters. Nevertheless, NATO air defences must be continuously vigilant to ensure that any intrusion into national airspace is deterred. This article presents an account of a typical QRA(I) sortie and is written by a pilot of No 43 Squadron, which flies Phantom FG Mk 1s from RAF Leuchars.

"MISSION 40, Vector 340, climb to flight level 350, to CAP Lima Echo Charlie, call Buchan on fighter stud 44, Scramble! Scramble! Scramble!"

The still night air is rent apart by the whine of two Rolls-Royce Spey jet engines starting up as the pilot, navigator and groundcrew work feverishly to get the Phantom fighter ready for take-off inside the 5-minute time limit.

"40 scramble taxy?"

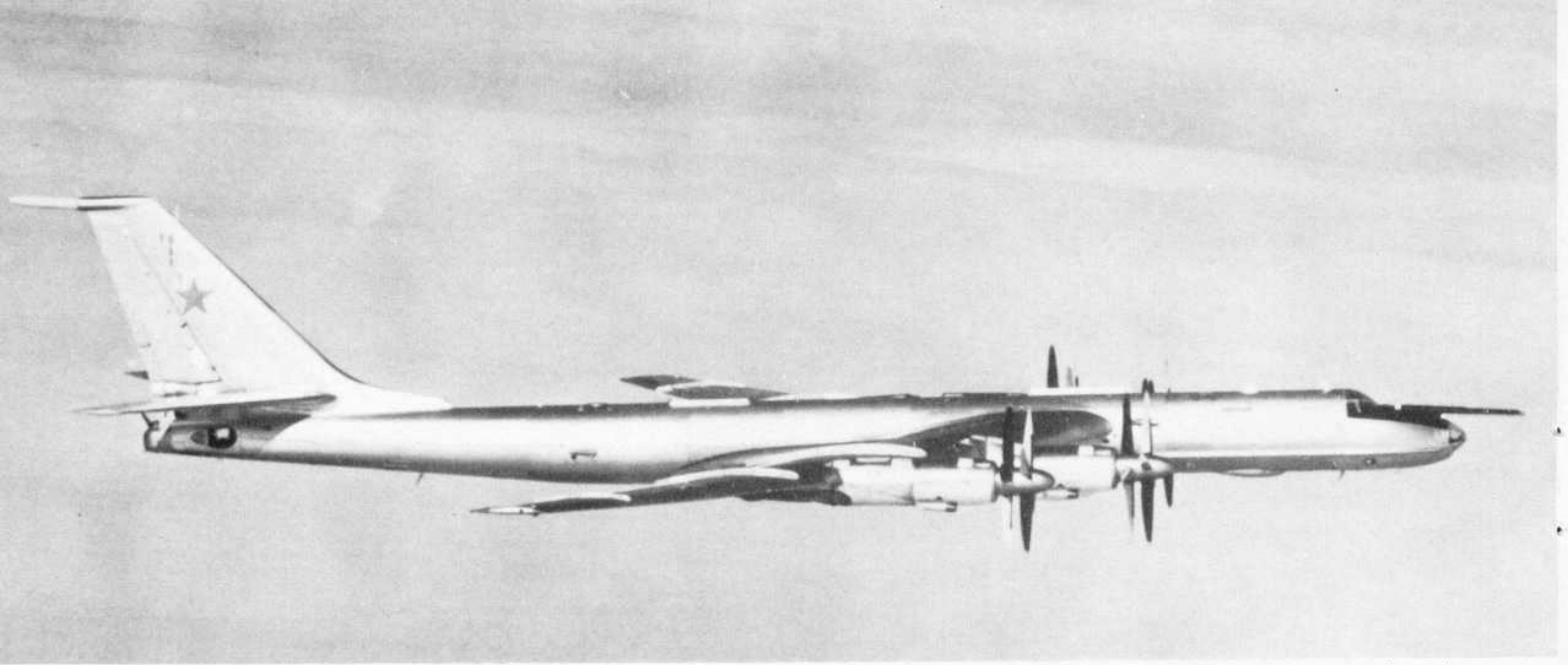
"40 clear taxy for runway 09, QFE 1008."

The Phantom taxies from its lair at the end of the runway, the pilot calls "40 take off?" and is cleared by the airfield controller one mile away in his glass-topped air traffic control tower. The pilot swings the aircraft onto the runway and, with all pre-flight checks complete, pushes the twin throttles "through the gate" and up to the maximum reheat position. Any lingering idea that this is just a quiet agricultural stretch of the East Scottish coast is now shattered by the enormous roar of the Phantom at full combat power as it thrusts itself down the mile and a half of concrete on two thirty-foot streams of yellow flame.

As soon as the aircraft is safely airborne the pilot banks hard round onto the vector given during the scramble message and continues climbing to 35,000 ft (10 670 m). Meanwhile the navigator is quickly bringing the radar into operation to search the sky ahead.

"Buchan, this is Mission 40 heading 340, climbing to flight level 350, radar and weapons serviceable."

(Heading photo) A Bear-D — with lack of propeller synchronisation strikingly illustrated — flies by with a Phantom escort. (Below) A Phantom FGR Mk 2 of No 23 Squadron — one of the units in the United Kingdom responsible for keeping the Bears at bay.



Several different versions of the Bear — a product of the Tupolev design bureau — remain in service. This is a Bear-F, which features enlarged and lengthened nacelles aft of the inboard engines and a slightly lengthened forward fuselage. The aft projection from the top of the fin is unidentified but is presumably some form of ECM or ESM.

So, barely four minutes after receiving the order to scramble, a Royal Air Force Phantom of No 43(F) Squadron is beginning its long and lonely transit 500 miles (805 km) north to the area known as the Iceland-Faroes Gap to intercept another unidentified intruder.

The Quick Reaction Alert (Interceptor) Force, in service abbreviation QRA(I), keeps four fully-armed fighter aircraft at the highest peacetime readiness state, for 24 hours a day, 365 days a year. RAF Leuchars in Fife holds Northern QRA(I) with at least two Phantoms all the year round. In the south, QRA(I) is held alternately by RAF Binbrook (Lightnings), RAF Coningsby (Phantoms), both in Lincolnshire, and RAF Wattisham (Phantoms) in Suffolk. These three southern bases share the task of providing at least two fighters all the year round.

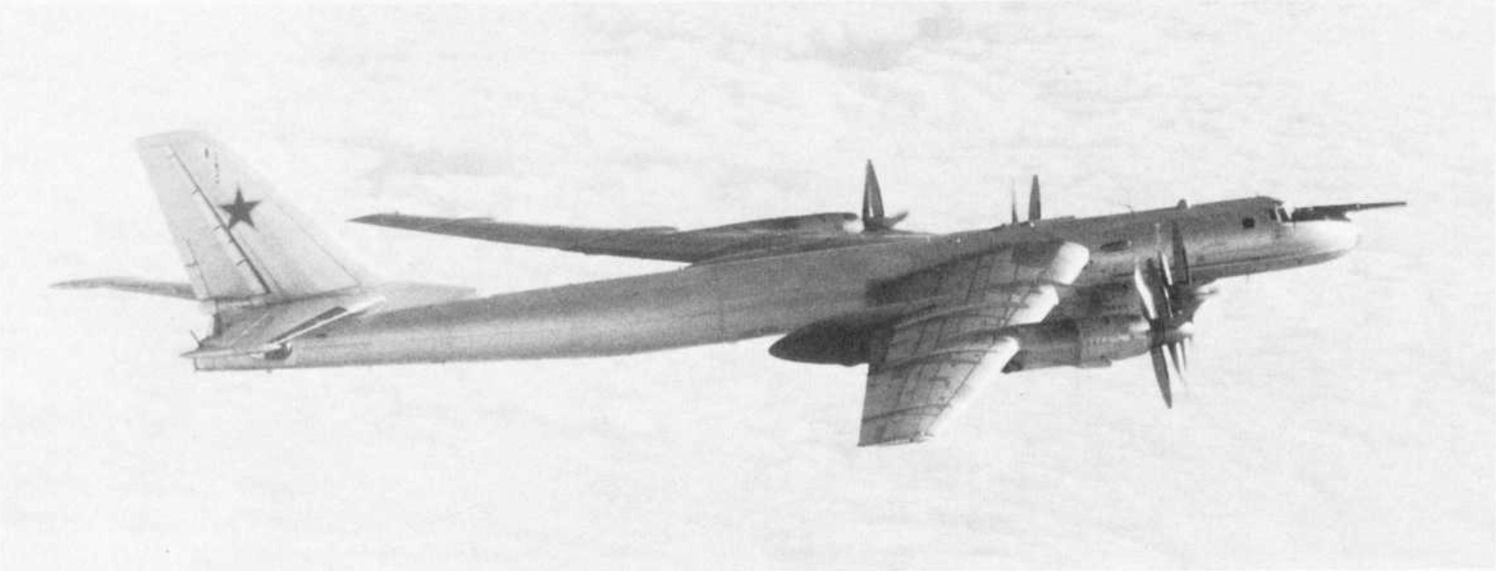
To support these fighters, Victor K2 air-to-air tankers are always available at a high readiness state, in order to keep the Phantoms or Lightnings airborne as long as required — sometimes up to seven or eight hours. These Victors are based at RAF Marham in Norfolk and will soon be supplemented by the VC10s modified from their civilian rôles to serve as tankers, which will greatly extend the endurance of the United Kingdom's fighter force.

In the north of Scotland, near Elgin, RAF Lossiemouth is the home of the RAF's Airborne Early Warning (AEW) force of Shackleton AEW Mk 2s. These Shackletons are capable of travelling great distances and providing radar cover over large areas which are beyond the range of land-based radar sites and can control the fighters to intercept targets as an airborne radar-equipped operations centre. The Shackletons will be replaced in the coming years by AEW Nimrods, which will give a multi-fold increase in the UK's air defence capability.

Of course, Phantoms or Lightnings would never be scrambled if targets were not detected in time, so a chain of long-range radar sites exists from Iceland to Norway and down through Europe. On a typical QRA sortie, approaching aircraft will have been tracked for many miles before they are finally detected by UK mainland radar sites.

The rôle of QRA(I) is to protect the integrity of the piece of airspace

This is a Bear-B, which is distinguished by the wide undernose radome and the flight refuelling probe. An AS-3 Kangaroo air-to-surface missile is carried under the fuselage.



Another example of Bear-F, some 40 examples of which were reported to be in service with the Soviet Navy at the beginning of 1982. This example lacks the fin-tip fairing shown on the opposite page. Originally developed as a long-range strategic bomber, Bear is sometimes referred to as the Tu-20, but that designation is unconfirmed.

allocated to the UK by NATO. As a result, any unidentified or potentially hostile track in what is known as the United Kingdom Air Defence Region (UKADR) is intercepted by an RAF fighter, which will then escort the aircraft, known in Air Force jargon as "trade", until it either leaves the UKADR or is no longer considered a threat.

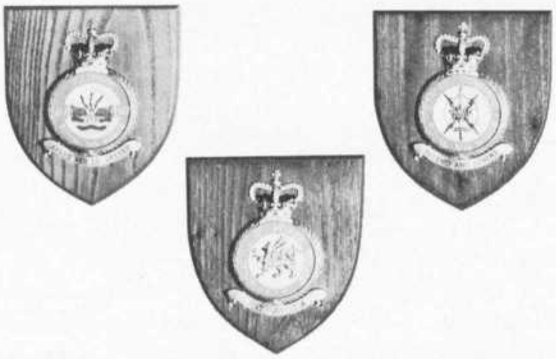
To keep all these RAF resources permanently ready for action is no easy task, but it is considered to be essential to prove to any potential aggressor that the country intends to defend itself and be seen to be capable of doing so — yet another form of deterrence.

"Mission 40 to Tanker 56, request join."

Our Phantom has now been joined on its transit north by a Victor tanker scrambled from RAF Marham.

"40 clear join."

The Phantom pilot eases his 25 tons of aeroplane behind the huge Victor, from which dangles a 50-ft (15-m) fuel hose. To make contact with this hose is like hitting "double tops" in darts every throw — only the board is bobbing up and down! Lights on the Victor illuminate to show that contact can be made and with tiny control movements the pilot nudges up and into the refuelling basket on the end of the hose. With only an eerie glow from the luminous cat's eye



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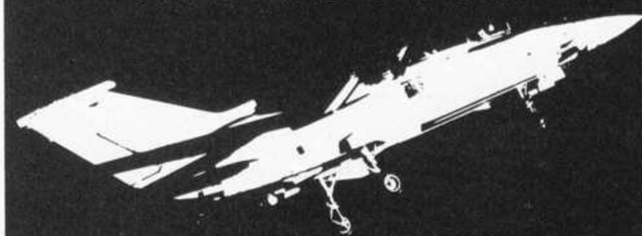

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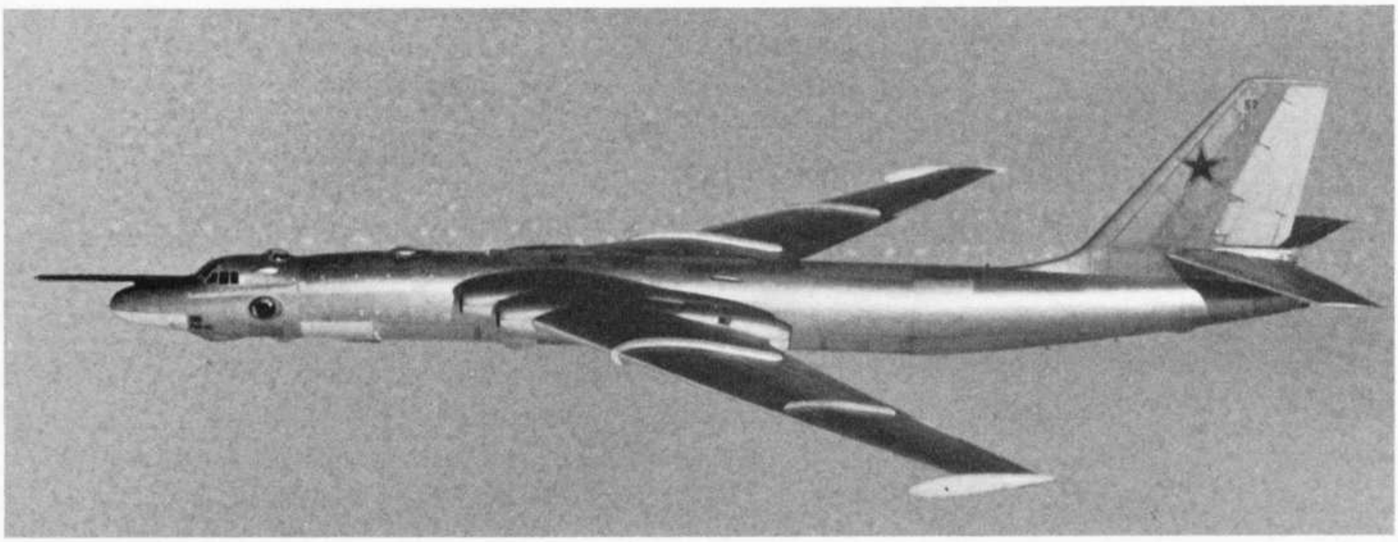


A Myasishchev M-4 maritime reconnaissance aircraft, known by the NATO code-name Bison-B. This jet-powered type has now been largely phased out of the Soviet Navy inventory.

beads on the basket's rim, the navigator has talked the pilot in and now both can relax a little as the vital fuel exchange proceeds, between aircraft 15 ft (4,6 m) apart, 35,000 ft (10 670 m) up and travelling at 500 mph (805 km/h).

Once the refuelling is complete, the fighter gently drops back clear of its own airborne petrol station and then continues north to its pre-briefed combat air patrol (CAP) position. As many as six air-to-air refuels can be required on a long-range QRA sortie, making this one of the most demanding of all flying skills.

The Q-shed

RAF Leuchars sits on the northern shore of the Eden estuary in Fife. On the other bank a mile away the visiting golfers to St Andrews can hear Phantoms on routine training missions, but most will be unaware of the rôle of the grey hangar-like building at the end of the runway. This is the "Q-shed", which houses RAF Leuchars primary peacetime task — two menacing looking Phantoms fully fuelled and armed and waiting only for the word to go.

The Phantom is getting old now but is still better equipped to do the job of defending the UK from air attack than any other fighter, apart perhaps from the US Navy's F-14 Tomcat and, soon, our own Tornado Air Defence Variant. The Phantom's major advantages over other types are its pulse doppler radar associated with four Sparrow or Skyflash radar guided air-to-air missiles, giving a look down, shoot down capability; four heat-seeking Sidewinder missiles; a highly accurate gun pod, and, most important of all, a two-man crew which spreads the work load and ensures greater mission success and survivability — very important when, as now, we are outnumbered.

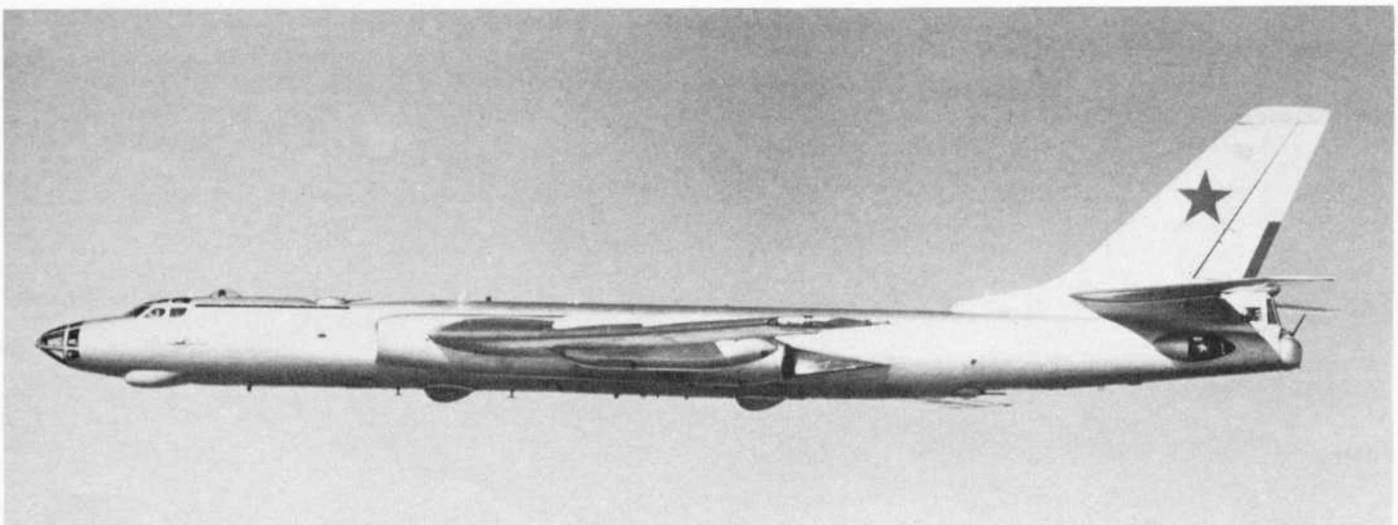
The Q-shed is big enough for only two Phantoms and their paraphernalia to keep them "gassed and oiled" at permanent readiness. The eight missiles on each aircraft are armed and the safety locks removed, only the Pilot's Master Arm switch and a trigger press being required for a missile launch. Next to the shed, in a connected bungalow-type building, are the two crews and seven engineers waiting for the scramble order. Each crew of pilot and navigator shares a bedroom and the two crews share a small lounge with a TV and magazines. They all remain in the shed in their flying kit, minus life jacket and helmet, for a 24-hour period of duty, a third crew being nominated as reserve but waiting at home for a phone call that can have them rapidly airborne if needed. The six airmen groundcrew and their Senior Non-Commissioned Officer are in the same building but have a separate lounge and two bedrooms where they spend a seven-day duty period; air and groundcrews share the same simple kitchen.

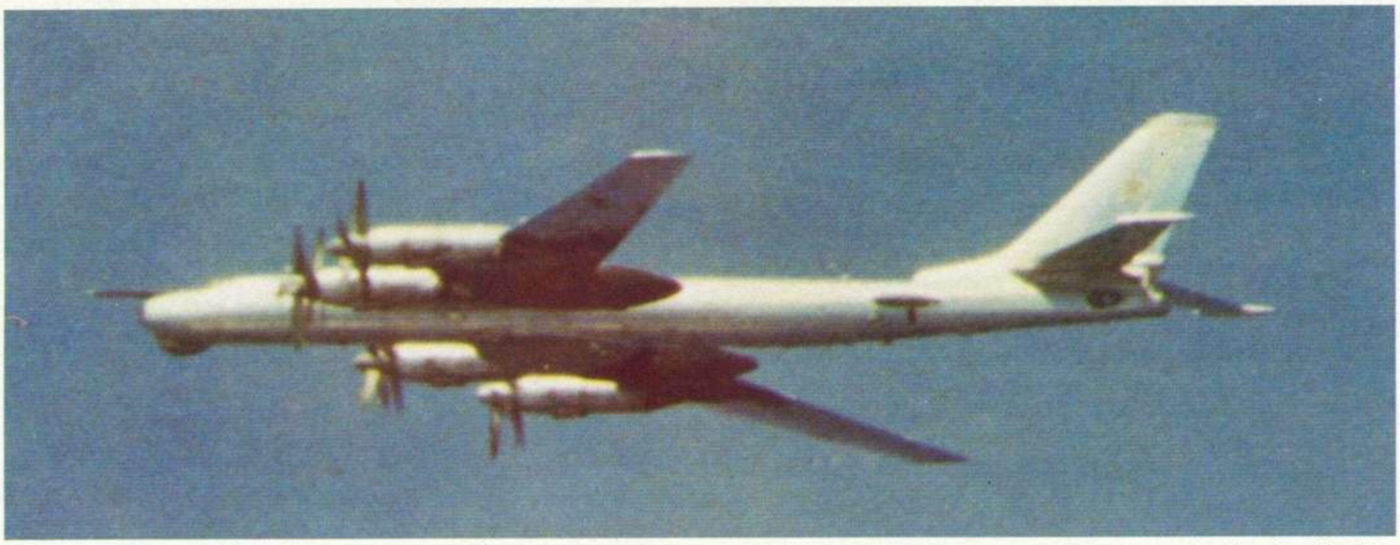
The flying kit the aircrews wear is hot, bulky, uncomfortable and very expensive, but all necessary to protect their lives in a rapid decompression at 40,000 ft (12 200 m), or in the event of an ejection into the icy waters of the North Atlantic.

The two resident squadrons at Leuchars, No 43(F) "The Fighting Cocks" and No 111 Squadron, split the year into two-three week segments and alternate QRA duties over the whole year. Each squadron will hold either Christmas or New Year QRA but swop round the following year. Both squadrons, like all the other QRA(I) squadrons, have a distinguished history dating back to World War One and there is much friendly rivalry in the messes.

"Shackleton 66 this is Mission 40 on CAP in Mike Lima Echo Charlie, flight level 350, looking 040°."

A variant of the Tupolev Tu-16 bomber, Badger-H is a stand-off or escort electronic countermeasures aircraft, the primary function of which is chaff dispensing.





Tupolev Bears have been operating over the Atlantic and Pacific for many years; this one was intercepted and photographed by aircraft of the US Navy. The current maritime surveillance versions have the design bureau designation Tu-142.

"40 this is 66, your trade bears from you 050° at 150 miles."

"40 roger."

One hour after take-off our Phantom has transited under a canopy of stars to a position 500 miles (805 km) north of Leuchars, half-way between Iceland and the Faroes. From the dark and cramped confines of the Shackleton AEW a radar operator gives the fighter crew the information they need to find the intruding Soviets.

"40 your trade is now 050° at 120 miles, tracking 230°, height unknown."

A pair of Bears

In the Phantom the navigator is searching the sky ahead with the electronic beam of the radar hoping to catch an early "pick-up" in order to give himself enough time to direct the pilot into a perfectly controlled intercept. A late radar pick up often means a rushed intercept which puts more strain on the crew.

"Mission 40, your trade has turned west and bears 040° at 100 miles." This means that the intruders have altered course and now the Phantom navigator has to work out a different intercept pattern.

"Roger Shackleton 56, 40 is now vectoring 020° for intercept." The navigator has made his counter move and hopes that if the trade maintains its course he will pick up the tell-tale "blips" on his radar scope in a few minutes. Still he searches the huge area of sky ahead of the Phantom, from sea level to 60,000 ft (18300 m). The crew together maintain an "air picture" in their heads of what is going on around them: where the "trade" is now; where the Shackleton and tanker are; what range it is to base, the nearest diversions and what their weather is like; how long before the fuel gets too low and they have to air-refuel again, and a multitude of other considerations.

"40 in contact two targets bearing 035°."

"Roger 40, you are clear to investigate. Check your weapon switches are safe."

Interpreting the information displayed to him on the radar scope, the navigator tells the pilot his own assessment of the intruders' heading, height and speed and then gives directions to fly that will bring the fighter up behind the target aircraft for an identification.

"They're in five mile trail, which one do you want to go for first?" the navigator asks the pilot.

"We'll take a look at the leader first and then throw an orbit behind the trailer. We'll shadow them both from the rear man until told otherwise," the pilot's reply is immediate whilst still concentrating on flying as accurately as possible the navigator's requested datums for the intercept and staring vainly out into the night blackness hoping for that glimpse of a flashing navigation light which would be the first visual sign of the unwelcome intruders.

"We're getting close now and I still can't see any lights, we'll have to go for a VID (visual identification profile)." The navigator controls the intercept carefully to roll out two miles (3,2 km) behind the lead aircraft and then the pilot and navigator together use the radar to control the VID which, as they close below a mile, requires very precise flying to the exact knot of speed and foot of height. A mistake now would mean a break off and set up again — five minutes and precious fuel wasted.

Through the reflected red glow of his instrument lights on the canopy the pilot makes out an area of even darker blackness in the night sky just ahead and above the Phantom. At the same time a gentle rumbling starts and noise can be heard from outside the fighter, both caused by resonance from the blades of eight huge

Most interception flights performed by the RAF, of the kind described in the accompanying article, are flown by Phantoms, although two UK-based squadrons of Lightnings are also involved. The air defence Phantoms now have an overall grey finish.

A Bear-B operating in the maritime surveillance rôle, with nose-mounted flight refuelling probe. Badgers have served as tankers, but a version of the Ilyushin Il-76 is reported to be taking over this rôle.

propellers thrashing the cold night air and driving the mighty bomber forward.

"It's a Bear!"

The intruders that QRA(I) are most regularly called on to intercept are the Tu-95 "Bears" and Tu-16 "Badgers" of the Soviet Long Range Air Force and Soviet Naval Air Force. Occasionally other types such as M-4 "Bisons" and Il-18 "Coots" come down far enough south to be intercepted by QRA fighters.

The Soviet aircraft are practising their war rôles of maritime surveillance, anti-shipping, anti-submarine warfare, and simulated strike attack against the mainland UK. QRA intercepts provide valuable information on Soviet aircraft and equipment and any changes to the tactics they may employ in a future conflict.

The number of Soviet aircraft in a group requiring intercept varies from singletons to quite large groups at one time. If large numbers of "trade" penetrate the UKADR several QRA fighters with AEW Shackletons and Victor tankers in support can be involved all at once. Squadrons holding QRA therefore have to be able to generate extra armed aircraft if required. The Soviets are no respecters of Western culture and the UKADR has been known to be full of "trade" with many fighters airborne even on Christmas and Easter holidays.

"Shackleton 66 this is 40, we are in company with the lead aircraft which is identified as a Bear Delta."

The pilot now has to hold the Phantom as steady as possible just underneath the Bear while the navigator looks through the magic green eye of the hand held image intensifier to discern any unusual features of this particular aircraft. This is a maritime surveillance aircraft and its number is recorded to be passed on for intelligence analysis. If the intercept had taken place during daylight the navigator would have taken photographs of the Bear which again would have been forwarded to the intelligence services after landing.

"40 is departing the lead aircraft and going to identify the rear."

After flying an orbit the Phantom rolls out two miles (3,2 km) behind the rear aircraft of the Soviet pair and the same procedure for an identification is followed — again it's a Bear Delta maritime surveillance bomber.

"40, this is Shackleton 66, you are to RTB (return to base)."

Back to base

The Phantom now leaves the Bears as they exit the UKADR and the crew decides whether any fuel is required from the Victor to get them safely home with enough to divert to another airfield, if they cannot land back at Leuchars because of poor weather.

"Leuchars tower, Mission 40 'finals' gear down to land."

"40 clear land, wind 080° eight knots."

As the dawn is beginning to break the Phantom screams in over the airfield fence and touches down on the runway with a flurry of grey smoke from the tyres. The pilot taxies back to the Q-shed as alarm clocks all over the country are beginning to wake others to a new day's work. As the weary crew unstrap from their rigid ejection seats after several trussed hours and climb down the aircraft ladders the engineers begin busily preparing the Phantom to be ready to go again to meet the next intruder.

After writing their reports, handing in any film used and checking their Phantom after turn-round, the pilot and navigator wait for the 0830 hours crew changeover. As others are normally on their way to work, Mission 40 is on its way home to bed after a normal "day at the office" on the Quick Reaction Alert (Interceptor) Force. □

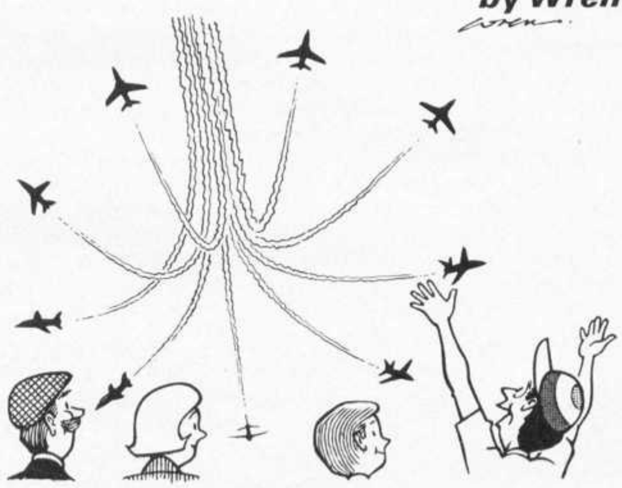
Wrenderings

by Wren

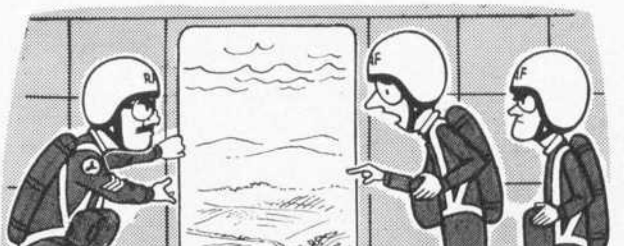
AT LEAST!
First apprentice fitter: ***"This test job has to be machined to within three thousandths of an inch, says Chiefy. How many thousandths in an inch, Harry?"***
Second apprentice fitter: ***"I dunno, Tom — bloody millions, probably."***

* * *

SAR
As a dramatic climax to the Edinburgh Tattoo, the lone piper in all his kilted finery was suspended beneath an RAF SAR (Search and Rescue) helicopter and deposited on the castle battlements. As he swung over the upturned heads of the spectators, somebody suggested that "SAR" might now be interpreted as "Suspend and Reveal".



"Encore! Encore!"



"OK — through the door and then which way?"

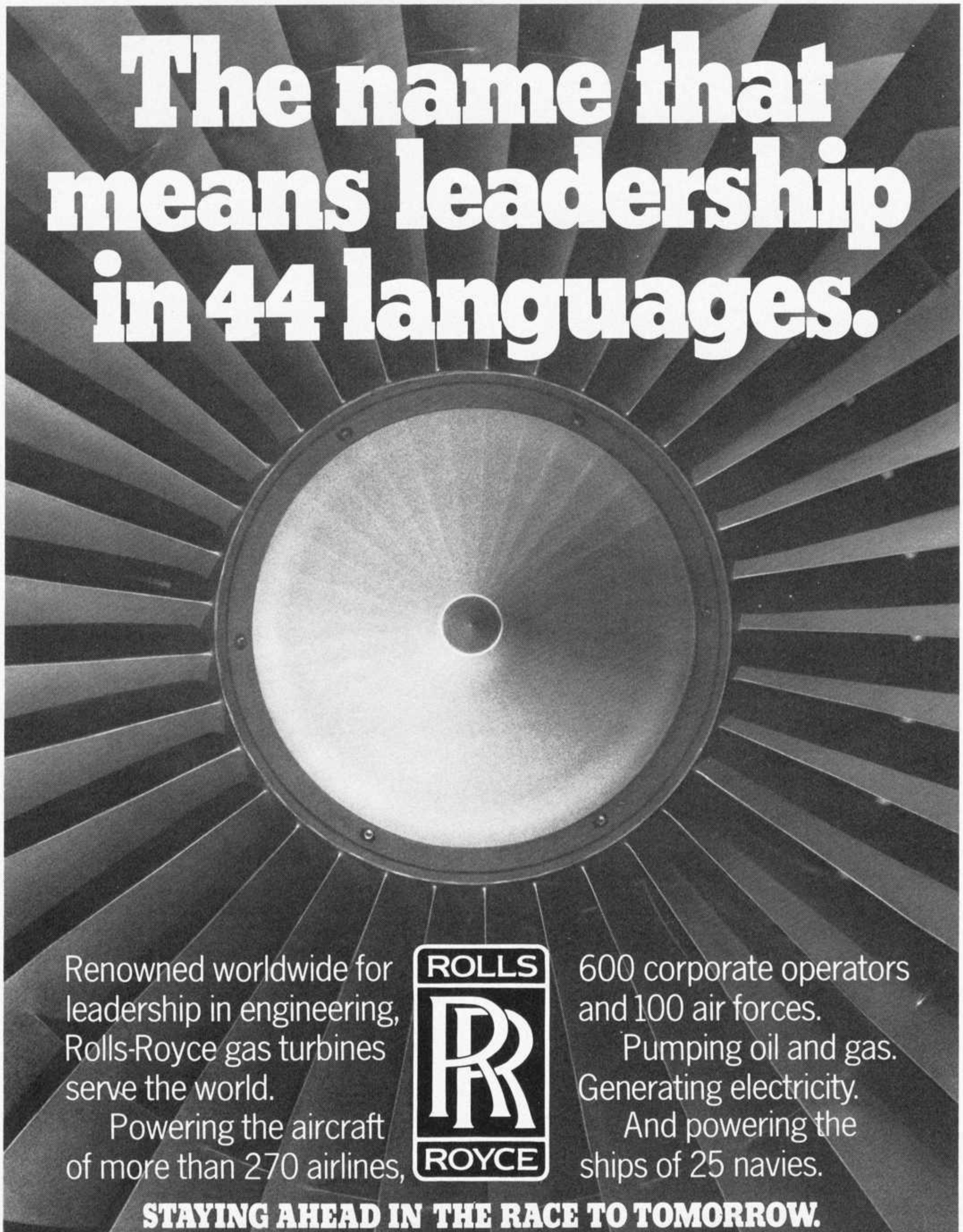
A young RAF airman told his girl friend that if she could guess what he had in a matchbox that he was holding in his hand, he would make passionate love to her. "An elephant?" she said. He replied "OK, that's near enough!"

* * *

NAAFI SAUCE?
Shake and shake the ketchup bottle,
None'll come out and then a lot'll.
– Ogden Nash

* * *

"Now then, you lot, that's not marching, that's simultaneous walking! Come on, now – LEP-RI-LEP-RI . . . !"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Testing Time for the Spitfire

The Royal Air Force has had no more famous aeroplane serving in its squadrons than the Spitfire. The first example of this most classic of all fighters reached No 19 Squadron in August 1938; production continued for 10 years and the last was not retired from an operational fighter squadron until 1952. From the earliest days of testing the prototype until the last variant was cleared for service, Jeffrey Quill, OBE, AFC, FRAeS, was intimately concerned with the flight testing and development of the Spitfire — a task on which he here reflects for the readers of *Royal Air Force Yearbook*.

WHEN I left the Royal Air Force in January 1936 to become a civilian test pilot for Vickers (Aviation) Ltd at Weybridge, that company was engaged exclusively with military aircraft design, development and production. The same applied to its wholly-owned subsidiary, The Supermarine Aviation Works (Vickers) Ltd, at Southampton. Less than two years earlier, the British government — after some years of appalling delay and indecision in responding to the re-armament of Germany under Hitler's rule — had initiated an expansion of the Royal Air Force. Its early plans had been tentative and most inadequate, but by 1936 Scheme "F" was current, calling for a home Air Force of 1,736 front-line aircraft by 1939 organised in 124 squadrons. At Weybridge and Southampton, therefore, I found companies that — like the rest of the aircraft industry — were fully pre-occupied with expanding their design and productive capacity to meet this new challenge.

Well-informed and prudent managements were already anticipating much greater expansion schemes than those so far announced. The Air Staff, too, had not neglected, during the "locust years", to think ahead to the types of aircraft which would be needed for the future, and some extremely important operational requirements had been conceived and issued to Industry in the early 'thirties. Notable amongst these were the B.9/32 which led to the Hampden and then, in considerably augmented form, to the Wellington (which greatly exceeded the original B.9/32 requirement in range and bomb load capability). Then, in 1934, had been issued the F.36/34 and the F.37/34 specifications which led to the Hurricane and the Spitfire. Many other key requirements were generated at about this time.

Within six months of my joining the company, prototypes of the B.9/32 Wellington, the F.5/34 Venom and the F.37/34 Spitfire would all make their first flights; the prototype G.4/31 Wellesley was already flying. Passing through the factory at Weybridge were some old Vickers Virginia night bombers on repair and overhaul, a batch of new Vickers Valentias (derivatives of the old Victoria troop carrier with Pegasus engines), some Vildebeest biplane torpedo bombers and some Hawker Hart trainers built by Vickers under Air Ministry contract. Very soon the Wellesley was to emerge in production form. At Supermarine the Walrus amphibian and Scapa and Stranraer flying boats were in production.

I did a lot of flying on the Wellesley prototype K7556 to complete the contractor's trials; I flew all the "old stagers" going through the factory, and I flew a lot in the prototype Venom and Spitfire. George Pickering of Supermarine checked me out on flying boats (which I had never flown before) so altogether I was lucky to get experience on a wide and varied selection of aircraft from the old to the very new, and spanning a long period of aeronautical development. In the Royal Air Force I had been a "fighter boy", so this great broadening of my experience came at a very fortuitous time for me.

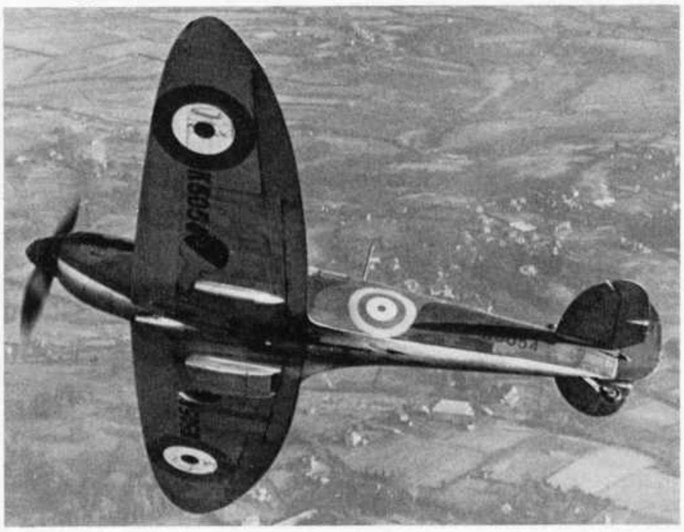
At Weybridge, the chief test pilot was "Mutt" Summers whose assistant (perhaps "apprentice" would be a better word) I became. He had joined Vickers in 1928, after serving a short-service commission in the RAF, and there were few other pilots in the industry who could, by 1936, match his experience; I was lucky indeed to serve under him and to learn from him a great deal of "horse sense" about testing new aeroplanes.

It would be difficult to overstate the importance to any aircraft company of the relationship between the chief test pilot and the chief designer. Mutt and Rex Pierson, who filled the latter rôle at Weybridge, had a remarkably close working relationship and in those days this was of immense benefit to the company. That great test pilot, George Bulman of Hawkers, used to say that testing aeroplanes was 50 per cent flying and 50 per cent being able to communicate with the designer; and he was certainly right. Mutt had also evolved a good working relationship with R J Mitchell as chief designer at the Supermarine company, where he had also become chief test pilot in 1928 upon the retirement of Henri Biard, and had thus become responsible for the first flights of the Scapa and Stranraer flying boats, and the F.7/30 fighter with its steam-cooled Goshawk engine. His assistant at Supermarine, as resident test pilot at Southampton, was George Pickering.

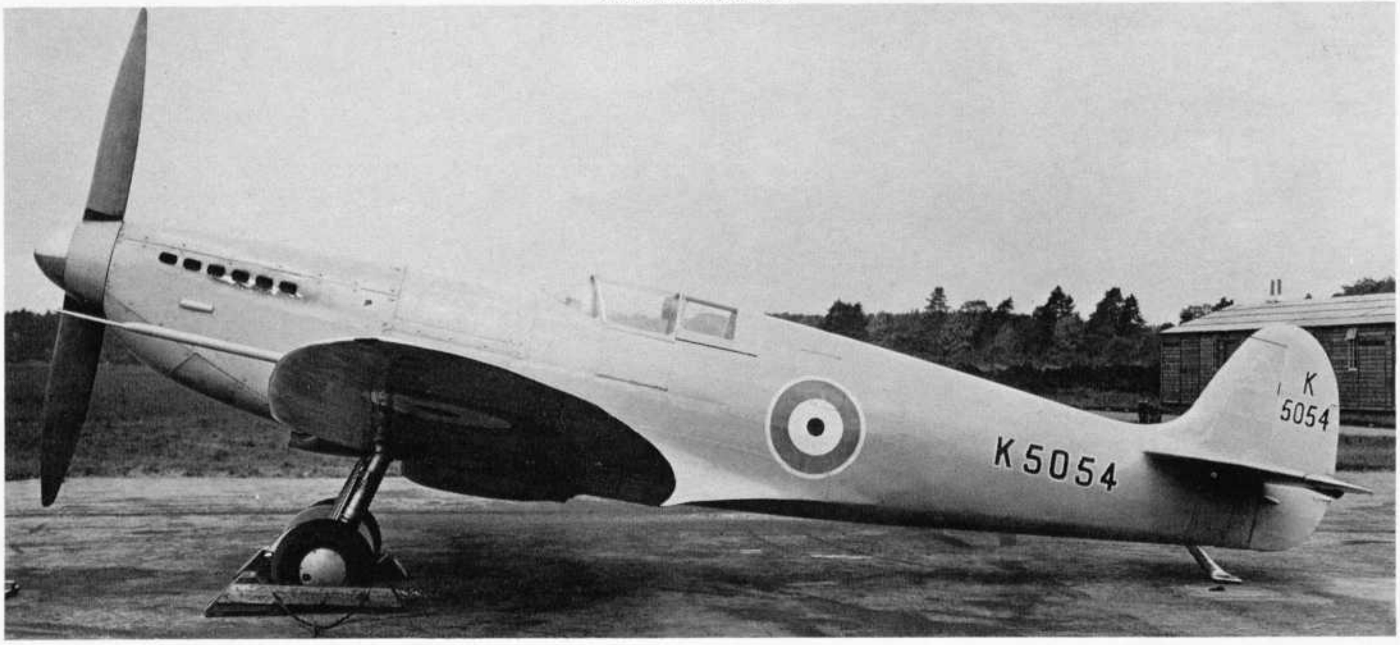
The year 1935 had seen the final collapse of the Geneva disarmament conference; the League's (and in particular Britain's) hostile but in the event futile reaction to Mussolini's Abyssinian adventure which had driven Italy into the arms of Hitler and resulted in the formation of the Rome-Berlin axis; the introduction of conscription in Germany, and the great shock to the Western powers when Hitler announced to the British Foreign Secretary that the *Luftwaffe* had achieved parity of strength with the Royal Air Force and was aiming for parity with *l'Armée de l'Air*, then nominally the most powerful air force in Europe.

The year also saw, as I have said, the first significant but belated step towards British re-armament in the air (Scheme "C"). With 1936 came the outbreak of the Spanish Civil War, and on 7 April 1936, one day after the Spitfire's first flight, Hitler marched his army into the Rhineland in direct and highly visible defiance of The Versailles Treaty. It is now known that had France and Britain reacted with even a token show of military force (the French Army alone comprised 100 divisions), Hitler's troops were under orders to retire immediately. But France and Britain, paralysed by political indecision, did nothing, and the last chance of checking Hitler's wild ambitions and probably destroying him politically in Germany was lost. From then on Locarno, the League of Nations and "Collective Security" lost all international credibility, the balance of power and the political initiative in Europe swung decisively towards Hitler and eventual war became inevitable. It became simply a question of when, and whether we could possibly be ready in time. So the Spitfire was born into the inevitability of war.

The atmosphere within the aircraft industry in 1936 became one of urgency, enterprise and buoyancy. After being the ugly duckling for so long it was a change and a tonic for the industry to know it was now of first rate national importance. Most firms, imbued as they were with a strongly competitive tradition, embarked upon a period of activity and enterprise. I found it refreshing and stimulating to work in an environment in which, apart from pinching the petty cash, about the only serious crime one could commit was to waste time. On 6 March, Mutt Summers made the first flight on the Spitfire K5054. In June he flew the Vickers Venom eight-gun fighter with Bristol Aquila engine and on 15 June he made the first flight on the B.9/32 (Wellington) prototype. It was obvious he would not be able to devote his full attention to all three of them and as the Wellington was of prime importance, not only to Vickers but also to the Air Staff, Mutt elected to concentrate upon that as his main commitment and had already told me that he looked to me to play a major part in flying both the Spitfire and the Venom under, of course, his overall supervision. This suited me well as I was first and foremost a fighter pilot, much as I had enjoyed my flying on the Wellesley, the (then) big twins, the Virginia and Valentia, and the flying boats. So it was an exciting prospect.



(Below) The first of the many — Spitfire K5054 was the original prototype for the flight development and testing of which Jeffrey Quill became largely responsible in 1936, when this photograph was taken. The same aircraft is depicted (above right) after it had acquired RAF camouflage and several small modifications, such as a tailwheel and aerial mast. (Heading photo, opposite page) An evocative photograph, by Arthur Gibson, of two surviving Spitfires "breaking" from line astern. In the lead is Adrian Swire's Mk IX (MH434) flown by Ray Hanna, AFC — a former leader of the Red Arrows — with the Mk IA (AR213) owned by The Hon Patrick Lindsay and flown by Flt Lt Pete Thorne, RAF, in hot pursuit.



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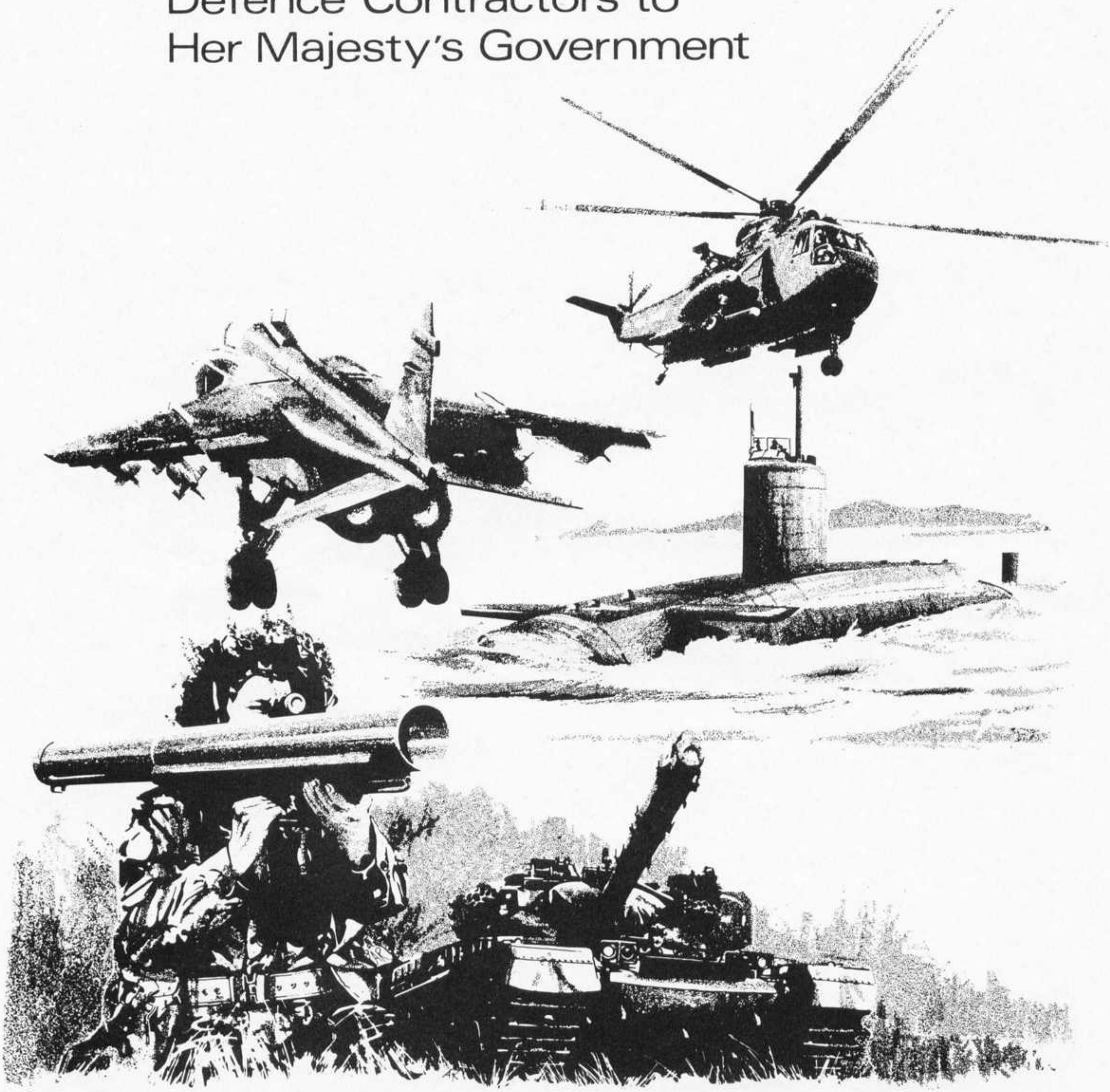


A few of the many stages in the evolution of the Spitfire are shown on this page. (Above) A Mk VB, showing the two wing cannon, with the "clipped" wing tips adopted for improved low-altitude manoeuverability. (Below) A Mk VC (with four wing cannon positions, although the guns are not here fitted) carrying the 170-Imp gal (773-l) tank specially developed to allow ferry flights to be made from Gibraltar to Malta; note the deepened nose cowling to house an enlarged oil tank.

(Above) The Spitfire VI was an early development for high altitude work, featuring extended wing tips and a somewhat rudimentary pressure cockpit. (Below) Spitfire floatplanes were developed with a view to specialised operations in Norway and, later, the Mediterranean. Three Mk V floatplanes reached Egypt in 1943 but did not see combat. A Mk IX prototype is illustrated.

I made my first flight in the Spitfire on 26 March 1936, by which time Mutt had already made some more flights in it following his first, and also by which time it had re-emerged from a spell in the shops with a smooth paint finish applied and some minor modification work. George Pickering, however, beat me to it by one day, making his first flight on 25 March when I was up at Martlesham flying the prototype Wellesley.

Up to this point no real performance work had been done, apart from some cursory speed checks at medium level, and on 27 March I made two flights devoted to a proper set of level speeds each side of the full throttle height, carrying a recording barograph, and also recording some cooling figures at various radiator flap settings. The results of these level speeds were extremely disappointing, showing a top speed only in the region of 335 mph (539 km/h) at about 17,000 ft (5182 m). Mitchell had set his heart on 350 mph (563 km/h) and was much worried by these poor results, so we set about doing everything which could be done to improve the performance.

During this phase of contractor's trials between the first flight and first delivery to Martlesham on 26 May 1936, the flying on K5054 was shared between Summers, Pickering and myself. I think I probably did the bulk of it, but where handling characteristics were marginal (as in longitudinal stability they were) the opinions of the other two pilots were always sought. We concentrated upon getting the maximum performance we could out of the aeroplane, as well as making all the necessary functional tests, determining its centre of gravity limits and ensuring adequate handling characteristics. Our grapevine intelligence system told us that the prototype Hurricane was doing about 335 mph (539 km/h) and Mitchell well knew that the Air Staff were hoping for a much greater performance from the Spitfire, and that unless it established a substantial lead over the Hurricane a production order could not be justified. So it was not until our propeller designers had diagnosed compressibility problems due to the high helical speed (eg, Mach No) of the propeller tips and had created a propeller with tip sections designed to ameliorate this problem that, on 5 May, I turned in a set of level speeds with this new propeller showing a peak performance of between 348 and 349 mph (560-562 km/h). Then, and only then, did Mitchell clear the aeroplane for delivery to Martlesham. It is interesting that Martlesham's subsequent official performance measurement lined up precisely with ours.

In those days, the techniques of measuring aircraft performance in the air and correcting by calculation the observed indicated airspeeds, altimeter readings and air temperatures to derive figures of true airspeeds and heights was already well understood and established. All that was really required were aircraft performance technicians who knew their business, test pilots with the necessary concentration and patience to fly very accurately and thoroughly, and an engine that would put up with prolonged running at full power rating. Instruments had to be very accurately calibrated, and such things as pitot position error thoroughly well measured by the various methods then available. Otherwise no special instrumentation was required except an accurate recording barograph as a check on the accuracy of the pilots' flying. Thus, the quantitative measurement of aircraft performance and system functioning was well advanced.

On the other hand, means for the quantitative measurement of aircraft handling qualities in the air were, in the pre-war era, virtually non-existent, and the assessment of handling behaviour was almost entirely qualitative in nature and thus dependent upon the observation, critical faculties and experience of the test pilot. When I first joined Vickers and Supermarine there were no devices for the accurate measurement of control forces (stick forces), nor control surface displacement angles or control surface hinge moments. During 1937/38, when Mutt made a visit to Germany, he came back with a fairly sophisticated Henschel stick force recorder which would measure aileron and elevator stick forces (but not displacements) and this we put to very good use, especially when trying to improve the Spitfire aileron control in 1940. Otherwise it was not until later on during the war that we were able to measure control surface angular displacements with real accuracy.

The only quantitative check which we could make of longitudinal stability (for instance) was by recording "phugoids" in the air. This was done by trimming the aircraft to fly straight and level at a certain speed and height and then disturbing it by, say, 20 mph (32 km/h), then leaving it to its own devices and recording its behaviour by stopwatch. Once disturbed, the aircraft would perform a series of oscillations which would either damp out until it returned to its original condition of flight — in which case the aircraft was stable — or would increase in amplitude until the pilot had to take over control again — in which case the aircraft was unstable. In extreme cases the aircraft would diverge from the very first oscillation, in which case it was very unstable. The recorded speeds against a time base could be plotted afterwards.

Of course, longitudinal instability could be assessed qualitatively by the pilot in steep turns or recovery from dives, but at that time "phugoids" were really the only practical quantitative measurement. Otherwise, all handling qualities, with the possible exception of rates of roll roughly measured by stop-watch, were determined purely by pilots' assessment. A very great deal therefore depended upon the test pilot's judgement and his ability to differentiate between the really important and the trivial.

It was only later, during the latter part of the war, that real progress began to be made in the quantitative assessment of handling and stability questions, and this was dependent upon the increasing availability of suitable instrumentation for measuring control forces and angles.

Study of the early A&AEE reports on the handling of the prototype K5054 show an entirely qualitative approach to handling assessment, with the exception of some phugoid plots included as a sort of confirmation of pilots' comments.

During our early tests on the prototype Spitfire before its delivery to Martlesham, it was necessary to establish the acceptable forward and aft limits of the centre of gravity. The forward limit was determined (qualitatively) by considerations of ground handling and nose heaviness under braking conditions, while the acceptable aft limit was also determined qualitatively, by checking the behaviour of the aircraft under *g* in steep turns and high-speed dive recoveries. During this process I tested the aircraft at an extended aft CG position at which it was violently unstable and quite unacceptable; eventually we settled for an aft limit at which the aeroplane was slightly unstable, which meant that at its normal service load the stability was just positive, and this was how we sent it to Martlesham. This made the aeroplane quite sensitive or "tender" fore-and-aft, but in fact gave it a certain feeling of liveliness and animation and a sense of finger-tip control which appealed to pilots and seemed compatible with its performance and its rôle as a fighter. But just acceptable (longitudinally) as the prototype was, the stability margins were very narrow indeed and the acceptable CG range in flight was small. This was to be a problem which was to remain with us throughout the Spitfire's long development life. As a matter of interest, the all-up weight of K5054 at that time was 5,819 lb (2 640 kg) and the CG was at 0·321 of the mean chord. Ballast was fitted in the wings in place of the guns (which were not then available) and the ammunition.

Production problems

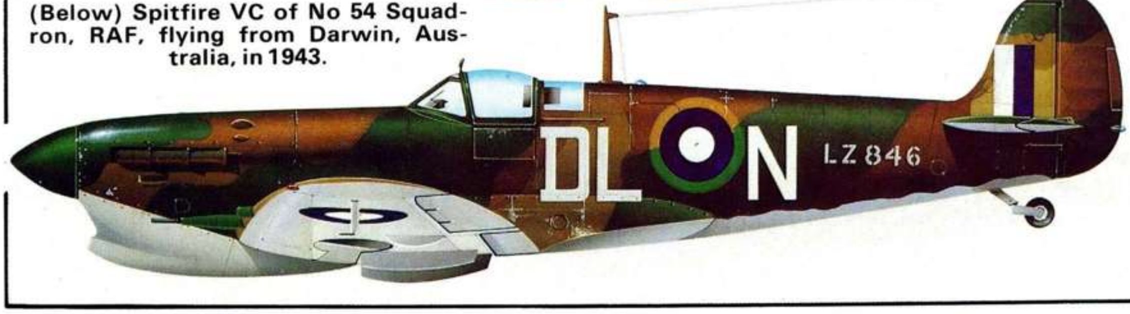
On 3 June 1936, an order was placed for 310 production Spitfires, with first delivery to be October 1937. Specification F.16/36 was produced to cover the required standard of the production aeroplanes. The items in this specification of principal significance were an increase in wing stiffness to ensure freedom from flutter up to diving speeds of at least 450 mph (724 km/h) indicated (in fact 470/756 was achieved), an increase in fuel capacity from 75 to 90 Imp gal (341-409 l), improved oil cooling capacity plus a number of other detailed but lesser requirements. This was the largest production order ever received by Supermarine up to that time, the company having hitherto existed on small orders for flying boats spread over a longish period. Putting this high performance fighter

(Below) Spitfire I as flown by Sqn Ldr Henry Cozens, CO of No 19 Squadron, RAF Duxford, October 1938.

(Right) Spitfire IIA of No 66 Squadron with long-range tank for Operation "Sunrise", July 1941.

(Below) Spitfire IIB of No 306 (Polish) Squadron, operating from Northolt in August 1941.

(Right) Spitfire VB serving with No 40 Squadron, SAAF, in Italy, August 1943.



(Below) Spitfire VC of No 54 Squadron, RAF, flying from Darwin, Australia, in 1943.

with, for those days, a very advanced technology structure, into mass production clearly represented a considerable challenge for a small firm.

At 30 September 1936, the number of employees at the Supermarine works was 1,370, staff comprised 179, and the Drawing Office workforce totalled 95. Factory floor space was not great and the company already had production orders for Walrus and Stranraer flying boats to fulfil, and skilled labour was short in Southampton. Thus the company was certainly very short of capacity for the execution of this large order for Spitfires. An extensive programme of sub-contracting was initiated, but in the first instance this was insufficient and serious problems and delays ensued.

It is also too easily forgotten that when the Spitfire was ordered into production in June 1936 it had done just enough performance testing at Martlesham to confirm its top speed, rate of climb and service ceiling, and just enough handling tests to ensure it was free of vices and could be safely flown by squadron pilots. It had no guns installed, no ammunition containers, no gunsight, no radio, no armour plate nor any other operational equipment. It was an elegant, high performance flying machine but still had to be developed into a practical fighting aircraft. This task would have to be performed in parallel with the process of "productionising" the aeroplane and

Of the several examples of the Spitfire still flying in Britain and often to be seen at air displays is the beautifully-restored and colourfully-finished Mk XIV G-FIRE, owned by Spencer Flack.

would certainly throw up a wealth of modifications — the bane of the production engineer's life.

There is no doubt that the company's early estimate for the delivery of production aeroplanes (given by Sir Robert McLean as chairman of Vickers in 1936) was over-optimistic to a serious degree and the problems involved, especially with the relatively inexperienced sub-contractors, were under-estimated. A major row developed between the Air Ministry and Sir Robert, but eventually, and much behind the original optimistic dates, I flew the first production aeroplane K9787

(Below) Spitfire VII of No 131 Squadron in high altitude grey/blue finish, with "Invasion" stripes, 1944.

(Below) Spitfire IXC of No 73 Squadron at Hal Far, Malta, in 1945.

(Below) Spitfire F Mk XIV flown by Sqn Ldr R A Newbury, CO No 610 Squadron, at Lympne in September 1944.

(Below) Spitfire F Mk 21 of No 91 Squadron, at RAF Ludham, in May 1945.

(Below) Spitfire FR Mk 18 flown by No 32 Squadron at Ein Shemer, Suez Canal Zone, in 1947/48.

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on 15 May 1938. Thus, a period of one year and eleven months elapsed between the first placing of the order for 310 examples and the flight of the first production aeroplane; the rate of build-up thereafter also was slow. I delivered the first service aircraft (K9789) to No 19 Squadron at Duxford on 4 August 1938.

The Air Council were much outraged by what they considered an unwarrantable delay. McLean, already on bad terms with the Air Staff anyway, was also losing the confidence of the Vickers Board and later in 1938 the control of the Aviation companies was transferred to Vickers Armstrongs Ltd under Sir Charles Craven; McLean resigned and became Chairman of EMI. In retrospect, it can be seen that the root cause of the trouble really lay in the fact that for too long the aircraft industry had been starved of orders and had supported itself more on prayers than on wings; so it was all very well for the Air Council to expect it suddenly to burst into vigorous life both in technology and production capacity after years of neglect, and when the British Government had delayed their response to the challenge from Hitler until the last possible moment because of their fear of the vociferous pacifist and disarmament lobbies. Where, on the fringe of a starved industry, were the experienced and able sub-contractors to be found to provide the additional production capacity?

At the outbreak of the war a total of some 300 Spitfire Mk Is had been delivered to the Royal Air Force. By the beginning of the Battle of Britain (10 August 1940) nearly 1,000 had been delivered and some of these came from the great new shadow factory at Castle Bromwich now under the management of Vickers Armstrongs Ltd.

By the time the last production aeroplane had been delivered by Supermarine in 1948, a total of 22,750 Spitfires and Seafires had been produced from all sources and at its peak the combined production rate from all factories had amounted to about 350 per month or more than 10 a day. Perhaps this puts some of the early traumas of pre-war Spitfire production into perspective. It should always be remembered that it was under McLean's enterprising and decisive leadership of the company that the Wellington and Spitfire were originally conceived and although he carried the can for early production delays, he deserves, in retrospect, full credit for his vital contribution.

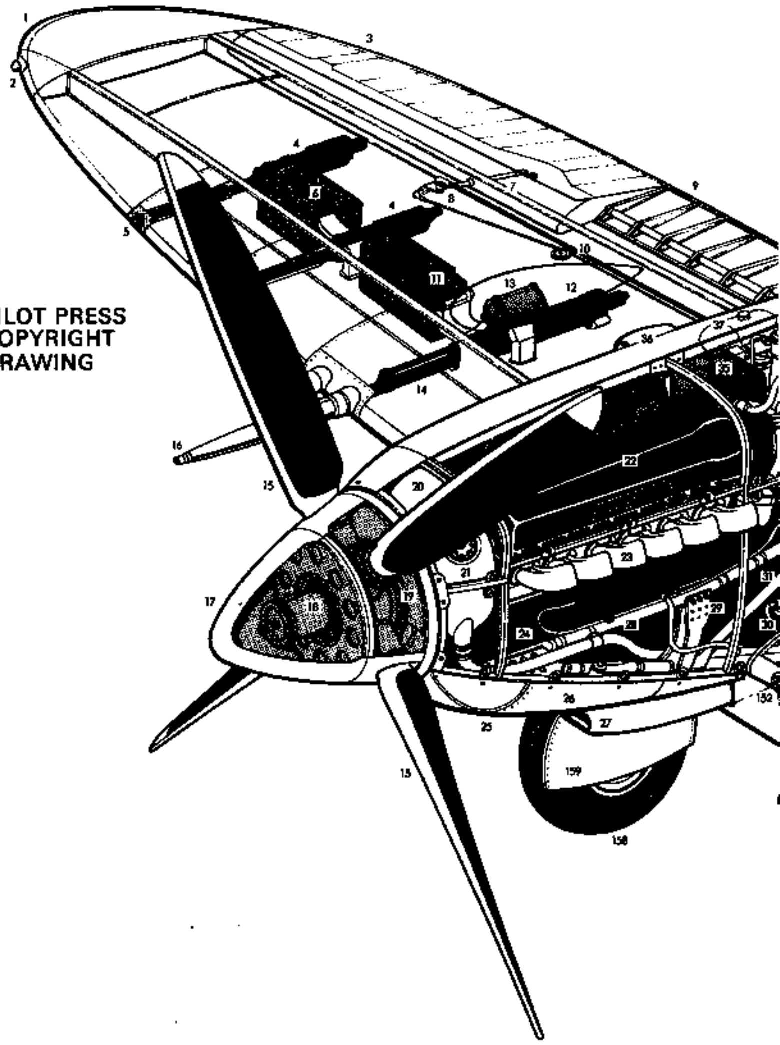
Improving the breed

To return to test flying. As time went on and the rate of production went soaring upwards, the task of getting each aeroplane off the production line thoroughly and properly tested became very great. Every aeroplane (and there were no exceptions) had to be climbed to above its full throttle height (18,000 ft/5 486 m) and later at least 22,000 ft (6 706 m), given a two-minute level speed run at full power to check performance and instruments, dived to its maximum Vᴅ (470 mph/756 km/h IAS and, on later marks, 525 mph/845 km/h IAS) and the functioning of all systems and engine operations thoroughly checked. In addition, three or four quick flights were usually needed for adjustment of ailerons, propeller constant speed settings and minor snags — and all this had to be done, as far as possible, independently of the weather (and there were no "let down" aids). We required, therefore, a considerable number of reliable pilots to cope with this task of testing the production aeroplanes, and soon after the outbreak of war we arranged that some RAF and Fleet Air Arm pilots should be seconded to the firm to help with this important work. They would come usually from operational squadrons and we would train them for the job; they would then stay for several months or perhaps a year and then return to squadron duties. A short while ago I made a list of all those I could remember and it came to at least 33 names — and that did not include the Service pilots whom Alex Henshaw had to help him out at Castle Bromwich, which was the largest single source of Spitfires.

These pilots did an excellent job, and I thoroughly enjoyed having them; they brightened up our lives enormously and also taught us a good deal because most of them brought valuable operational experience with them. Also, I like to think that most of them went away the better for their test flying experience at Supermarine; in fact I met one of them again a short while ago, who had done a full operational tour on Spitfires before he came to us, and he said to me, "You know, Jeffrey, I never really learned about flying aeroplanes until I came to Supermarines".

The other major flying task was the experimental and development work. The Spitfire was produced in over 40 distinct operational variants, and performed a whole range of military rôles which were never envisaged in the original design. Each one of these variants had to be thoroughly tested before being committed to production, to establish its performance, to check its flight handling, its systems, its functioning and safety.

The scope of development can perhaps best be illustrated by comparing the Spitfire Mk I of 1938 with the last of the line of fighter development, the Seafire Mk 47 of 1947. In all-up weight, the Seafire 47 was equivalent to the Mk I with 32 airline passengers aboard! It had 2½ times the power (thanks to the massive efforts of Rolls-Royce), was 100 mph (161 km/h) faster, had three times the range, double the rate of climb and fired double the weight of projectiles from its fixed armament, as well as carrying secondary armament in the form of bombs and rockets. The large number of intermediate stages which led to this remarkable augmentation of the aircraft's



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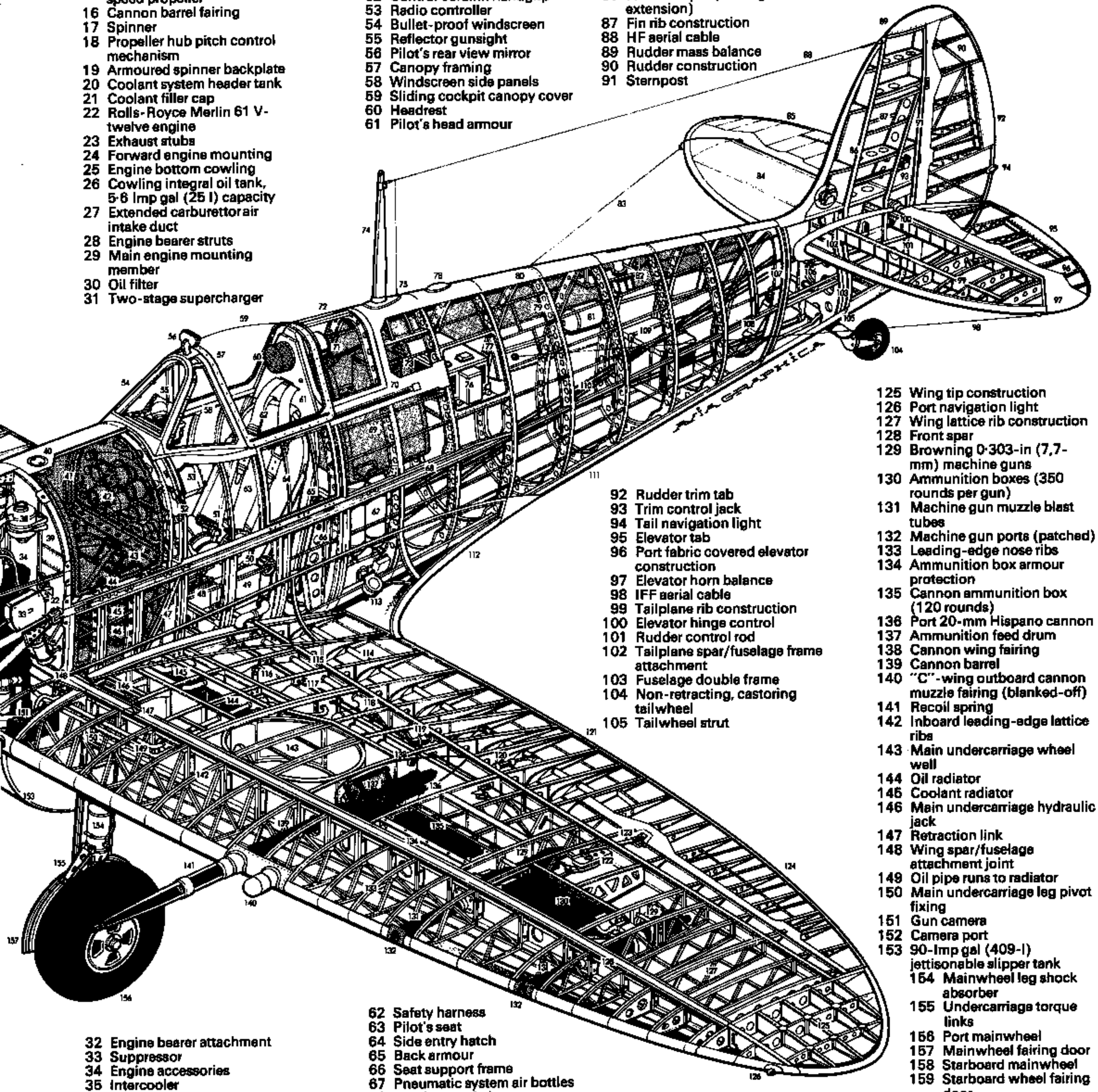
capability involved a process of progressive redesign and modification and, of course, the incorporation of the successively more powerful engines, Merlins and Griffons from Rolls-Royce, with the development of propellers to absorb the power. Some while ago I said, in a lecture to the Royal Aeronautical Society, that almost every

Supermarine Spitfire IX Cutaway Drawing Key

1 Starboard wingtip
2 Navigation light
3 Starboard aileron
4 Browning 0·303-in (7,7-mm) machine guns
5 Machine gun ports (patched)
6 Ammunition boxes (350 rounds per gun)
7 Aileron control rod
8 Bellcrank hinge control
9 Starboard split trailing edge flap
10 Aileron control cables
11 Cannon ammunition box (120 rounds)
12 Starboard 20-mm Hispano cannon
13 Ammunition feed drum
14 Cannon barrel
15 Rotol four-bladed constant speed propeller
16 Cannon barrel fairing
17 Spinner
18 Propeller hub pitch control mechanism
19 Armoured spinner backplate
20 Coolant system header tank
21 Coolant filler cap
22 Rolls-Royce Merlin 61 V-twelve engine
23 Exhaust stubs
24 Forward engine mounting
25 Engine bottom cowling
26 Cowling integral oil tank, 5·6 Imp gal (25 l) capacity
27 Extended carburettor air intake duct
28 Engine bearer struts
29 Main engine mounting member
30 Oil filter
31 Two-stage supercharger
32 Engine bearer attachment
33 Suppressor
34 Engine accessories
35 Intercooler
36 Compressor air intake scoop
37 Hydraulic reservoir
38 Hydraulic system filter
39 Armoured firewall/fuel tank bulkhead
40 Fuel filler cap
41 Top main fuel tank, 48 Imp gal (218 l) capacity
42 Back of instrument panel
43 Compass mounting
44 Fuel tank/longeron attachment fitting
45 Bottom main fuel tank, 37 Imp gal (168 l) capacity
46 Rudder pedal bar
47 Sloping fuel tank bulkhead
48 Fuel cock control
49 Chart case
50 Trim control handwheel
51 Engine throttle and propeller controls
52 Control column handgrip
53 Radio controller
54 Bullet-proof windscreen
55 Reflector gunsight
56 Pilot's rear view mirror
57 Canopy framing
58 Windscreen side panels
59 Sliding cockpit canopy cover
60 Headrest
61 Pilot's head armour
62 Safety harness
63 Pilot's seat
64 Side entry hatch
65 Back armour
66 Seat support frame
67 Pneumatic system air bottles
68 Fuselage main longeron
69 Auxiliary fuel tank, 29 Imp gal (132 l) capacity, used in conjunction with very long range slipper tank
70 Sliding canopy rail
71 Voltage regulator
72 Cockpit aft glazing
73 IFF radio equipment
74 HF aerial mast
75 Aerial cable lead-in
76 Radio transmitter/receiver
77 Radio compartment access hatch
78 Upper identification light
79 Rear fuselage frame construction
80 Fuselage skin plating
81 Oxygen bottle
82 Signal cartridge launcher
83 IFF aerial
84 Starboard tailplane
85 Starboard elevator
86 Fin front spar (fuselage frame extension)
87 Fin rib construction
88 HF aerial cable
89 Rudder mass balance
90 Rudder construction
91 Sternpost
92 Rudder trim tab
93 Trim control jack
94 Tail navigation light
95 Elevator tab
96 Port fabric covered elevator construction
97 Elevator horn balance
98 IFF aerial cable
99 Tailplane rib construction
100 Elevator hinge control
101 Rudder control rod
102 Tailplane spar/fuselage frame attachment
103 Fuselage double frame
104 Non-retracting, castoring tailwheel
105 Tailwheel strut
106 Rudder control lever
107 Sloping tail assembly joint frame
108 Tailwheel shock absorber strut
109 Battery
110 Tail control cable runs
111 Fuselage bottom longeron
112 Wing root trailing edge fillet
113 Radio and electrical system ground socket
114 Trailing edge flap shroud ribs
115 Rear wing spar
116 Radiator shutter jack
117 Aileron cable runs
118 Gun heater air duct
119 Flap hydraulic jack
120 Flap synchronising jack
121 Port split trailing edge flap
122 Aileron control bellcrank
123 Aileron hinge control rod
124 Port aileron construction
125 Wing tip construction
126 Port navigation light
127 Wing lattice rib construction
128 Front spar
129 Browning 0·303-in (7,7-mm) machine guns
130 Ammunition boxes (350 rounds per gun)
131 Machine gun muzzle blast tubes
132 Machine gun ports (patched)
133 Leading-edge nose ribs
134 Ammunition box armour protection
135 Cannon ammunition box (120 rounds)
136 Port 20-mm Hispano cannon
137 Ammunition feed drum
138 Cannon wing fairing
139 Cannon barrel
140 "C"-wing outboard cannon muzzle fairing (blanked-off)
141 Recoil spring
142 Inboard leading-edge lattice ribs
143 Main undercarriage wheel well
144 Oil radiator
145 Coolant radiator
146 Main undercarriage hydraulic jack
147 Retraction link
148 Wing spar/fuselage attachment joint
149 Oil pipe runs to radiator
150 Main undercarriage leg pivot fixing
151 Gun camera
152 Camera port
153 90-Imp gal (409-l) jettisonable slipper tank
154 Mainwheel leg shock absorber
155 Undercarriage torque links
156 Port mainwheel
157 Mainwheel fairing door
158 Starboard mainwheel
159 Starboard wheel fairing door



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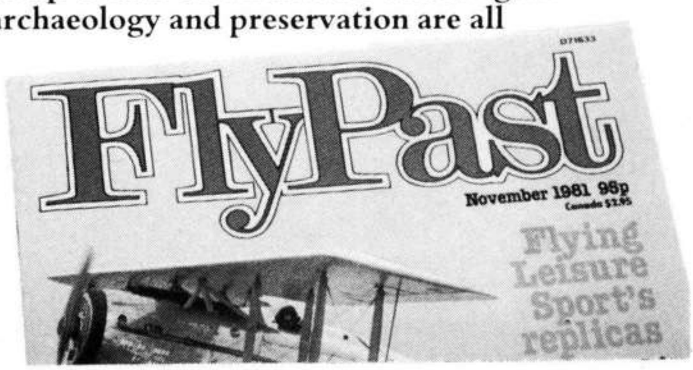

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major design change incorporated during the Spitfire's development life had been in some way deleterious to its handling qualities in the air and as each successive variant came along it had therefore been necessary to take positive steps to restore the standard of handling qualities. I roughly listed the factors which had tended to be damaging to handling qualities as follows:

1. Longer and longer noses (arising from increased engine length).
2. Progressive increases in propeller solidity (blade area).
3. Increased moments of inertia, through increases in, and redistribution of, mass.
4. Extended flight envelopes in speed and height.
5. The carriage of greatly increased loads of fuel and armament both internal and external.

Changes which we introduced to try to maintain good flight handling characteristics had to be such that they caused minimum disruption to the production line and minimum increases in weight. As a result, we had to resort to various aerodynamic "fiddles" and other expedients and on the whole we managed to keep the flight handling characteristics within acceptable limits. Although the later and vastly more powerful and potent marks of Spitfire were not so sweet to fly as the early versions, and not all pilots liked them, their performance and fighting potential, in our view, more than made up for this.

R J Mitchell once wrote, before the war, "In the design of this aircraft the performance has been considered of paramount importance and various sacrifices of other requirements have been made to obtain this object." These words really capture the essence of the philosophy which guided Supermarine after Mitchell's death and during the development of the Spitfire, especially if the word "performance" is given its full interpretation to mean *fighting* performance. We were not trying to produce the most elegant flying machine possible but the most potent fighting machine.

It fell to my lot to concentrate primarily upon the development testing task at our flight development centres, firstly at Worthy Down and latterly at High Post. It was a big and complex task, and without the help and expertise of my colleague pilots it could not have been done. It is invidious perhaps to mention names when so many contributed but those of George Pickering (until his near fatal crash in 1941) and Alex Henshaw (until he took over his mammoth task at Castle Bromwich) stand out in the early days, and later those of Don Robertson, Frank Furlong, George Errington, Pat Shea-Simmonds and Mike Lithgow. Many of the RAF and RN pilots in secondment also played most valuable parts.

In these days of highly sophisticated instrumentation, air data computers, automatic flight control and stability systems, inertial navigation, automatic weapon aiming and telemetry of test data directly from aircraft in the air to sophisticated receiving and analysis systems on the ground, the test flying which we did in the 'thirties and 'forties seems like a totally different world. And so it was.

Nevertheless, the robot test pilot is not yet with us and designers and system engineers still rely heavily upon the judgement, experience and good sense of human test pilots. In my opinion it will always be so. □

Another of the surviving Spitfires, this Mk VB (AB910) is now part of the RAF Battle of Britain Memorial Flight. It was prepared for presentation to the flight by BAC (into which the Supermarine company had been absorbed), and was given Jeffrey Quill's initials as part of code letters representative of No 92 Squadron, which flew Spitfires throughout the war. The author is seen here (centre background) with "his" Spitfire.

REFLECTIONS AT RUNNYMEDE

**Sustaining air, soft moving, sighs through lithic wings;
Column-blinkered light casts shapeless shadow shrouds
Mute as spent flak, sea depth, cold metal,
On convocations past their points of no return.**

**Marble file index of stone white panels,
Number, name, initials clean printed,
As on visiting cards
Proffered from the unknown grave.**

**No cloister this, angular, stark,
Yet cloister-shaped, without spark
Of inward life. Cold stone projects
The passive gaze of butchered ghosts.**

**This muster of names, this directory
Of faceless, formless beings
Suffocates the mind. Is it solely a tabulation,
As on pages of Smiths in Volume S to Z,**

**Or a company of friends, awaiting recognition
Amidst a legion of strangers?
In the quest, shadows emerge; forgotten faces
Relive brief moments of shared experience,**

**Then call upon yet others to be identified.
Now what became of him? And him?
And their names, too, are carved in the marble.
I dare not look for my own. It should be there.**

**Cold, austere, remote, those styles record
The warm blemished humanity of beings
Now labelled and deep frozen in time.
Why am I here, remembering, rather than still amongst them?**

**Our Flight Commander, Banks; quiet Ronnie Frost,
He joined with me; young Naylor lost
In the North Sea. Was he twenty
When he came into my room and cried**

**Like a child the night Geoff Hewitt died
Leaving a pregnant wife?
Three weeks later, I helped to clear his room
And found his Bible by his bed.**

**Butler was his pilot; he's there too.
Pale, quiet, reserved; who else was in that crew?
Is that the Nicholson from OTU
Shot down on his first sortie, over Lorient?**

**And there is Jack, rear gunner, friend,
Married five days after me and wed
Six weeks; then reported 'Missing',
Over Brest. Now, presumed dead.**

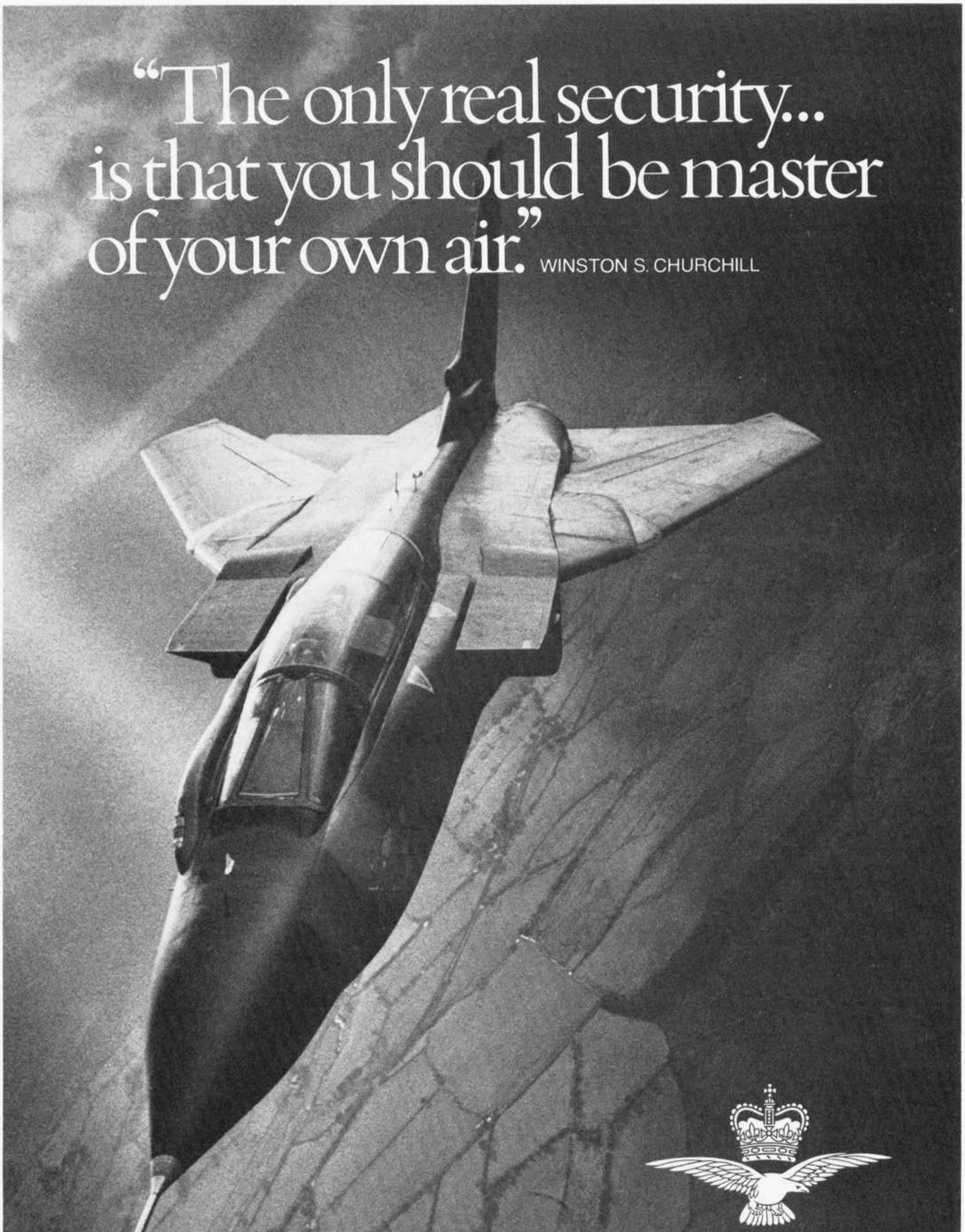
**Why was their promised fruit laid waste,
As blossom is destroyed in the orchard
By bullfinches? Did random chance
Snuff out the Genesis of greatness?**

**Seed and pollen, wantonly expended
In part-payment of debts incurred by others.
Now they are the creditors
Their monuments, promissory notes claiming redemption.**

**When we, who survived, are dead, will others comprehend
The profound meaning behind those inscriptions
Or, like lexicographers studying ancient tablets,
Grope merely for an approximate significance?**

**We lived to secure acceptance of that debt;
To seek some settlement. Perhaps our contribution
Was the creation of children with an understanding
To thrust a mirror of shame before an unrepentant World.**

**R D C
Nos 9, 142, 516 and 167 Squadrons**


"The only real security...
is that you should be master
of your own air." WINSTON S. CHURCHILL

The Tornado comes to Honington

This is the year of the Tornado in the Royal Air Force. The Tornado Weapons Conversion Unit began operations in January and the first operational squadron, No IX, was forming in May — both at RAF Honington in Suffolk. Group Captain Mike Shaw, the Station Commander RAF Honington, and Wing Commander Duncan Griffiths, the Officer Commanding the Tornado Weapons Conversion Unit, have been closely involved with Tornado's introduction into service. Their views of the RAF's newest and most potent warplane are reported here.

"IT IS going to be a success. There is no doubt about that ..." Gp Capt Mike Shaw, the Station Commander, RAF Honington, is unequivocable in his assessment of Tornado.

"People have said that, with Tornado, the Royal Air Force has put all its eggs in one basket. If that is the case, then I would say it has proved to be a very good basket. Already, at this quite early stage of in-service life, the aircraft is doing as well, or better, than anything we have had before.

"Its biggest benefit is accuracy of weapons delivery — particularly in adverse weather or at night. Tornado is dropping bombs on radar (blind delivery) more accurately than previous aircraft have been able to do visually. For the first time we have a genuine all-weather tactical bomber — with a very good self-defence capability.

"There is no doubt that we have to maintain the quality of our aircrews in the future. However, Tornado promises to be an easy aircraft to handle. Whereas previous aircraft have demanded a great deal of crew attention and have been uncomfortable at low level, Tornado is particularly good in turbulent conditions and gives the crew more opportunity to concentrate on weapons delivery.

"In support equipment, the aircraft requires a step change. It is a complicated system and needs an enormous spares back-up. However, it is designed to be 'maintainable' and many repairs can be made simply by replacing 'black boxes'. Also the aircraft has built-in test equipment and diagnosis of faults should be easier because of this 'self-test' facility," says Gp Capt Shaw, adding that "We have put some pretty high quality people into the Tornado training system because we have to give this aircraft the best possible start to its service life".

Wg Cdr Duncan Griffiths is the Officer Commanding the Tornado Weapons Conversion Unit. Explaining the encouraging development of an entirely new training programme, he says: "In the beginning a Tornado Course Design Team, comprising aircrew from TWCU, was formed. It was difficult to write a course specification without having flown the aircraft and knowing that Tornado would have capabilities which were new to us. Members of the course design team visited operational conversion units to get a 'feel', and had a close look at United States Air Force F-111 training, which particularly incorporates 'terrain following'. Our basic course was designed around the Buccaneer, but incorporates the best aspects of other operational conversion units and training organisations. In addition, account was taken of Tornado's considerable ability to defend itself.

"In August 1981 our first aircraft arrived and we began training instructors and validating the course. As part of this validation, new crews who were to be instructors flew actual syllabus sorties to ensure that everything was logical and workable. Our first formal course, beginning in January 1982, was for another four instructor crews. Once fully manned, we will have 19 pilots and 15 navigators as instructors and 22 aeroplanes. The first course to produce crews for the first operational Tornado squadron — including the squadron commander and some of his executives — was beginning in February 1982 and towards the end of 1982 we shall be training crews for the second operational squadron.

"When they have completed the basic aircraft conversion course at

(Heading photo) The first Tornado arriving at Honington in July 1981. (Below) It was flown by Sqn Ldr Symonds, accompanied by AVM Michael Knight, AOC No 1 Group, seen left and right, respectively, with Gp Capt Mike Shaw, the station commander.

(Left) Honington is the first RAF base in the UK to have "hardened" aircraft shelters of the type already in use in RAF Germany. Twelve shelters will be built at Honington for the Tornadoes, as well as personnel shelters, squadron HQ, combat operation centres and aviation fuel tanks and pipelines to permit aircraft to be refuelled, re-armed and serviced under protective cover. In this photograph, a Tornado is seen in an HAS, together with the first example of the "W" type weapons loader produced by Portsmouth Aviation Ltd, with a lift capacity of 2,600 lb (1 180 kg). (Right) Tornado ZA544 arrives at Honington.

the Tri-National Tornado Training Establishment, RAF Tornado crews come to the TWCU to learn the weapons and operational aspects of handling the aeroplane. Our prime purpose is to introduce them to the weapons and their application and to further develop their navigational and operational delivery techniques with a particular bias towards the way in which the RAF operates.

"The course itself follows on from the basic 40-hours conversion course at TTTE, RAF Cottesmore. Although, in the light of experience, there might still be modification to the course, the programme at present is to give pilots 32 hours flying and navigators $29\frac{1}{2}$. Of this, some 17 hours for pilots and 15 for navigators are dual with instructors and $14\frac{1}{2}$ flown as a student crew. Student crews are paired when they first arrive at Honington. After initial familiarisation sorties, students cover laydown and loft bombing techniques and conventional attack (strafe) before a mid-course progress check. This is followed by tactical defence, terrain following and night flying and finally an operational phase, comprising tactical formation, formation simulated attack profiles and low-level evasion.

"We are also running a Tornado Weapons Instructor course — taking experienced pilots and giving them advanced flying and ground schooling. The RAF Tornado Standards Unit is also part of the TWCU. This unit ensures that standards and procedures are maintained throughout the RAF and that the content of courses is monitored and is satisfactory.

"During the early stages of Tornado flying, auto-pilot operation in conjunction with terrain following is performed at 1,000 ft (305 m). As operating experience is gained, speeds will be increased and we will operate at lower altitudes. That will, of course, take time. We shall be taking a 'softly, softly' approach."

After working up, the first Tornado squadron should be fully operational early in 1983. Honington itself will then represent the face of the Royal Air Force of the future — equipped with Tornadoes operating from hardened shelters — and forming the backbone of the Royal Air Force well into the next century. □

More Wrenderings by Wren

Today's combat aircraft, like the Tornado, cost over ten million pounds each and to train a pilot up to front-line combat standard takes around three years and more than a million pounds.

The Royal Air Force, which is short of pilots, is scheduled to receive 385 Tornadoes. When a fighter pilot heard this, he commented "Good! Two each!"

* * *

Scene: ***Frankfurt Airport, 1960.***
Air Traffic Control to BEA Viscount captain who appears to be uncertain where to taxy after landing: "Have you not been here before?"
Captain: ***"Yes, in 1943, but I didn't stop!"***

"I fixed it with a hairclip."

THE FRIENDLY SERVICE
An airman failed to salute an officer. "I'm sorry, sir," he said, "I didn't see you."
"That's quite all right," the officer replied. "For a moment, I thought you were mad at me."

* * *

NATCHERLEY ATCHERLEY
The late Air Marshal Sir Richard Atcherley, nick-named "Batchy" because of his pre-war flying escapades, was a "character" who exercised discipline in his own way. When an airman once greeted him with "Good morning, sir," he stopped the transgressor and said "All I want from you, my lad, is a salute, not a weather report."

THE RAF'S YEAR - 1981

(Above) Buccaneers from No 16 Squadron were among the RAF aircraft taking part in Exercise "Red Flag 81/2" in Nevada in January 1981. (Below) No 208 Squadron provided Buccaneers for the joint "Maple Flag 7" exercise at Cold Lake in Canada in April 1981.

January

1: RAF New Year's Honours: Air Chief Marshal Sir Rex Roe (Air Member for Supply and Organisation) appointed Knight Grand Cross of the Order of the Bath; Air Marshal David Craig (Vice Chief of the Air Staff) and Air Marshal John Curtiss (Air Officer Commanding No 18 Group) knighted.
5: John Nott MP appointed Secretary of State for Defence.
8: Bomb incident at RAF Uxbridge. Terrorist incendiary device neutralised by two alert RAF men and an MOD policeman.
12-16: Exercise *Mallet Blow* 81/1 tests RAF Jaguar, Buccaneer and Harrier pilots in offensive support techniques.
17: Exercise *Red Flag* 81/2 begins at Nellis AFB, Nevada; RAF Germany Jaguars fly ultra low-level offensive support missions in this major six-week USAF exercise.
29: Formal opening of the Tri-National Tornado Training Establishment at RAF Cottesmore, with the Chiefs of the Air Staff of the RAF, German AF and Italian AF, and the C-in-C Fleet, German Navy, present.

February

1: First standard of No 22 Squadron laid up at a special service in Dover, Kent.
2: Senior RAF appointments: Air Chief Marshal Sir Peter Terry becomes Deputy C-in-C Allied Forces Central Europe; Air Marshal Sir Thomas Kennedy becomes C-in-C RAF Germany and Air Marshal Peter Bairsto becomes Deputy C-in-C RAF Strike Command.
5: Fortieth anniversary of the formation of the Air Training Corps.
Last Whirlwind SAR flight at RAF Valley as SAR Training Unit prepares to convert to Wessex.
12: Commendations awarded to Uxbridge bomb heroes by AOC-in-C RAF Support Command.
17: 500,000th Vulcan-force flying hour achieved by No 230 OCU aircraft from RAF Scampton, captained by Sqn Ldr Ian Prior.

March

12: Air Marshal Alec Morris appointed Chief Engineer of the RAF.
18: Red Arrows begin Middle East tour with displays in Saudi Arabia, United Arab Emirates, Bahrain and Jordan — followed by announcement from the Prime Minister of a potential sale of up to 35 Hawks to United Arab Emirates.
24: Queen's Commendation for Valuable Service in the Air awarded to Flt Lt Thomas McDonald, an RAF flying instructor who saved his Jet Provost in particularly difficult conditions after a complete loss of power.

(Above) The Boeing Chinook HC Mk 1 entered service with No 18 Squadron at RAF Odiham in May 1981. (Below) A Nimrod MR Mk 2 of No 42 Squadron shares the apron at Gibraltar with a US Navy P-3 during Exercise "Springtrain" in April.

April

3: HRH Princess Alice presents Diamond Jubilee Sword of the RAF to Wg Cdr P A Field for "outstanding services to the RAF Benevolent Fund".
7: Senior RAF appointments: Air Chief Marshal Sir John Gingell becomes Deputy C-in-C Allied Forces Central Europe in succession to Air Chief Marshal Sir Peter Terry, who becomes Deputy Supreme Allied Commander Europe from 9 April.
7-14: NATO maritime exercise *Springtrain* takes place in Gibraltar.
8: Commendations awarded to Corporal Tim Thorpe and SAC Dave Hill who saved 49 passengers from a crashed school bus in Cyprus.
13-15: Exercise *Priory* 1-81 provides an important and realistic test of Britain's air defences, with aircraft of the RAF and seven other air forces involved.
14: Gallantry awards for No 202 Squadron Sea King crew who rescued 22 survivors from a blazing chemical cargo ship in extremely difficult conditions. Helicopter captain Flt Lt Mike Lakey receives the George Medal, radar/winch operator Flt Lt Thomas Campbell the Air Force Cross, winchman Sgt Rick Bragg the Air Force Medal, co-pilot Flt Lt David Simpson the QCVSA and medical officer Sqn Ldr Hamish Grant, the Queen's Commendation for Brave Conduct.
27: Air Marshal Michael Beavis becomes AOC-in-C RAF Support Command.
Exercise *Maple Flag* 7 begins at CFB Cold Lake, Canada. Eight Buccaneers of No 208 Squadron, RAF Honington, take part in the

(Above) The third prototype Tornado F Mk 2, in which testing of the Marconi Avionics Foxhunter radar began in June. (Below left) Gp Capt Mick Simmons, station commander RAF Cottesmore (right) and Oberst Helmut Ochsenkuhn, senior German officer at the TTTE, congratulate each other on notching up the 1,000th flying hour on the Tornado.

20-day exercise which provides realistic offensive support training in a combat environment.

May

1: Fiftieth anniversary of the office of Provost Marshal (RAF).
5: First RAF Chinook ground school begins at No 240 OCU, RAF Odiham.
5-8: Exercise *OSEX* 3 tests RAF offensive support aircrews and army forward air controllers.
10: Annual commemorative service at the Commonwealth Air Forces Memorial, Runnymede.
11-22: First 1981 RAF Germany Harrier field deployment with aircraft from RAF Gütersloh operating near Lippstadt.
19: Flying begins on first Chinook conversion course at No 240 OCU, RAF Odiham.
20-7 June: NATO exercise *Ardent Ground* takes place in Portugal.
25: Thirtieth anniversary of entry into service of the Canberra.

June

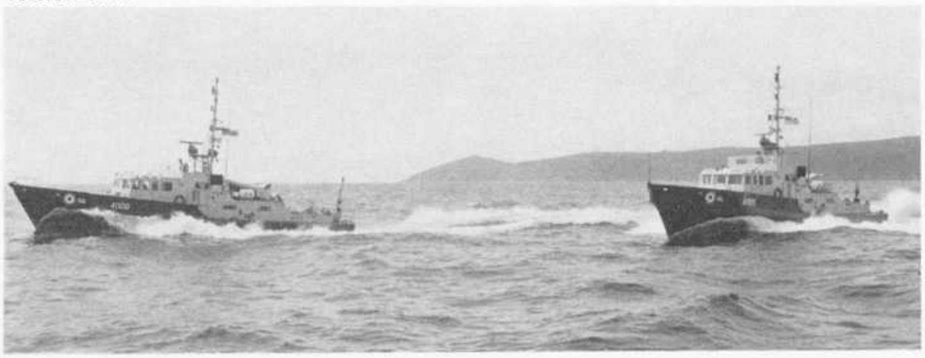
1-12: RAF teams win three trophies in *Volante Rodeo* 81, the USAF Military Airlift Command tactical airlift competition at Fort Bragg, North Carolina, USA.
12: Centralisation of RAF Canberra force at RAF Wyton announced. Nos 7 and 100 Sqns to amalgamate, No 360 Sqn and No 231 OCU to be reduced in size.
13: Air Marshals Michael Beavis and Peter Bairsto Knighted in Queen's Birthday Honours.
In a speech at the RAFA conference in Brighton, CAS announces that interceptions of Soviet aircraft in the UK Air Defence Region have risen to nearly six a week in the last year, and reveals the operational rôle which the Red Arrows would assume in a war situation.
Flypast of RAF Vulcans, Jaguars and Phantoms over Buckingham Palace marks the Queen's official birthday.
15-18: Strike Command Tactical Bombing and Navigation Competition at RAF Lossiemouth.
17: First flight of advanced Foxhunter air defence radar system in Tornado F Mk 2.
23-25: NATO Exercise *Cloudy Chorus* 81/2 tests RAF offensive support aircrews and the aircrews of other NATO nations in the Central Region.
HRH Princess Margaret visits RAF St Mawgan.
30: Formation of first all-RAF Tornado unit begins with arrival at RAF Honington of the first aircraft of the Tornado Weapons Conversion Unit.

July

1: 100th Phantom Major service completed at RAF St Athan.
4: Air Marshal John Rogers becomes Air Member for Supply and Organisation.
6-8: RAF Vulcans compete with USAF B-52s to take top honours in Strike Command's annual bombing contest *Double Top* 81.
8: HRH The Duke of Gloucester visits RAF Wyton.
9: Two new high-speed launches — HMAFV's *Lancaster* and *Wellington* — join the RAF marine branch.
17: Red Arrows participate in Humber Bridge opening ceremony.
19: No 84 Sqn standard laid up in a ceremony at the Abbey Church, Beaulieu.
20-23: Exercise *Priory* 2-81, another major air defence exercise in the regular series.
24: The Queen, accompanied by Prince Philip, visits RAF Cranwell for the first Royal Review of the RAF College.
25: Silver jubilee of the entry into RAF service of the Vulcan bomber.
29: Red Arrows salute Royal wedding day with special "Prince of Wales Feathers" formation over Caernarvon Castle.

August

3: A "stretched" Hercules C Mk 3 of No 70 Sqn leaves RAF Lyneham to rescue British residents and holidaymakers stranded in the Gambia following an attempted coup. Operating from Dakar, Senegal, the RAF crew under the command of Sqn Ldr Rod Caffady evacuates approximately 200 refugees from Banjul airport during the next week.
4: A posthumous George Medal is awarded to Master Air Loadmaster David Bullock, a



(Above) Seen at speed off RAF Mount Batten, Plymouth, are HMAFVs Lancaster *and* Wellington, *latest of the RAF Marine Branch's high-speed launches used for rescue and target towing. (Below) A No 14 Squadron Jaguar keeps company at RAF Bruggen with an A-7H Corsair II from No 347 Squadron, Hellenic Air Force, during an exchange visit in July 1981.*

(Above) Vulcan B Mk 2s from seven squadrons line up at RAF Scampton during celebrations to mark the aircraft's 25th anniversary on 25 July 1981. Thereafter the Vulcan force began to wind down rapidly; disposals included XH554 (below right) to the RAF Fire Fighting School at Catterick.

No 202 Sqn helicopter winchman who gave his life while attempting to rescue a USAF pilot from the sea.

4-6: *OSEX* 4, a large scale tactical training exercise for RAF, USAF and Royal Danish Air Force aircrews, takes place.

8-18: NATO maritime exercise *Ocean Safari* tests RAF Nimrod crews' anti-submarine warfare capabilities.

11: Queen's Gallantry Medal awarded to Corporal Michael Purvis, an RAF Gibraltar aerial rigger who braved a gale to secure an unstable radio mast which was in imminent danger of plunging down a 1,000-ft slope on to a village below.

15: Prince and Princess of Wales arrive back from honeymoon at RAF Lossiemouth aboard a No 10 Sqn VC10.

16: New Met Office computer complex declared open by Philip Goodhart MP, Under Secretary of State for the Armed Forces.

19: RAF Regiment receives its first Spartan and Scorpion armoured fighting vehicles, which will greatly increase the Regiment's defence capability on front-line airfields.

20: 2,500th SAR sortie by "C" Flight of No 22 Squadron based at RAF Valley flown by a Wessex under the command of Flt Lt Laurence.

24: Anglo-American memorandum of understanding on joint production of AV-8B Harrier II signed. RAF to receive 60 aircraft, to be known as Harrier GR Mk 5s.

26: RAF Belize Harriers and Pumas assist in the arrest of smugglers transporting over £21 million of marijuana through Belizean territorial waters.

31 Air Marshal Ian Pedder appointed Controller, National Air Traffic Services.

September

12-22: NATO exercise *Amber Express* in Denmark is the first overseas deployment of the RAF's Chinook medium lift helicopters. Also involved are Jaguar and Harrier offensive support aircraft, and Puma and Wessex helicopters.

13: Golden Jubilee of the 1931 Schneider Trophy, which was won outright for the RAF by Flight Lieutenant John Boothman. This major pre-war triumph is marked 50 years later with a commemorative air race over the Solent.

12-20: Battle of Britain Week celebrations throughout the nation, with "At-Home" days at Abingdon, St Athan, Finningley and Leuchars, and a commemorative service at Westminster Abbey to mark the 41st anniversary of the decisive air battles over Southern England.

14-25: NATO exercise *Cold Fire* 81 involves the RAF Jaguar force in a major test of its capabilities, both in the UK and on the Continent.

15: Princess Anne presents a new standard to No 24 Sqn, RAF Lyneham.

28-7 October: RAF Nimrod Mk 2 of No 206 Sqn, RAF Kinloss, competes with Australian, New Zealand and Canadian entries for the Fincastle Trophy, an annual anti-submarine warfare competition held this year in Australia.

October

6: RAF Valley awarded RAF Wilkinson Sword of Peace for outstanding efforts in the field of humanitarian activities.

21: 21st anniversary of first hovering flight by P1127, forerunner of the Harrier.

25-31: People's Republic of China Air

Force team visit Britain to observe RAF flying training techniques and fly in RAF training aircraft.

26-28: Exercise *Priory* 3-81 tests the RAF's air defences.

November

9: First Hardened Aircraft Shelter (HAS) for RAF aircraft in the UK completed at RAF Honington.

11: Flt Lt Mike Lakey named as RAF Man of the Year at the annual Man of the Year awards presentation at London's Savoy Hotel.

25: Flt Lt Lakey and his crew honoured by the Shipwrecked Fishermen and Mariners' Society with the Edward and Maisie Lewis Award for outstanding air-sea rescue achievements.

30: Last RAF Whirlwind helicopters on active SAR duties in Great Britain retire from service with "A" Flight, No 22 Sqn at RAF Chivenor.

December

11: Last flight of Dambusters No 617 Squadron made by Wg Cdr John Herbertson in a Vulcan (XL318) over Derwent Reservoir — in the area used in training for the raid of Spring, 1943. No 617 to be reformed as a Tornado Squadron in 1983.

14-18: Operational debut of Tornado GR1 strike aircraft in Exercise *Mallet Blow* over central and eastern England and Border country.

Vulcans flown by No 44 (Rhodesia) Squadron and No 617 (Dambusters) Squadron swept the board in the Strike Command Bombing and Navigation Competition in July 1981. No 44 Squadron crews (below right) won the Blue Steel, Laurence Minot, Bristol Siddeley, Sasoon and Armament Officer's Trophies, while No 617 Squadron crews (below left) won the Camrose, Electronic and General Precision Systems Trophies.

RECORD-SETTING WITH THE RAF

THE STORY OF THE HIGH SPEED FLIGHTS, RELATED BY DEREK JAMES

SPEED — absolute speed — has been described as "the aristocrat of movement". But apart from its nobility, speed in the air and the results of the never-ending search for it have brought many important benefits to mankind, not least the freedom to move about our planet and even outside the earth's gravity into outer space.

Sheer speed was not usually the primary aim of the early aeronauts; flight at any speed was their goal, but once this had been achieved by the Wright brothers and others had followed them into the air in powered aircraft, it was to be expected, because man is by nature a competitor, that there would be competitions for powered aeroplanes. They were not long in coming and in 1909 the world's first organised aeroplane race — for the Gordon Bennet Aviation Cup — took place at Rheims in France. In 1913, at the Monaco Hydro-Aeroplane Meeting, seaplanes became locked in combat in the greatest contest for this type of aircraft, the Schneider Trophy.

Powered flight had been achieved by engineers and sportsmen; thus the pilots in early air races were civilians. Even after World War I, in which aerial combat between opposing military air forces had added a third dimension to war, civilians outnumbered uniformed pilots in air races of the day. This was certainly the case in the Schneider Trophy contests, in which, initially, the competing countries were France, Great Britain and Italy. With the exception of the war years and 1924, these contests were held annually until 1927, then biennially until 1931.

With only one exception, the winning pilots of the first six contests were all civilians, generally flying aircraft provided by the manufacturer and entered by their national aero clubs. But when the seventh contest was being planned in 1923 at Cowes, the cry went up "The Yanks are coming". And come they did, with four aircraft and a team of US Navy pilots and mechanics all of which arrived in Britain a month before the contest to acclimatise themselves and to practice their flying techniques thoroughly over the Solent. So effective were their planning, their aircraft and their flying technique that the USN Lts Rittenhouse and Irvine took first and second places at 177·37 mph (285,5 km/h) and 173·35 mph (279,06 km/h) respectively in their sleek, powerful Curtiss CR-3 biplane floatplanes, leaving Britain's old Supermarine Sea Lion III flying boat, flown by Henri Biard, to come home a poor third — and last — averaging 157·17 mph (253 km/h).

For the 1925 contest at Baltimore, the US team was made up of two US Navy Lieutenants, Cuddihy and Ofstie, plus an Army pilot, Lt James Doolittle. In Britain, the Air Ministry at last began to realise the importance of the Schneider contests and, for the first time, the British effort was meticulously planned and well supported by Air Ministry funds. In the event, Doolittle won the contest in his Curtiss R3C-2 averaging 232·56 mph (374,33 km/h), with Hubert Broad — the last civilian pilot to fly in the contests — taking second place in the Gloster IIIA at 199·17 mph (320,58 km/h). Britain's participation had cost nearly £50,000, including £16,000 for two Gloster floatplanes.

The following year, in Norfolk, Virginia, all six competing aircraft were flown by Service pilots, three from the USA and three from Italy, among the latter being Maj Mario de Bernardi who won the contest at 246·496 mph (396,70 km/h) in his scarlet Macchi M.39 monoplane floatplane.

Without doubt, these victories by the United States and Italy showed that success was most likely to stem from an attempt planned as a military operation, with a team of Service pilots and ground crew backed by the manufacturers' specialists. This fundamental truth had been less well appreciated and understood in Britain, with its love of the amateur sportsman and where sporting aviation was controlled by the Royal Aero Club, "an entirely amicable institution conducted by amiable gentlemen who, like the House of Lords in *'Iolanthe'*, do nothing in particular and do it very well", as wrote an aviation journalist of the day. But not all Britons believed in the pitting of amateurs against the professional aviators of other countries, particularly in contests of such renown as the Schneider events. In 1925, Air Vice-Marshal Geoffrey Salmond, then Air Member for Supply and Research, wanted the RAF to mount Britain's next entry in the contest, and there was a large body of opinion among senior people that the contests should be a vital part of the nation's overall aviation endeavour. However, the Chief of the

Air Staff, Air Chief Marshal Sir Hugh Trenchard, while ready to accept the benefits which would accrue from the development of high performance aircraft for the contests, said that neither Service pilots nor aircraft should fly in private races.

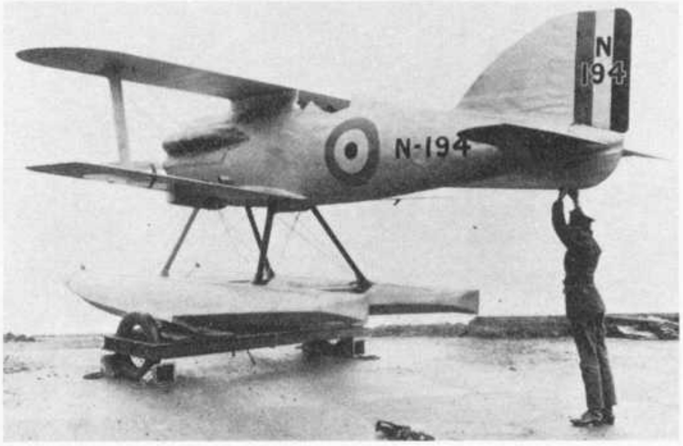
Enter the High Speed Flight

While other nations continued to plan for a 1926 contest, such was the inertia in the Air Ministry and Government as a result of these differences of opinion in the corridors of power, that Britain looked toward full preparations only for the 1927 contest. Almost covertly, the embryo of a Royal Air Force High Speed Flight was formed at the Marine Aircraft Experimental Establishment at Felixstowe on 1 October 1926, with Sqn Ldr Leslie J Slatter as Commanding Officer. Officially the formation of this Flight had no connections with the Schneider Trophy; it was administered by the Air Ministry's Supply and Research Department and was charged with providing a pool of experienced pilots for researching the problems of high-speed flight. But was it pure chance, luck or covert planning that the old Gloster I and III racing floatplanes were made available at Felixstowe for the pilots of this new Flight?

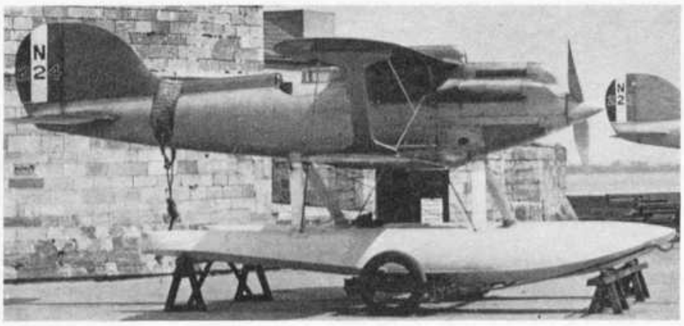
Because the High Speed Flight was based at MAEE, it was anticipated that the pilots would be experienced on seaplanes. However, Flt Lt O E Worsley, the first to be posted in, came from Martlesham Heath. He was also the only full-time pilot of the Flight, but was later joined by Flt Lt Sidney N Webster from MAEE "B" Flight, and Flg Off Harry M Schofield from Martlesham, who had been selected from a number of applicants from RAF squadrons and establishments.

Although all full of enthusiasm for their new rôle, the eager young pilots had to contend with the rigours of an East Coast winter with long periods of bad weather which severely limited their flying. It was not until 13 May 1927 that the High Speed Flight was put on an official basis, coming under the control of Headquarters Coastal Area. With this change came the exciting news of that year's contest in Venice, following the Italian victory in the previous year, and the prospect of flying Britain's new racing floatplanes. These were three Supermarine S.5s, three Gloster IVs and the Short Crusader. The first of these to arrive at Felixstowe, during the third week of April 1927, was the Crusader N226, which was immediately dubbed "Curious Ada" by the Flight's pilots. But their hopes of flying it were short-lived when it was announced that Bert Hinkler, an experienced professional test pilot, would make the preliminary flight trials. This was, perhaps, a wise move as John Lankester-Parker, Short's test pilot, had only taxied the Crusader on the Medway at Rochester. He, too, could have been somewhat disgruntled at not making the first flight of this Bristol Mercury-powered monoplane. Webster was the first pilot of the Flight to fly the Crusader; then Schofield.

During July, the entire Flight moved to Calshot, Worsley having



(Above) One of the two Gloster III floatplanes which were built in 1925, and in 1926 became the first aircraft issued to the RAF High Speed Flight as it prepared for the 1927 Schneider contest. (Below) The Gloster IV and (background) Gloster IVB at Calshot as practice aircraft for the 1929 team.



(Above right) The Gloster IVA N222, with Flt Lt S M Kinkead in the cockpit, at Calshot prior to its despatch to Venice for the 1927 Schneider contest. (Below) The Supermarine S.5 N219 participating in the 1929 contest in the Solent, piloted by Flg Off Richard Atcherley; its sister-ship N220 won the event in 1927, flown by Flt Lt S N Webster.

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Two products of the British aircraft industry that were unsuccessful in their intended rôle as participants in the Schneider contests — (above) the Gloster VI and (below) the Short Bristow Crusader.

been detached there a few weeks earlier to fly the first Supermarine S.5, N219, and soon they were getting a little flying in the Gloster IVA, N222 and IVB, N223, before the contest aircraft were despatched to Italy by sea — the cheapest means — at a cost of £500. In Venice, the British team, under the overall command of Air Vice-Marshal F R Scarlett, was joined by Flt Lt Sam Kinkead, a skilled South African pilot. Then, on 11 September, the Crusader was written off when Schofield, attempting to stop a roll to port on take-off, found that corrective aileron movement increased the rate of roll and the aircraft plunged into the water. When the wreckage was salvaged it was found that the aileron control wires were crossed!

Three scarlet Macchi M.52 monoplanes opposed the two S.5s and the Gloster IVB in the contest — but not for long as, one by one, the Italian aircraft retired with engine or fuel system failures, leaving Webster in S.5 N220 to win at 281·65 mph (453,27 km/h), a world speed record, with Worsley in S.5 N219 close behind averaging 273·07 mph (439,45 km/h). Kinkead's Gloster IVB retired when the propeller shaft vibrated so badly that, on inspection back in the hangar, it was found to be cracked. In spite of this sparkling victory, the RAF's High Speed Flight was disbanded soon after, the pilots and ground crews moving to other units and duties. Later the Air Council expressed its opposition to further official participation by Service aircraft and pilots, saying that, apart from the high cost — some £196,000 in 1927 — the publicity given to the event and acclaim to the pilots "was not good for morale". These objections continued to be raised, even when the expected refusal of the Treasury to fund a British entry in the 1929 contest failed to materialise. However, in February 1928, the Air Ministry finally settled to the task of organising Britain's participation to ensure another victory once Government funding was assured.

On 13 December 1928, an Air Council letter to the AOC Coastal Area informed him that "The High Speed Flight will form at Felixstowe on 1 February 1929 as part of the Marine Aircraft Experimental Establishment, and will later move to Calshot on an unspecified date". The new team, commanded by Sqn Ldr A H Orlebar, was named in January; it comprised Flt Lts D D'Arcy Greig and G H Stainforth, Flg Offs R L R Atcherley, H R D Waghorn and with T H Moon as Engineer Officer following his experience with the 1927 Flight. Most of these pilots had no experience of seaplanes and had been chosen principally for their great piloting skill and knowledge of high-speed flight in Service aircraft. Their new racing aircraft were two Napier Lion-powered Gloster VI monoplanes and two Supermarine S.6s, basically bigger versions of the S.5 but powered by the superb new 1,900 hp Rolls-Royce R racing engine. Completing the team was the old S.5, N219 from the 1927 contest.

The contest venue was the Solent, and the Italian opposition comprised two Macchi M.67s and an older M.52R, but the Isotta-Fraschini engines of one M.67 gave trouble and the cooling system of the second M.67 failed, causing both aircraft to retire, leaving Waghorn in S.6 N247 to romp home first at 328·629 mph (528,84 km/h). Dal Molin's M.52R was second, averaging 284·2 mph (459,38 km/h) and D'Arcy Greig's S.5 came third at 282·11 mph (454 km/h). Atcherley in S.6 N248 lost his goggles in the slipstream and, when he crouched down in the cockpit for protection, his outside vision was impaired and he turned inside a pylon and was disqualified.

With two consecutive British victories, the 1931 contest was critical to the future of the Schneider Trophy series, for any country scoring three victories in five consecutive contests would retain permanent possession of the Trophy. Prime Minister Ramsay McDonald, speaking at a celebratory dinner after the 1929 contest, said "We are going to do our level best to win again". But almost immediately the Chief of the Air Staff, MRAF Sir Hugh Trenchard, repeated his opposition of earlier years, writing "I can see nothing of value in it" adding that high-speed machines would be developed "as and when necessary for research purposes" and that the expense was out of all proportion to the results obtained. On 25 September,

The first of the three Supermarine S.6s built in 1929 is manhandled down the slipway to be launched at Calshot, with Flt Lt H R D Waghorn in the cockpit. In this aircraft, N247, he won the 1929 Schneider contest.

the Cabinet agreed not to enter an RAF team in the 1931 contest, leaving private enterprise to provide the money for this venture and to plan, organise and run the event. Throughout the following year arguments continued for and against official support for participation, and it was not until 19 January 1931, after Lady Lucy Houston, widow of a wealthy ship-owner, had promised to give £100,000 to back Britain's entry, that the Government was prepared to allow the RAF to defend ownership of the Trophy.

The final Schneider

Once again the High Speed Flight was reformed, with Orlebar as Commanding Officer and Stainforth as senior pilot. They were joined by newcomers Flt Lts F W Long and E J L Hope; then, later, Fg Off L S Snaith, Lt R L Brinton, RN, plus Flt Lt W F Day as Engineer Officer. When Stainforth moved on, Flt Lt J N Boothman replaced him in the Flight. Because of the delays in settling whether Britain would participate or not, only nine months were left in which to develop new aircraft and engines; so Rolls-Royce undertook to increase the R engine's power to 2,300 hp while R J Mitchell at Supermarine was limited to refining the S.6's design to use this extra power. The result of this combined effort was the S.6B.

Italy went all out to develop an entirely new aircraft, the Macchi-Castoldi MC.72, and France worked desperately hard to produce an entrant, but both countries withdrew from the contest when their attempts failed to produce a viable contender in time. This left Britain having only to fly over the course to win the contest and the Trophy for all time. The honour of making this epic flight fell to Flt Lt John Boothman who, in S.6B S1595, averaged 340·08 mph (547,30 km/h).

Apart from competing in and winning three of the Schneider Trophy contests, the High Speed Flight pilots also set a number of world speed records. On 10 September 1929, Flt Lt Stainforth averaged 336·3 mph (541,22 km/h) in the Gloster IVB — which was eclipsed a few hours later by Sqn Ldr Orlebar in an S.6 flying at 355·8 mph (572,60 km/h). Two days later he increased this to 357·7 mph (575,66 km/h). After the 1931 contest on 29 September, Stainforth pushed the record up to 408·6 mph (657,58 km/h) in the S.6B S1595.

The post-war effort

With these great victories and achievements to its credit the High Speed Flight finally was disbanded in 1932. It was not to be reformed for competitive flying until after World War II*, when flight development of the Gloster Meteor and its Derwent engines was indicating that this war-proven twin-jet fighter was faster than any other aircraft then flying. Thus, in July 1945, Gloster Aircraft Co and Rolls-Royce approached the Ministry of Aircraft Production and received its consent and promise of collaboration for an attempt on the World Air Speed Record. A High Speed Committee was formed, with representatives of all three organisations, and Gp Capt H J Wilson was appointed Commanding Officer of a Special Attachment Flight of the Empire Test Pilots' School specially detailed for the attempt. Eric Greenwood, Gloster's Chief Test Pilot, whose enthusiasm was to spur on the whole operation, was the other nominated pilot while Flt Lt Clark was detailed to fly the Meteor during timing equipment trials. Sqn Ldr Walters was Engineer Officer with Flt Lt Everson as Administrative Officer.

**In 1938, the Air Ministry, through the Director of Technical Development Air Cdre R H Verney, agreed to sponsor development of a specially modified Spitfire for an attempt on the World's Air Speed Record. The attempt was to have been made by an RAF pilot from the RAE Farnborough, Sqn Ldr H "Bruin" Purvis, but the Spitfire was not in the event developed to a sufficient standard for an attempt to be made before the war brought a halt to all such activity.*

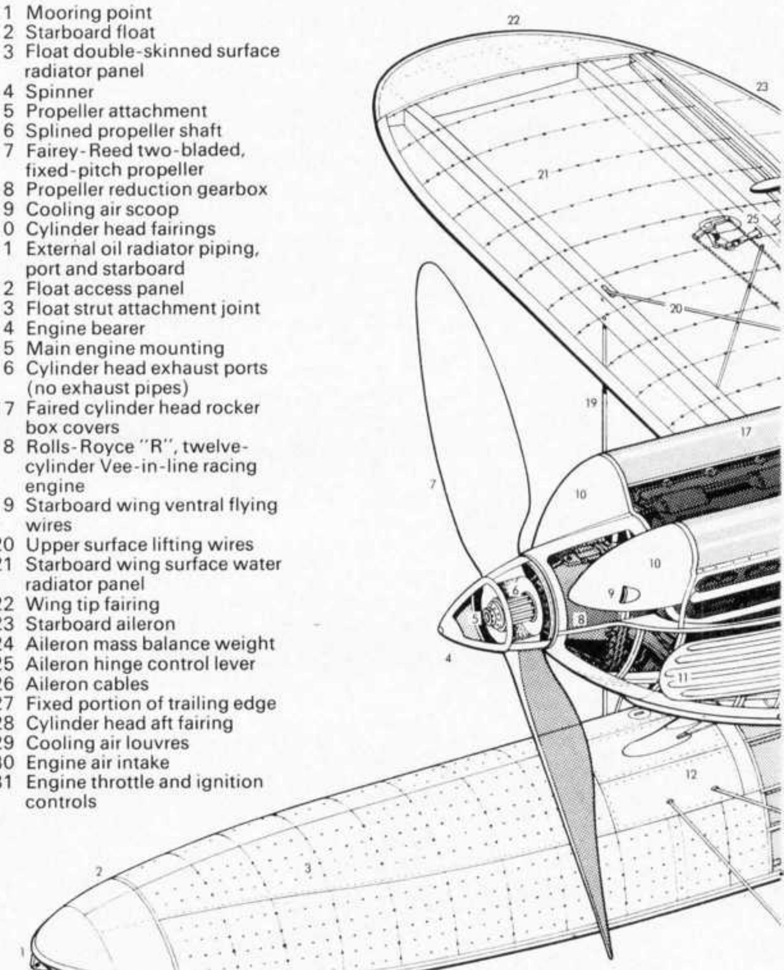
Flt Lt F W Long, who joined the High Speed Flight early in 1931, is carried ashore after making a flight in the Supermarine S.6B S1595 — outright winner of the Schneider Trophy for Britain in September that year, flown by Flt Lt John Boothman.

Although the attempt — which was made over a 3-km course at Herne Bay, Kent — was delayed until 7 November, by which time the weather was not wholly ideal, Gp Capt Wilson established a new record of 606·262 mph (966,71 km/h) in a Derwent-powered Meteor IV EE454; Eric Greenwood achieved 603·125 mph (961,60 km/h) in a second Meteor, EE455. Soon afterwards the Flight returned to ETPS with Wilson moving to the MAP as Assistant Director of Special Projects — which title cloaked his task of developing military jet aircraft.

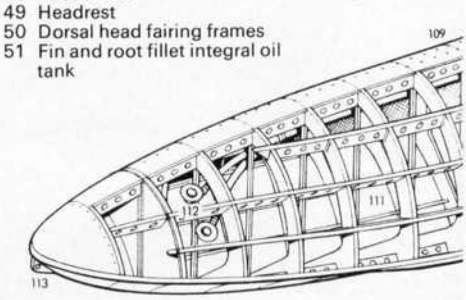
By the spring of 1946 the RAF was showing unmistakable signs of wanting to push the record higher and out of reach of the United States, which was casting covetous eyes upon it. Happily the Air Ministry, Ministry of Supply and the C-in-C Fighter Command, all realised the commercial need to promote Britain's prestige in the air. In July 1946 the High Speed Flight was reformed at Tangmere to

Supermarine S.6B Cutaway Drawing Key

1 Mooring point
2 Starboard float
3 Float double-skinned surface radiator panel
4 Spinner
5 Propeller attachment
6 Splined propeller shaft
7 Fairey-Reed two-bladed, fixed-pitch propeller
8 Propeller reduction gearbox
9 Cooling air scoop
10 Cylinder head fairings
11 External oil radiator piping, port and starboard
12 Float access panel
13 Float strut attachment joint
14 Engine bearer
15 Main engine mounting
16 Cylinder head exhaust ports (no exhaust pipes)
17 Faired cylinder head rocker box covers
18 Rolls-Royce "R", twelve-cylinder Vee-in-line racing engine
19 Starboard wing ventral flying wires
20 Upper surface lifting wires
21 Starboard wing surface water radiator panel
22 Wing tip fairing
23 Starboard aileron
24 Aileron mass balance weight
25 Aileron hinge control lever
26 Aileron cables
27 Fixed portion of trailing edge
28 Cylinder head aft fairing
29 Cooling air louvres
30 Engine air intake
31 Engine throttle and ignition controls

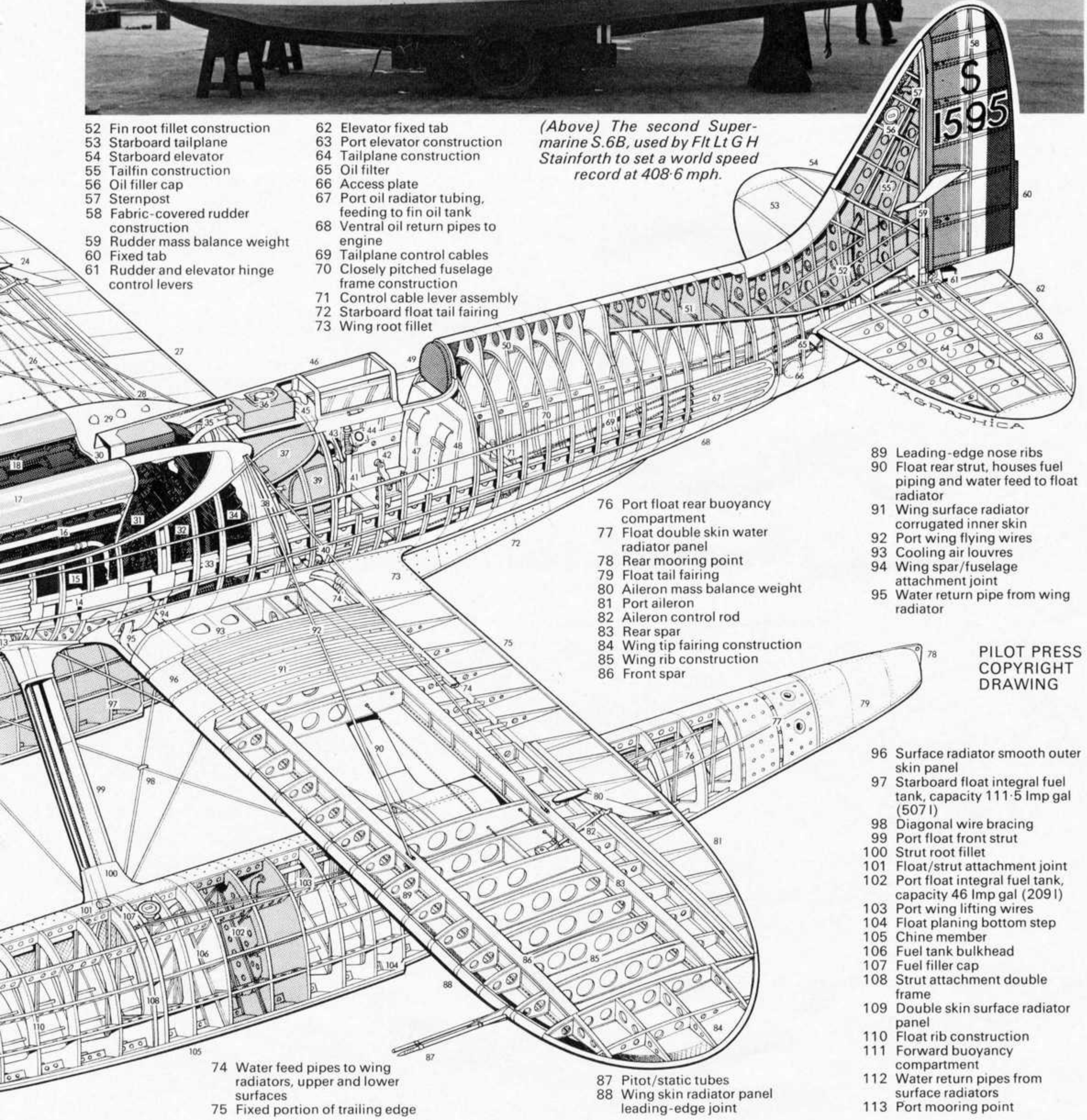


32 Supercharger
33 Fuselage main longeron
34 Engine supercharger intake ducting
35 Cooling water return pipes from engine
36 Water filler cap
37 Water system header tank
38 Engine compartment sloping bulkhead
39 Fuel system header tank
40 Rudder pedals
41 Control column
42 Engine throttle lever
43 Instrument panel
44 Ignition switches
45 Water system overboard vent pipe, starboard side
46 Forward hinged cockpit canopy cover
47 Safety harness
48 Pilot's seat
49 Headrest
50 Dorsal head fairing frames
51 Fin and root fillet integral oil tank



(Above) The second Supermarine S.6B, used by Flt Lt G H Stainforth to set a world speed record at 408·6 mph.

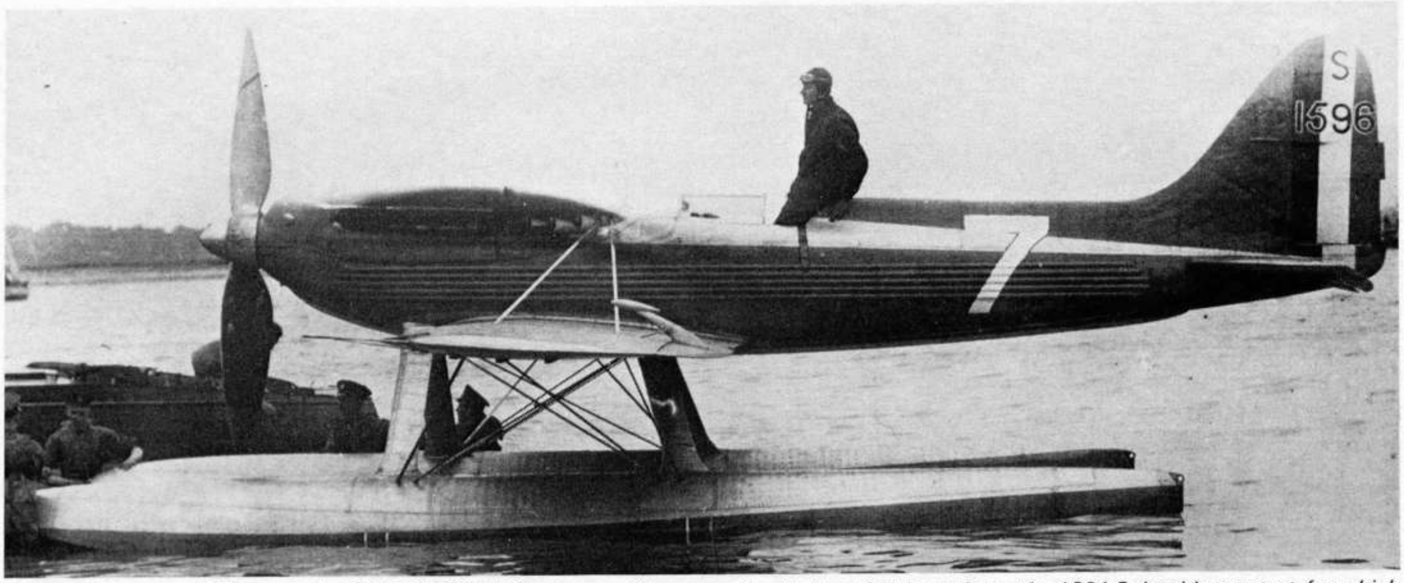
52 Fin root fillet construction
53 Starboard tailplane
54 Starboard elevator
55 Tailfin construction
56 Oil filler cap
57 Sternpost
58 Fabric-covered rudder construction
59 Rudder mass balance weight
60 Fixed tab
61 Rudder and elevator hinge control levers
62 Elevator fixed tab
63 Port elevator construction
64 Tailplane construction
65 Oil filter
66 Access plate
67 Port oil radiator tubing, feeding to fin oil tank
68 Ventral oil return pipes to engine
69 Tailplane control cables
70 Closely pitched fuselage frame construction
71 Control cable lever assembly
72 Starboard float tail fairing
73 Wing root fillet



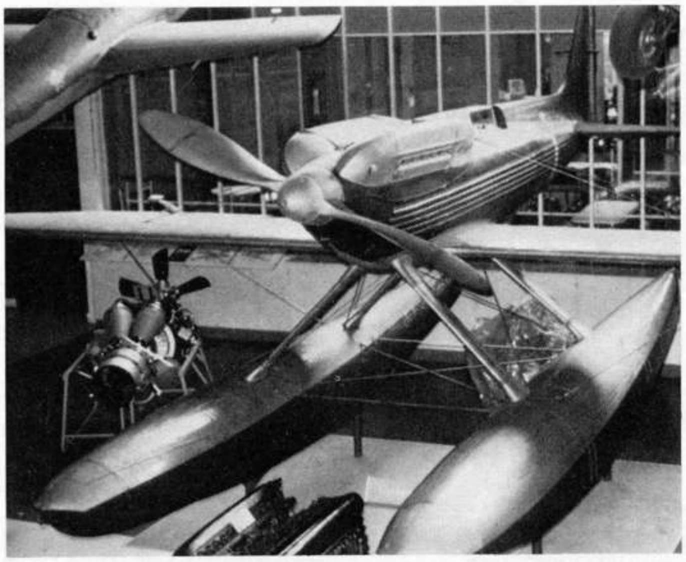
74 Water feed pipes to wing radiators, upper and lower surfaces
75 Fixed portion of trailing edge
76 Port float rear buoyancy compartment
77 Float double skin water radiator panel
78 Rear mooring point
79 Float tail fairing
80 Aileron mass balance weight
81 Port aileron
82 Aileron control rod
83 Rear spar
84 Wing tip fairing construction
85 Wing rib construction
86 Front spar
87 Pitot/static tubes
88 Wing skin radiator panel leading-edge joint
89 Leading-edge nose ribs
90 Float rear strut, houses fuel piping and water feed to float radiator
91 Wing surface radiator corrugated inner skin
92 Port wing flying wires
93 Cooling air louvres
94 Wing spar/fuselage attachment joint
95 Water return pipe from wing radiator

PILOT PRESS COPYRIGHT DRAWING

96 Surface radiator smooth outer skin panel
97 Starboard float integral fuel tank, capacity 111·5 Imp gal (507 l)
98 Diagonal wire bracing
99 Port float front strut
100 Strut root fillet
101 Float/strut attachment joint
102 Port float integral fuel tank, capacity 46 Imp gal (209 l)
103 Port wing lifting wires
104 Float planing bottom step
105 Chine member
106 Fuel tank bulkhead
107 Fuel filler cap
108 Strut attachment double frame
109 Double skin surface radiator panel
110 Float rib construction
111 Forward buoyancy compartment
112 Water return pipes from surface radiators
113 Port mooring point



(Above) The second Supermarine S.6B, S1596, being prepared for a practice flight at Calshot prior to the 1931 Schneider contest, for which purpose it bore the contest number "7". In the event, this aircraft was not required to participate, the contest being won by its sister ship S1595.



establish a new record. It was led by Gp Capt E M Donaldson, who moved from HQ Fighter Command to announce his intention of raising the record to 621 mph, or 1 000 km/h, at least. Two other pilots joined the Flight; Sqn Ldrs W A Waterton from the Central Fighter Establishment at West Raynham and Neville Duke, who was a member of ETPS at Farnborough. Chief Technical Officer was Wg Cdr McGregor, with Sqn Ldr Porter as Engineer Officer.

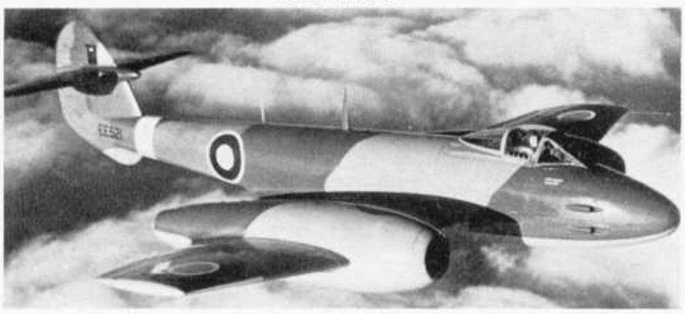
Using standard line-production Meteor IVs with cleaned-up fuselages and which had had their Derwent engines "tweaked" to deliver some 4,300 lb (1 950 kg) of thrust — about 30 per cent above normal — the High Speed Flight had to overcome many technical problems involved in flying very fast at low altitude over water. Yet again the weather took a hand, with long periods of gale-force winds and very low temperatures. Donaldson had calculated that for every one degree Centigrade below the normal ambient temperature of 30 degrees, the effect was to reduce by 1 mph (1,6 km/h) the maximum flying speed attainable for a given Mach number.

At Muroc Dry Lake in the USA, weather conditions in August were perfect; there, in the early days of September, a Thunderjet clocked 608 mph (978,48 km/h); however, it did not exceed the Meteor's 606 mph (966,7 km/h) record by the FAI-required 5 mph (8 km/h)

(Above) The winning aircraft in the 1931 contest, Supermarine S.6B S1595 is now a permanent exhibit in the Aeronautical Galleries of the Science Museum, London. The other S.6B is displayed in the Mitchell Memorial Hall, Southampton. (Below) This full-size replica of the S.6B S1595 can be seen at the Thorpe Park leisure centre at Chertsey, Surrey.

(Above) The all-yellow Meteor IV EE455 which was flown by Eric Greenwood during the record-making flights in 1945, alongside the camouflaged EE454 (shown in the heading illustration on page 48) used by Gp Capt H J Wilson. (Below) The late Eric Greenwood (left) and Gp Capt Wilson in front of the Meteor EE454 "Britannia".

(Below) For the final record-setting efforts by the RAF High Speed Flights in 1946, three standard short-span Meteor IVs were used, as shown here.



and so could not be claimed as a record. This news did nothing to ease the tension at Tangmere, where the Flight waited in vain for an improvement in the low temperature conditions which were the worst in 60 years! Eventually, on 7 November, a break was forecast and at 6 pm Donaldson set out to make the most of it. He returned an average speed of 616 mph (991,36 km/h) during four runs over the 3-km course off Littlehampton; Waterton, who made his attempt 30 minutes later, averaged 614 mph (988,14 km/h).

That was the limit to which the High Speed Flight pilots could push the Meteor in the prevailing conditions. In smooth air at 30 deg C instead of the turbulent 10-15 deg C they experienced, Donaldson and Waterton would without doubt have achieved the magic 621 mph (1 000 km/h) they so keenly sought. This then is an all-too-brief record of some of the great achievements of men of the Royal Air Force who, with courage and using their great skill, both in the air and on the ground, put the creations of British aero-engineering genius to the ultimate test — that never ending search for the Pimpernel-like "aristocrat of movement": speed. □

More Wrenderings — by Wren

ADJUTANT'S LAMENT

"What's the good of putting up notices? Some 60 per cent of the chaps don't read them, 30 per cent read but don't understand them, and 10 per cent read and understand them and then ignore them."

* * *

"It's no good taking short cuts, Corporal — this job's needed in a hurry!"

"I suppose you chaps make a packet out of overtime work at these shows?"

EIRE BORN

RAF Air Traffic Control to Irish aircraft entering Control Zone: "What is your position, height and course?"
"Sure now, Oi'm sittin' up at the front, Oi'm foive foot six and Oi've just finished me prunes and custard."

* * *

THE GOOD OLD BAD OLD DAYS

In the very early days of military flying, around 1913, a bad crash was caused by the inept piloting of an officer who turned out to be the son of a General. The enquiry board, anxious to avoid trouble, recorded their opinion that "the accident came about because there was a lack of lift in the air that day".

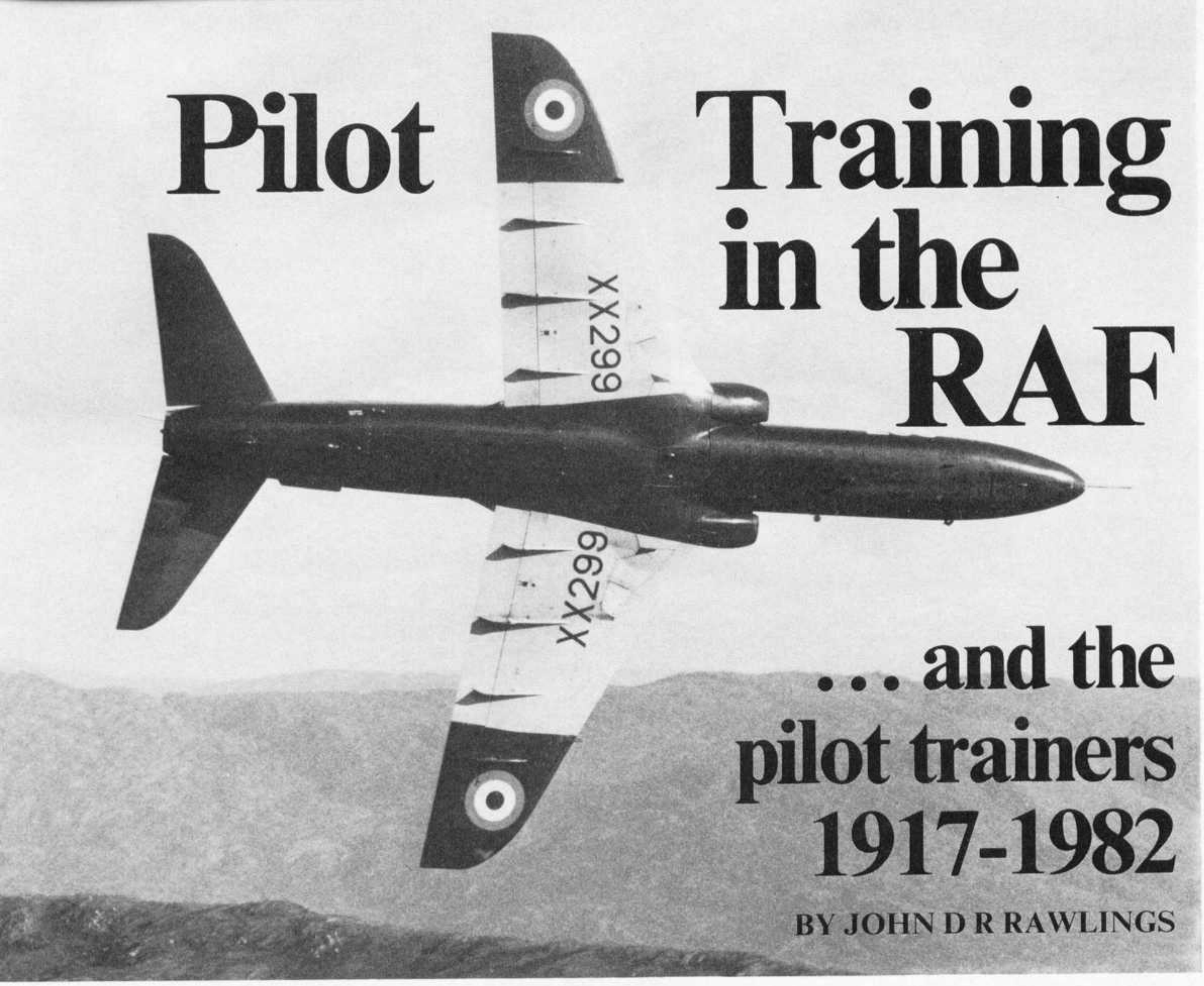
* * *

From a Royal Flying Corps Summary of Accidents, December, 1916: "During this month, sixteen B.E.2s and nine Farman Shorthorns have had complete engine failures, a marked improvement on the November figures. Accidents during the last three months cost £317.10.6, sufficient to buy new gaiters and spurs for every pilot and observer in the Service."

Pilot Training in the RAF

... and the pilot trainers 1917-1982

BY JOHN D R RAWLINGS



"THIRTY-THREE, downwind to roll." The call comes from the Jet Provost T Mk 5A as it trundles eastwards at 1,000 ft above the Lincolnshire fields. "33 clear to finals Number 3" comes the reply from Cranwell tower. Shoulder to shoulder with his student pilot in the JP's compact cockpit, the instructor identifies the two aircraft ahead — one coming over the threshold of the runway, the other descending on its final turn in — and keeps up his patter in a relaxed monotone: "let your airspeed begin to decay, check airbrakes in, select undercarriage down, flaps to take-off, re-trim, check brakes, watch that heading, it should be 090 [as the student lets the JP veer to port], check harness and now look to see where the runway is". It is time to begin the turn in; the patter continues and as the aircraft begins to skid outwards and speed drops off too fast, the instructor adds "bring the bank up to 30 degrees and lower your nose to get the speed back to a steady 115 knots" in the same monotone. In due course the pupil makes his first landing and rolls out to go round again . . . and again, and again.

The pattern goes on, five days a week, week after week, at all the RAF flying training airfields, part of what is widely regarded as one of the finest systems of flying training in the world. No other nation can better it, and indeed many air forces have patterned their training methods on those of the Royal Air Force. It all dates back to an officer named Smith-Barry who, in 1917, began the School of Special Flying at Gosport. Appalled at the ineptitude of the pilots sent out to No 60 Squadron, which he had been commanding on the Western Front, he had sent a barrage of letters back to England, protesting but also making constructive suggestions as to how the training of pilots could be re-organised. The commander of the Training Division in England had known Smith-Barry when they were both at the Central Flying School, and arranged for him to be brought back to England to take charge of a flying school where he could try out his new ideas.

These ideas were exactly contrary to what had been common practice until then. Previous instruction, which had had such bad results, had largely been in the hands of bored pilots returned from the Western Front and consisted, in principle, of teaching the pupils what to avoid in flying so that they always flew safely and nowhere near the limits of the aircraft. Smith-Barry's idea was to put the pupil deliberately into unfamiliar situations and then talk him out of them so that he could handle his aircraft logically and sensibly in any attitude or situation that he might encounter. As a first step, Smith-Barry scrapped the collection of unsuitable aircraft then in vogue for training and standardised on just one type which he considered suitable, the Avro 504J. This classic biplane had the advantage that its performance was well on the way to that of operational aeroplanes, and its controls and engine would thus teach the pupils what to expect in the aircraft to which they were likely to graduate. It was an "easy aircraft to fly but a difficult one to fly well", and this characteristic was to become a standard point of reference for all future pilot training aircraft in the RAF.

On the early aircraft used for training, it was customary for the instructor and pupil to communicate by the wave of a hand with pre-determined signals, or by rocking the control column from side to side. This pleased Smith-Barry not one whit and, until suitable modifications could be made to the Avro 504Js, he instituted a method whereby, if the instructor wanted to say anything to the pupil, he would stall the aircraft and give his patter in the few moments of silence which followed. It was a technique that may well have enabled the instructor to assess whether his pupil had the strong nerves necessary for operational flying, but obviously also had its shortcomings. As a longer term solution to this problem, Smith-Barry rigged up a rubber tube with mouthpieces in both cockpits and attached to earpieces on the helmets; this was the "Gosport Tube", still in use in RAF instructional aircraft (Tiger Moths) up to 1950. When the first batch of pupils trained at the SSF at Gosport were examined by official inspection they were found to be of such a higher standard than any pupils trained elsewhere that, despite earlier misgivings, the School of Special Flying's methods were adopted by the Central Flying School and a syllabus drawn up for the standardised training of all Royal Air Force (as the RFC had by now become) pupils, based on Smith-Barry's principles.

The first real pilot trainer in use in the Royal Air Force was thus the legendary Avro 504J and its immediate derivative, the 504K, which differed in having the front fuselage modified to take a variety of engines in place of the Gnome Monosoupape of the 504J. By the time the Armistice came there were no fewer than 2,267 Avro 504s on the establishments of the RAF's flying training schools.

After the War had ended, and when Trenchard was fighting to retain the separate identity of the RAF, he concentrated his policies on achieving excellence in everything. Training to the highest standard was to be part of this philosophy, with the Avro 504K continuing to serve as the mainstay, equipping the five Flying Training Schools into the late nineteen-twenties. In order to keep flying costs down, special efforts were made to ensure that pilots, when they arrived on their operational squadrons, did not waste precious squadron hours converting to their operational type. Consequently, the Flying Training Schools (FTSs) were issued with a few D.H.9As, Bristol Fighters and Vickers Vimys to provide conversion courses before their pilots moved out of the training orbit.

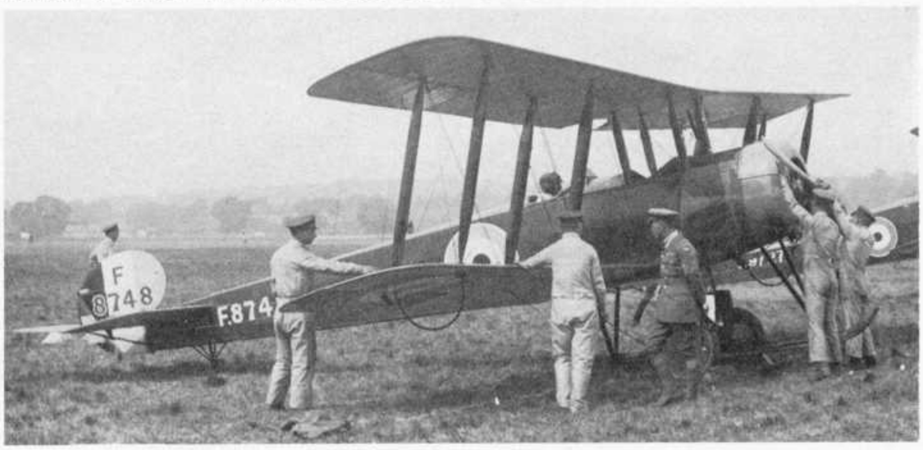
In the mid-'twenties the Royal Air Force was modestly re-equipping with new types of aircraft, at least to the extent that the Treasury would permit, but the training fields inevitably came a poor second in the race for new aircraft; efforts were therefore made to improve the Avro 504. The basic modification was to replace the rotary engine with a standard radial, for which purpose the Armstrong Siddeley Lynx was found to be ideal; with it went an overall clean-up, at first with tapering ailerons for a quicker rate of roll, but subsequently replaced by rectangular Frise-type ailerons, and a new undercarriage to eliminate the narrow track and single skid so typical of all the previous 504s. The resulting aircraft, designated Avro 504N, went into production and service in 1927, and this venerable but resuscitated trainer went on teaching RAF pilots to fly into the mid-'thirties.

Towards the end of the 'twenties, two other types came into service as trainers, to cater for the advanced portion of the FTS course and to replace the D.H.9As and "Brisfits" (Bristol Fighters), which were getting decidedly long in the tooth. First of these new types was a two-seat conversion of the Armstrong Whitworth Siskin III single-seat fighter, known as the Siskin IIIDC (dual control). This was followed in the early 'thirties by another Armstrong Whitworth conversion from an operational type, the Atlas Trainer, adapted from the Army Co-operation version by fitting a dual-control, forward-facing rear cockpit. No fewer than 175 of these aircraft were built for the RAF, serving with several of the Flying Training Schools as well as the Central Flying School.

Coincidentally with the introduction and production of the Atlas Trainer and the Avro 504N, the Air Ministry was looking towards their eventual replacement, and at the end of the decade small batches of suitable training aircraft were ordered for service with the Royal Air Force. The first of these was the de Havilland Gipsy Moth, an aircraft that had already acquired a great reputation, and many sales, in the flying clubs and light air taxi firms, and was being exported (and copied) overseas in great numbers. Examples of both the original Cirrus Moth and the Genet Moth had already appeared in RAF markings for use at the CFS in the second half of the 'twenties, more as specialist aircraft than as serious trainers, but when a metal version of the Moth appeared the Service showed greater interest and in 1929 more than 120 were ordered. They provided a core of elementary training aircraft at the RAF College, the CFS and No 5 FTS at Sealand, the CFS using them for formation and inverted aerobatic exhibitions at the Hendon Displays of 1930 and 1931.

In the search for a long-term replacement for the Avro 504N, small batches were ordered of two competitive types: the Avro Trainer, of which 22 were brought into service, and the Hawker Tomtit, of which 25 were acquired. Both types were fitted with the 150 hp Armstrong Siddeley Mongoose engine. The Tomtit also featured Handley Page automatic slots for the first time on an RAF trainer and — another innovation — a blind-flying hood on the rear cockpit. Hitherto, pilots had shown little inclination to fly in other than what is known today as VMC (Visual Meteorological Conditions) — well clear of clouds, and preferably in daylight or clear moonlight. The advent of the Turn and Bank Indicator had shown, however, that pilots who obeyed the directions of this instrument, rather than their own "seat of the pants" instinct, could fly quite successfully in conditions of zero visibility.

In furtherance of this development, one of the CFS instructors, Flt Lt W E P Johnson, was seconded to the Farman company in France, where they were teaching "blind" flying; that is, flying completely on instruments without the aid of any visual reference outside the cockpit. So successful was this technique that when Johnson came back to CFS a new "E" Flight was formed and equipped with Avro 504Ns modified to have a folding hood over the rear cockpit. Johnson soon demonstrated to the Air Ministry that he could fly a complete circuit from take-off to landing without sight of the ground, and the technique became from then on an integral part of RAF pilot training. It was into this revolution that the Hawker



(Above) Avro 504K trainers in service with the RAF immediately after the end of the Great War. (Below) The ultimate development of the famous Avro biplane, the 504N — this example being in service with the Cambridge University Air Squadron in 1928.

(Above) Avro 504N, Oxford University Air Squadron, mid-thirties. (Below) De Havilland Tiger Moth in typical World War II finish.

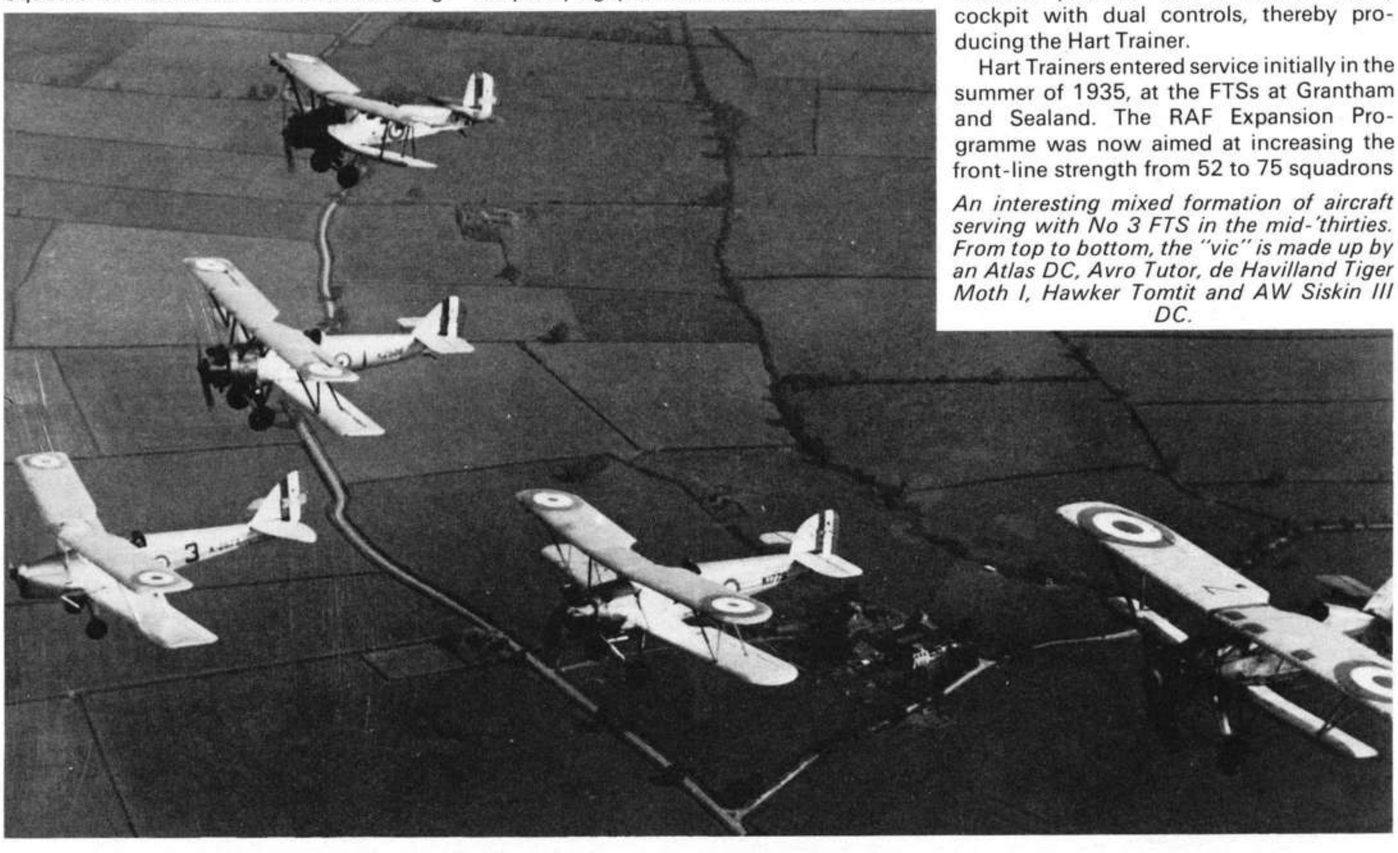
(Above) Hawker Tomtit, with blind-flying hood on rear cockpit. (Left) Avro Tutor, successor for the Avro 504N. (Below) Blackburn B2, impressed civilian aircraft for the E&RFTS.

Tomtit came, with Reid & Sigrist blind flying panels in both cockpits and a folding hood cover over the rear cockpit. Also at the turn of the decade, the Bristol Bulldog TM (training machine) came into service to replace the Siskin IIIDC.

To provide the RAF with a successor to the Avro 504N, it was finally decided to go into full production with a development of the Avro Trainer, but re-engined with the Armstrong Siddeley Lynx rather than the uncowled Mongoose; with a Townend ring, a new fin and rudder and low-pressure tyres, the resultant aircraft was named the Avro Tutor. This became the standard basic trainer at all the FTSs and in the University Air Squadrons. These latter had come into being during the late 'twenties, using operational types such as the Bristol Fighter, but with a high proportion of trainers on strength. From the Tutor was developed the first specific seaplane trainer for the RAF, the Sea Tutor, 14 of which were built for service with the Seaplane Training Squadron at Calshot from the end of 1934 onwards.

The Gipsy Moth had earned a good reputation in RAF service, but was considered too docile an aircraft to make a good trainer. De Havilland produced a successor in 1931 named the Tiger Moth, developed from the Moth Major, which had an inverted Gipsy engine giving a better forward view, and staggered and swept-back wings giving crisper flying qualities. A batch of 35 of these trainers was built as Tiger Moth Is for the RAF. A re-engined version with the more powerful 130 hp Gipsy Major engine appeared in 1934, also having squared off wing-tips for a higher rate of roll; 50 of these being ordered to replace the remaining Gipsy Moths and arriving on the scene as expansion began within the RAF. Meanwhile, adoption of the Hawker Hart two-seat day bomber and its variants was causing problems in the training pipeline because it was too big a step up from the then-standard Atlas "advanced" trainer. The Hawker company thereupon took an Audax airframe (the Army Co-operation version of the Hart), removed all the armament and replaced the observer position with a forward-facing cockpit with dual controls, thereby producing the Hart Trainer.

Hart Trainers entered service initially in the summer of 1935, at the FTSs at Grantham and Sealand. The RAF Expansion Programme was now aimed at increasing the front-line strength from 52 to 75 squadrons



An interesting mixed formation of aircraft serving with No 3 FTS in the mid-'thirties. From top to bottom, the "vic" is made up by an Atlas DC, Avro Tutor, de Havilland Tiger Moth I, Hawker Tomtit and AW Siskin III DC.

(Above) There is a long tradition of RAF aerobatic teams mounted on training aircraft flown by instructors from the Central Flying School — as exemplified by this trio of Avro Tutors. (Below right) Siskin III DC dual control trainers of the RAF College in the early 'thirties, with a couple of the standard single-seaters (second and third in line).

immediately, and to 128 squadrons in five years. In consequence, the Hart T (as it became known) was fully in service with ten FTSs within 18 months of its introduction, and eventually no fewer than 507 were built (by Vickers and Armstrong Whitworth, as well as Hawker).

This great expansion also brought about a radical change in the methods of operation in what was now Training Command. Instead of providing all-through training, the Flying Training Schools were now allocated the task of advanced training only. In July 1936, the same month that Training Command was established, the new RAF Volunteer Reserve had been formed to train a vast pool of part-time airmen who would be brought up to "wings" standard in their spare time. To train them, new Flying Training Schools were set up all over the country, most, if not all, being run by civilian organisations under contract. As most of the VR part-timers would be flying only at weekends, the new schools were given the task of teaching the elementary stage of flying training to the regular pilots of the RAF during the week. So were born the Elementary & Reserve Flying Training Schools (E&RFTS) and within three years no fewer than 44 such schools had been formed across the UK. To equip them, the Hart T was maintained in full production, and the Tiger Moth II was ordered in great quantity to become the most famous of all British elementary trainers. One or two E&RFTSs used other types such as Blackburn's B-2 at Brough and Hanworth and Avro's Cadet at Hamble.

It will not have escaped the reader's notice that, in the mid-'thirties and with war only four years away, the pilots of the RAF were still being trained on World War One configuration biplanes, although monoplanes were now being developed for all the operational rôles. The Air Ministry therefore issued, in 1936, three specifications for an elementary trainer, an advanced trainer and a twin-engined trainer, all to be monoplanes, and the latter two to incorporate retractable undercarriages. The outcome of the ensuing

(Below) Miles Magister I, the RAF's first monoplane primary trainer.

(Below) North American Harvard II of No 2 FTS.

(Below) Miles Master II, with practice bombs for weapons training.

(Above) The training version of the Hawker Hart served in the 'thirties as the RAF's principal advanced pilot and weapons trainer. This Hart T is from No 7 FTS. (Below left) An Audax of 18 E&RFTS in 1938, in the then-standard colour scheme of yellow with green/brown camouflage on the upper surfaces.

design competitions was to be the production of the Miles Magister I, Miles Master and Airspeed Oxford I and II.

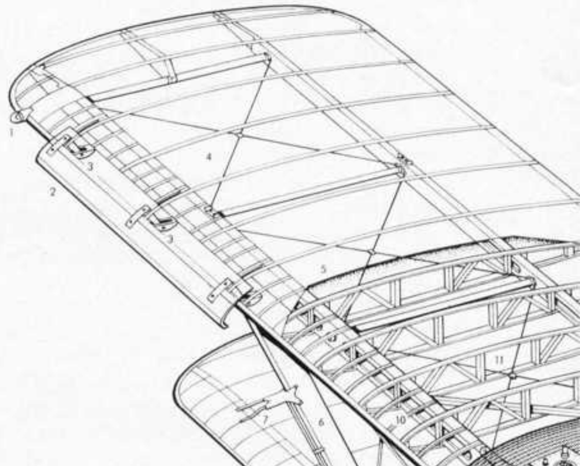
The Magister was typically an example of refinement of a breed and had a fine pedigree through all the variants of Miles Hawk and Hawk Major lightplanes. It was a tandem-seat, open cockpit, low-wing monoplane with spatted undercarriage (the spats being soon discarded in service) and wing flaps, a novelty for an RAF elementary trainer. In fact, some RAF pilots had already received their elementary instruction on forerunners of the Magister at the E&RFTS operated by Phillips and Powis at Woodley. Quantity production was undertaken and eventually 1,293 Magisters were built, the majority of these serving at the Elementary & Reserve Flying Training Schools, sixteen of which were at some time Magister-equipped.

The Miles company had earlier designed as a private venture an advanced trainer around the Rolls-Royce Kestrel engine (which powered the Hart and Fury families of aircraft) and eventually, when no suitable designs appeared to the Air Ministry specifications, the company was requested to submit a much modified version of this trainer. This was eventually ordered but because of the delay in getting it into service an interim advanced trainer had to be acquired from the USA, this being the first American aircraft ordered into quantity production for the RAF. The original intention was to use this American type, a British version of the US Army Air Corps' North American BC-1, as a stop-gap only until the introduction of the Master, but the 400 ordered as Harvard Is, which began their service in December 1938 at Grantham, proved to be the forerunners of an eventual quantity of more than 5,000, the great majority of which came to Britain under lend-lease arrangements.

The first Master Is entered RAF service in May 1939, 900 being produced within the next year or two. Many of the Battle of Britain pilots were therefore trained on the Master I, and its handling similarity to the Hurricane provided an easy transition. The problem was, however, that the Kestrel engine had been out of production for some time, so there was a limit to the number of Master Is that could be produced. The Air Ministry suggested the substitution of the Bristol Mercury radial engine and a prototype in November 1939 was found to be faster than the better streamlined Kestrel version. As the Master II, 1,799 examples of this version were produced, but the supply of Mercury engines could not match the demand and a third version of the Master appeared, the Mk III with Pratt & Whitney Twin Wasp Junior, 602 of these being produced before the Master production came to an end.

The third of the monoplane trainers initiated in 1936 was the Airspeed Oxford. The Airspeed company had been leaders in the field of low-wing monoplanes with retractable undercarriages and a highly suitable configuration already existed in the Envoy twin-engined light airliner. From this general configuration a service trainer was developed, with two Armstrong Siddeley Cheetah engines, retractable undercarriage and flaps. It was originally built in two versions, the Mk I with a dorsal turret, bomb-bay and guns, intended for all aircrew training duties, and the Mk II for pilot training. Although the majority of Oxfords produced were Mk Is, they were pre-

The de Havilland Tiger Moth probably has trained more RAF pilots at the ab initio *stage than any other type. This is a Mk I, lacking the anti-spin strakes added to the tailplane on the Mk II as shown in the cutaway drawing.*



1 Starboard navigation light
2 Automatic leading-edge slat, open
3 Slat hinges
4 Starboard upper wing panel
5 Wing fabric covering
6 Starboard interplane struts

dominantly used for pilot training. The first Oxfords were delivered in November 1937.

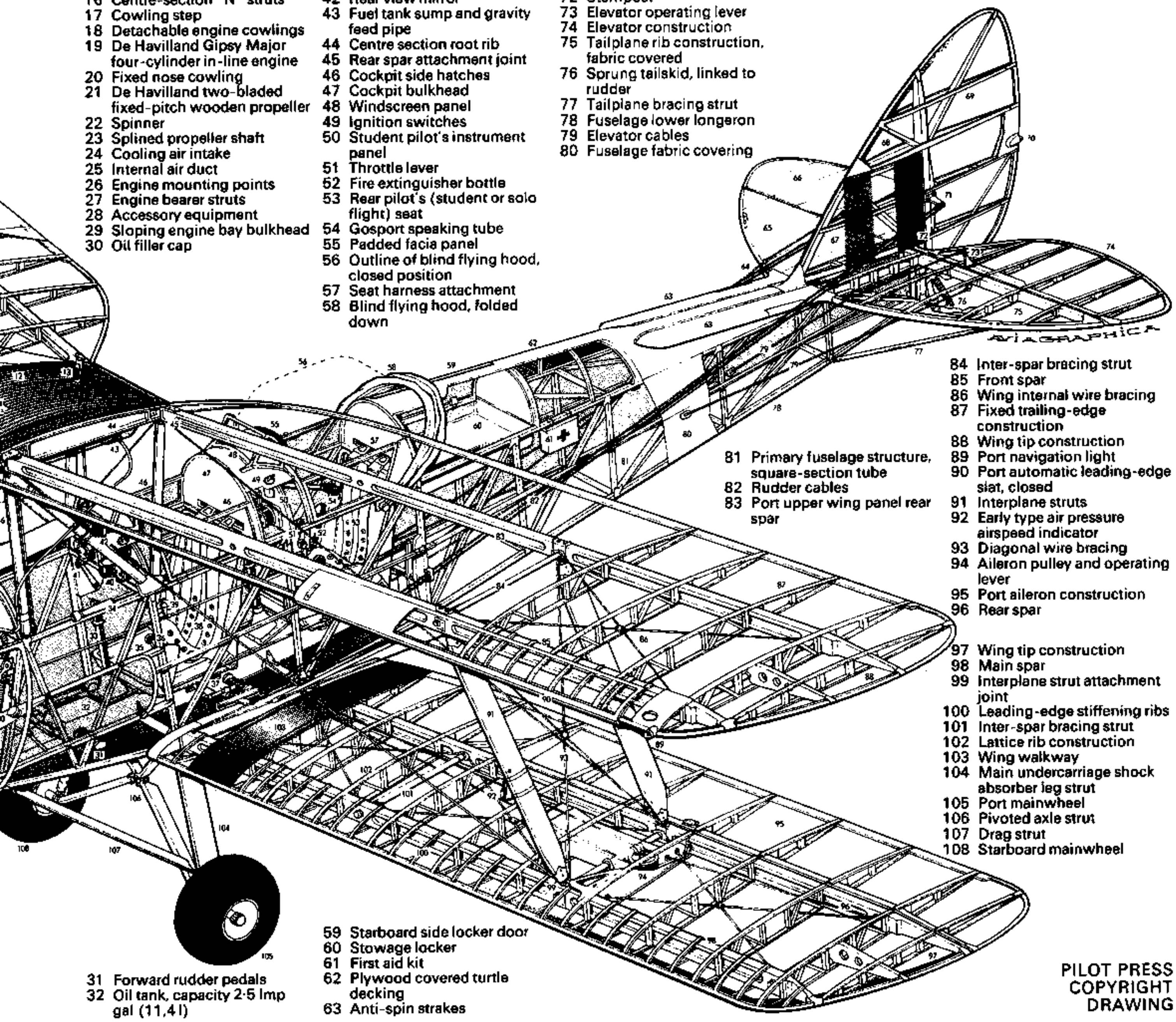
Within months of the start of World War II, it had been decided that the skies of Britain would be too crowded and too belligerent for trainee pilots in any but small numbers and a complete transformation of the whole pattern of RAF training began, with the setting up of the Empire Air Training Scheme under the British Commonwealth Air Training Plan Agreement signed in Ottawa on 17 December 1939. Under this scheme, it was agreed that the training of aircrew up to "wings" standard for the total wartime requirements of the RAF and the Dominion Air Forces would be conducted in the skies of Canada, Australia and New Zealand, with Southern Rhodesia and the Union of South Africa later being added.

Very large quantities of aircraft would obviously be required and some degree of standardisation was clearly necessary. For elementary training, the Tiger Moth was selected rather than the Magister, perhaps because the de Havilland company had sister organisations in Canada, Australia, South Africa and New Zealand. Production of the Tiger Moth was initiated in Canada, Australia and New Zealand, and in all 7,149 Tiger Moths were built during the War, 4,200 of them in the United Kingdom. Many of these stayed in this country because, although elementary instruction was slowly reduced as the Empire schools took up the task, the EFTSs in the United Kingdom took over the grading task for the enormous numbers of volunteers pouring into the RAF at home, including the escapees from Occupied Europe. The grading task consisted of approximately 12 hours instruction for each volunteer, in which time he had to show himself sufficiently proficient in flying to be allowed to continue to train as a pilot.

For this task, no fewer than 28 EFTSs remained in being, each with an establishment of about 100 Tiger Moths. The single engined advanced trainer presented more of a problem because the supply of Miles Masters, as already noted, was limited by power plant availability and the production rate from the rather limited resources of the Miles company was not as high as required. The answer was found in the North American Harvard, which was now ordered in very large quantities, amounting to over 5,000 before deliveries ended in 1944. Most of these were of a later version than the original Mk Is, and came into service as the Mks II,

De Havilland D.H.82A Tiger Moth Cutaway Drawing Key

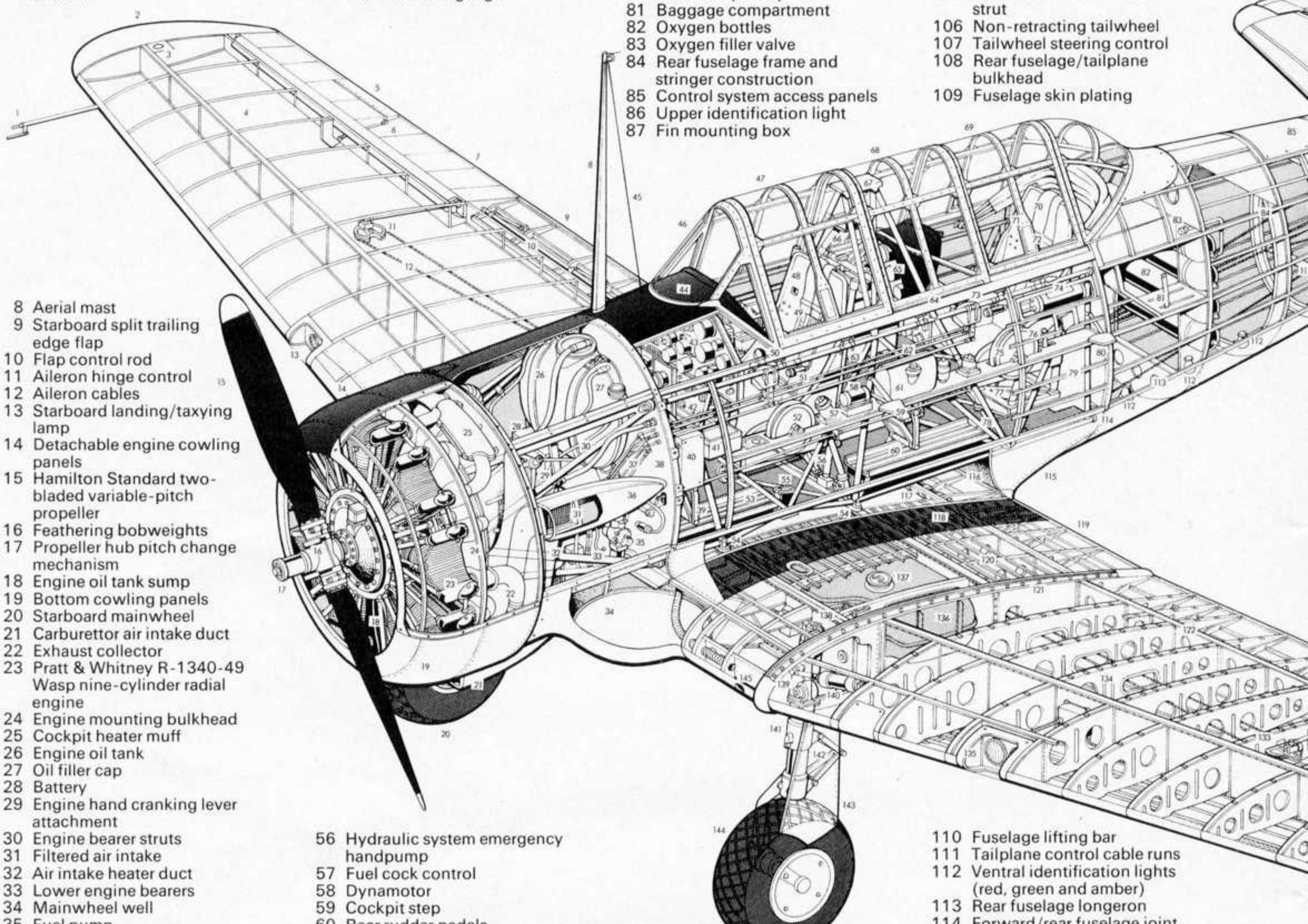
7 Pitot static tubes
8 Starboard lower wing panel
9 Diagonal wire bracing
10 Leading-edge stiffening ribs
11 Lattice rib construction
12 Fuel tank, capacity 22·8 Imp gal (104 l)
13 Fuel contents gauge
14 Filler cap
15 Main spar attachment joint
16 Centre-section "N" struts
17 Cowling step
18 Detachable engine cowlings
19 De Havilland Gipsy Major four-cylinder in-line engine
20 Fixed nose cowling
21 De Havilland two-bladed fixed-pitch wooden propeller
22 Spinner
23 Splined propeller shaft
24 Cooling air intake
25 Internal air duct
26 Engine mounting points
27 Engine bearer struts
28 Accessory equipment
29 Sloping engine bay bulkhead
30 Oil filler cap
31 Forward rudder pedals
32 Oil tank, capacity 2·5 Imp gal (11,4 l)
33 Control column
34 Instrument venturi
35 Front pilot's (instructor's) seat
36 Tailplane trim control lever
37 Rear rudder pedals
38 Seat safety harness
39 Engine throttle lever
40 Instructor's instrument panel
41 Slat locking lever
42 Rear view mirror
43 Fuel tank sump and gravity feed pipe
44 Centre section root rib
45 Rear spar attachment joint
46 Cockpit side hatches
47 Cockpit bulkhead
48 Windscreen panel
49 Ignition switches
50 Student pilot's instrument panel
51 Throttle lever
52 Fire extinguisher bottle
53 Rear pilot's (student or solo flight) seat
54 Gosport speaking tube
55 Padded facia panel
56 Outline of blind flying hood, closed position
57 Seat harness attachment
58 Blind flying hood, folded down
59 Starboard side locker door
60 Stowage locker
61 First aid kit
62 Plywood covered turtle decking
63 Anti-spin strakes
64 Control cable runs
65 Starboard tailplane
66 Starboard fabric-covered elevator
67 Tailfin construction
68 Rudder horn balance
69 Fabric-covered rudder construction
70 Tail navigation light
71 Rudder operating lever
72 Sternpost
73 Elevator operating lever
74 Elevator construction
75 Tailplane rib construction, fabric covered
76 Sprung tailskid, linked to rudder
77 Tailplane bracing strut
78 Fuselage lower longeron
79 Elevator cables
80 Fuselage fabric covering
81 Primary fuselage structure, square-section tube
82 Rudder cables
83 Port upper wing panel rear spar
84 Inter-spar bracing strut
85 Front spar
86 Wing internal wire bracing
87 Fixed trailing-edge construction
88 Wing tip construction
89 Port navigation light
90 Port automatic leading-edge slat, closed
91 Interplane struts
92 Early type air pressure airspeed indicator
93 Diagonal wire bracing
94 Aileron pulley and operating lever
95 Port aileron construction
96 Rear spar
97 Wing tip construction
98 Main spar
99 Interplane strut attachment joint
100 Leading-edge stiffening ribs
101 Inter-spar bracing strut
102 Lattice rib construction
103 Wing walkway
104 Main undercarriage shock absorber leg strut
105 Port mainwheel
106 Pivoted axle strut
107 Drag strut
108 Starboard mainwheel



PILOT PRESS COPYRIGHT DRAWING

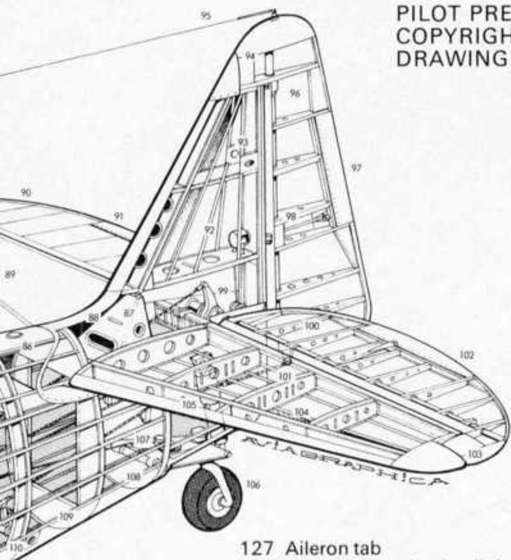
North American Harvard Mk IIB Cutaway Drawing Key

1 Pitot tube
2 Wing tip fairing
3 Starboard navigation lights
4 Starboard outer wing panel
5 Aileron tab
6 Tab control rod
7 Starboard fabric-covered aileron
8 Aerial mast
9 Starboard split trailing edge flap
10 Flap control rod
11 Aileron hinge control
12 Aileron cables
13 Starboard landing/taxying lamp
14 Detachable engine cowling panels
15 Hamilton Standard two-bladed variable-pitch propeller
16 Feathering bobweights
17 Propeller hub pitch change mechanism
18 Engine oil tank sump
19 Bottom cowling panels
20 Starboard mainwheel
21 Carburettor air intake duct
22 Exhaust collector
23 Pratt & Whitney R-1340-49 Wasp nine-cylinder radial engine
24 Engine mounting bulkhead
25 Cockpit heater muff
26 Engine oil tank
27 Oil filler cap
28 Battery
29 Engine hand cranking lever attachment
30 Engine bearer struts
31 Filtered air intake
32 Air intake heater duct
33 Lower engine bearers
34 Mainwheel well
35 Fuel pump
36 Intake fairing
37 Engine control rod runs
38 Fireproof bulkhead
39 Forward rudder pedals
40 Fuse box
41 Generator control unit
42 Electrical control panel
43 Front pilot's instrument panel
44 Instrument panel shroud
45 Aerial cable lead-in
46 Windscreen panels
47 Forward sliding canopy section
48 Front pilot's seat
49 Safety harness
50 Throttle mixture and propeller control levers
51 Cockpit light
52 Tailplane trim control wheels
53 Footboards
54 Wing spar/fuselage attachment joint
55 Fuel contents gauge
56 Hydraulic system emergency handpump
57 Fuel cock control
58 Dynamotor
59 Cockpit step
60 Rear rudder pedals
61 Hydraulic reservoir
62 Engine and propeller control rods
63 Radio equipment stowage
64 Sliding canopy rail
65 Rear instrument panel
66 Undercarriage warning horn
67 Roll-over protection frame
68 Canopy fixed centre-section
69 Rear sliding canopy section
70 Rear pilot's seat
71 Canopy emergency exit side panel
72 Emergency exit handle
73 Rear pilot's throttle box
74 Fire extinguisher
75 Trim handwheels
76 Flap lever
77 Rear seat mounting
78 Forward fuselage steel tube primary structure
79 Non-structural side panels
80 Rear cockpit step
81 Baggage compartment
82 Oxygen bottles
83 Oxygen filler valve
84 Rear fuselage frame and stringer construction
85 Control system access panels
86 Upper identification light
87 Fin mounting box
88 Fin root fairing
89 Starboard tailplane
90 Starboard elevator
91 Elevator tab
92 Tailfin construction
93 Tail navigation lights, port and starboard
94 Rudder mass balance
95 H/F aerial cable
96 Fabric-covered rudder construction
97 Rudder tab
98 Tab control rod
99 Elevator hinge control
100 Fabric-covered elevator construction
101 Rudder hinge control cable
102 Elevator tab
103 Elevator mass balance
104 Tailplane construction
105 Tailwheel shock absorber strut
106 Non-retracting tailwheel
107 Tailwheel steering control
108 Rear fuselage/tailplane bulkhead
109 Fuselage skin plating
110 Fuselage lifting bar
111 Tailplane control cable runs
112 Ventral identification lights (red, green and amber)
113 Rear fuselage longeron
114 Forward/rear fuselage joint
115 Wing root fillet
116 Central flap segment
117 Flap hydraulic jack
118 Wing walkway
119 Split trailing edge flap
120 Wing centre-section construction
121 Outer wing panel bolted joint
122 Rear spar
123 Outboard split trailing edge flap segment
124 Aileron hinge control
125 Aileron false spar
126 Fabric-covered aileron construction



IIA, IIB and III, many of these being built in Canada by the Noorduyn company. The Harvards predominantly went to the Commonwealth training schools until late in the War, when they began to appear in the UK to replace the Miles Master. In addition, a large batch of Masters went out to South Africa in 1941 as advanced trainers, but it was found that the hot, dry climate was not kind to their all-wood construction and by 1944 they too had been replaced by the ubiquitous Harvard IIA.

(Left) The Magister — based on the Miles company's very successful line of Hawk lightplanes — was the RAF's first monoplane trainer.



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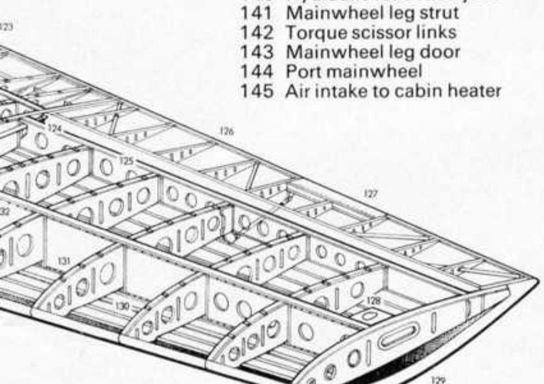
127 Aileron tab
128 Starboard navigation lights
129 Wing tip fairing
130 Bottom wing skin/stringer panel
131 Leading-edge nose ribs
132 Outer wing panel main spar
133 Aileron control
134 Wing rib construction
135 Landing/taxying lamps
136 Port centre-section fuel tank; total aircraft fuel capacity 91·5 Imp gal (416 l)
137 Fuel filler cap
138 Undercarriage leg locking mechanism
139 Main undercarriage leg pivot fixing
140 Hydraulic retraction jack
141 Mainwheel leg strut
142 Torque scissor links
143 Mainwheel leg door
144 Port mainwheel
145 Air intake to cabin heater



In 1939, Fairey Battles were also pressed into service as pilot trainers, many of them being simply modified by fitting pilot controls in the rear cockpit. A more definitive dual pilot trainer version, with separate cockpits, emerged early in 1940 and 200 of these were built, most of which served in Australia and Canada briefly as pilot trainers in the Empire Scheme. A few also served in this country but, with a plentiful supply of Masters and Harvards coming along their time as pilot trainers was short.

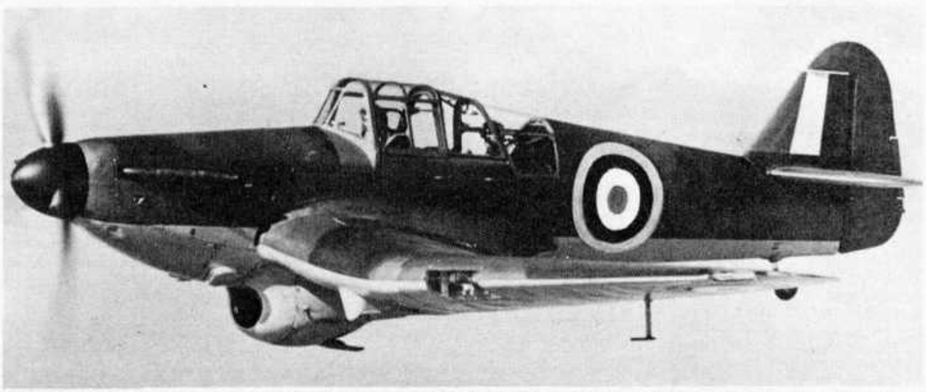
For the twin-engined and other aircrew training rôles, the Airspeed Oxford appeared to be the answer and production was stepped up, de Havilland, Percival and Standard Motors all joining in the task of building an eventual total of 8,586 by July 1945.

With the complexity of War came new procedures and techniques on which pilots had to be trained. One of these tasks was to teach pilots how to use the new Blind Approach Systems, based on the pre-war Lorenz Beam device, and many Beam Approach Training (BAT) Flights were established, up to 50 in all, throughout the United Kingdom, equipped almost exclusively with Airspeed Oxfords.

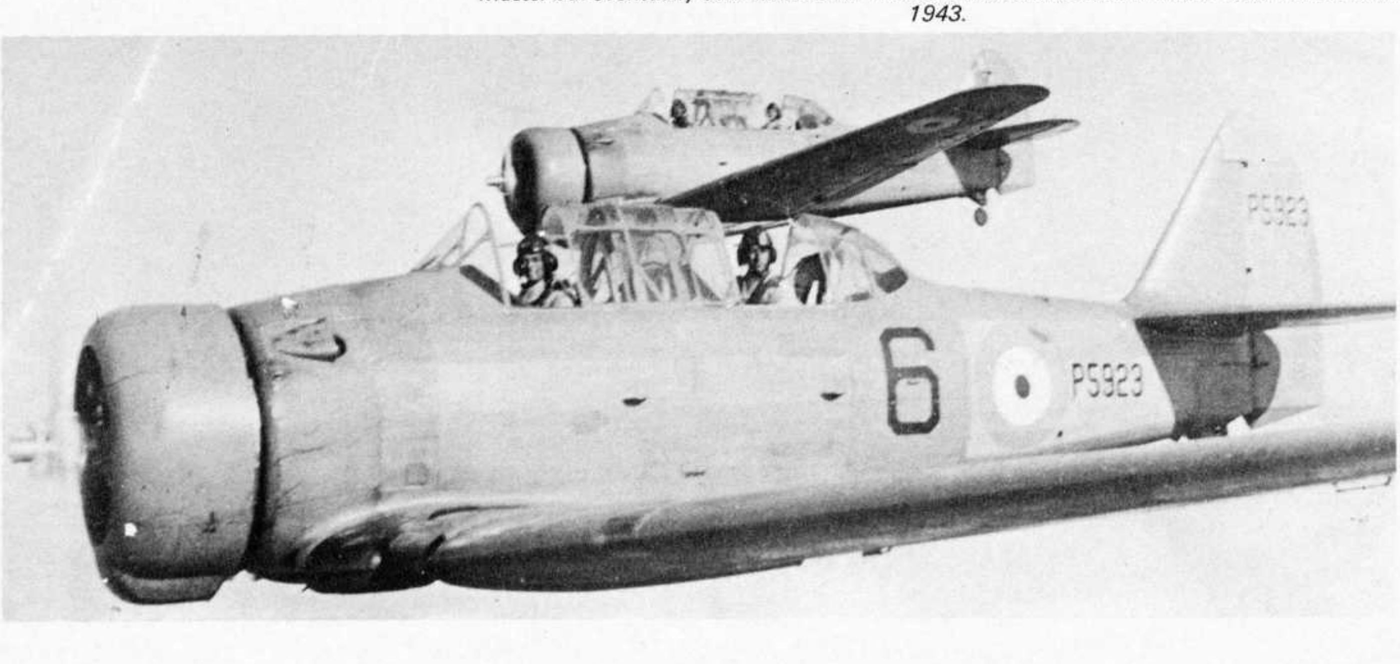
From war to peace

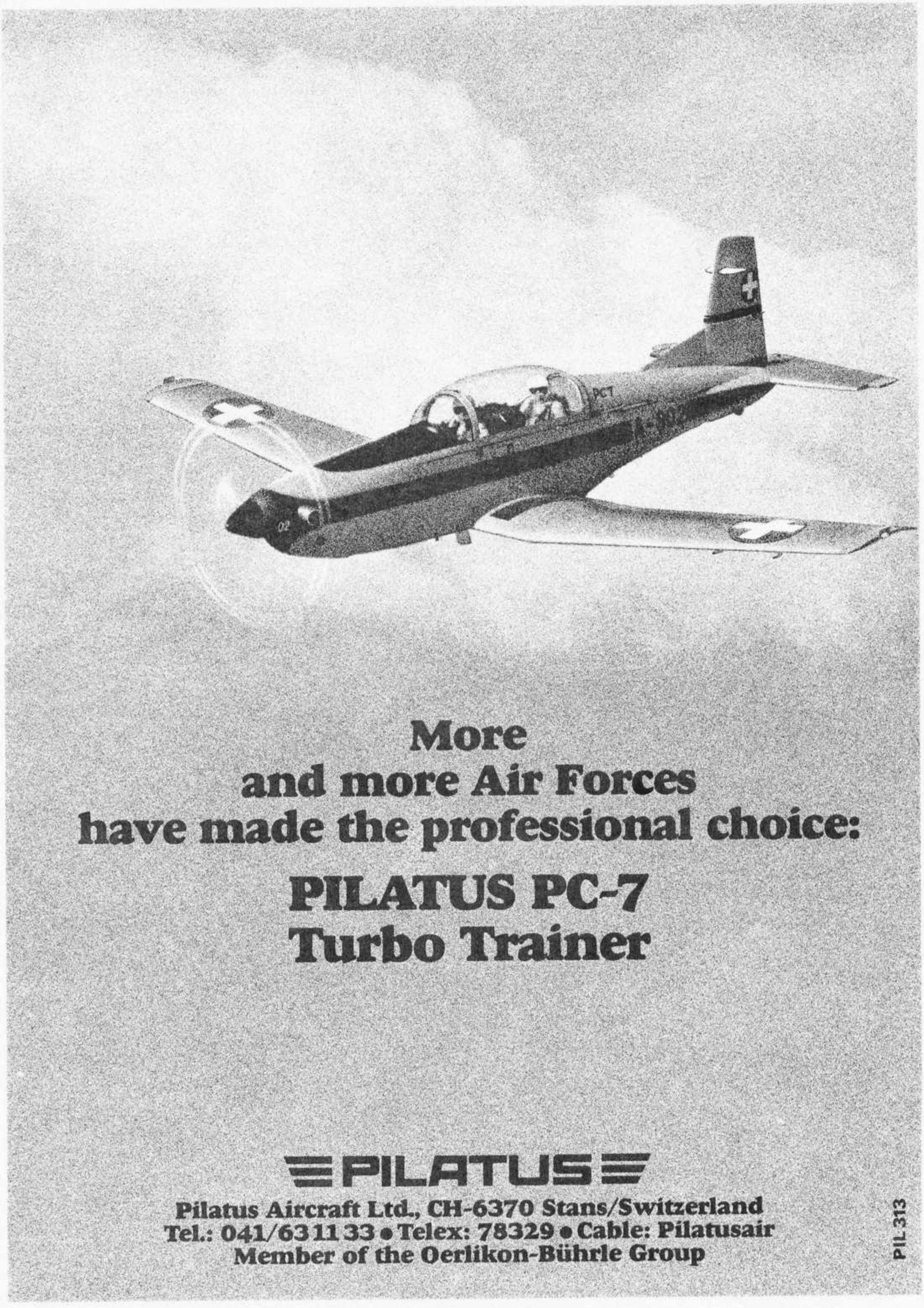
This then was the general training picture up to the end of the War. As hostilities drew to a close, in fact, there was a gradual running-down in both the EATS and in the training units in the UK, for casualties had not been as heavy as expected, either in the Second Front or in the Far East, where the atomic bombs dropped on Hiroshima and Nagasaki had brought an unexpectedly abrupt end to the fighting. Consequently, a considerable surplus of aircrew had accumulated, to such an extent that, by the end of 1944, trainee pilots were having to wait around nine months before moving on from Initial Training to Elementary Flying.

The RAF, itself contracting somewhat in size even before VE Day, was able to live off the fat of this surplus for a year or two, and in that time re-organise the Training Command pattern in the UK to be self-sufficient once more. All the wartime aircrew had, technically, been members of the RAF Volunteer Reserve and this organisation was rebuilt post-war on a voluntary, part-time basis once more, for two purposes: to keep many of those who were being demobilised in flying practice and thus provide a reserve of trained aircrew, and to train new youngsters as recruitment eventually got under way again. This was accomplished by forming Reserve Command on 1 May 1946, and transferring to this Command the EFTSs which had been busy on grading and pre-AFS flying, renaming them at the same time as Reserve Flying Schools. Equipped with Tiger Moths for pilot training, the RFSs also received a small complement of Ansons to



(Above) Designed to complement the Magister in a more advanced rôle, the Master I matched the introduction of such types as the Spitfire and Hurricane in the squadrons. (Below) The North American Harvard was bought to supplement British production of the Master but eventually outnumbered it. These are Harvard Is used in the EATS in Rhodesia in 1943.

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(Below) Fairey Battle T, a bomber adapted as an advanced trainer.

(Below) Airspeed Oxford I, the first RAF training "twin".

(Above) De Havilland Mosquito T Mk 3 in post-war training yellow.

enable the other aircrew trades to fly as well. At the same time, the University Air Squadrons were re-established so that every university in the country had access to a few Tiger Moths to begin again the task of encouraging undergraduates to seek a permanent career in the RAF. For the further training of RAF aircrew, Flying Training Schools were once again established and equipped initially with the inevitable Tiger Moths and the Harvard IIBs, of which there were plenty. Little account was taken of multi-engined training, for the great need at this stage was to train up young entrants to fly the growing number of fast jets entering the Service — larger aircraft could be taken care of by the older aircrew who were opting to stay on after the War. Thus, the Airspeed Oxford disappeared almost completely from the training scene within a few years of the War's end.

The advent of the turbine engine was now a great pre-occupation of the British aviation scene and many questions had yet to be answered, particularly as to whether the piston engine was doomed for ever, whether the progress would be in turboprops and turbojets or just the latter and whether the latter would be better with axial-flow or centrifugal-flow configuration. Without any clear answers to these questions the Air Ministry had to plan the next generation of RAF trainers. The most urgent need was for a new basic trainer. It was absurd that a generation of "jet jockeys" should begin their training on an aircraft akin in both configuration and performance to the trainers of World War One. Preparations had already begun with the writing of a wartime Specification, T.23/43, for a replacement for the Tiger Moth. The new aircraft was to be much more powerful than the Tiger Moth and was to be equipped to introduce the pupil to radio, variable-pitch propellers and flaps from the very beginning. Side-by-side seating was specified, and in order to economise, the new aircraft was to have a third seat in the rear so that an additional pupil could go along as an onlooker and learn by the mistakes of his colleague in the left-hand seat. Out of this requirement eventually emerged the Percival Prentice, which entered RAF service early in 1948, and 344 examples of which were built after a trials batch of 20. The third seat idea was soon dropped in practice as it was found to be off-putting, both to the pupil under instruction and, even more so for the pupil in the back, who displayed a high tendency to air-sickness under the influence of his colleague's abrupt manoeuvering.

To complement the Prentice, Specification T.7/45 called for an advanced trainer with three seats and a turboprop engine. Prototypes were produced by Avro (the Athena) and Boulton Paul (the Balliol) but before a production decision could be taken the Air Ministry lost interest in the three-seat arrangement, as already noted, and also in the use of a turboprop engine. For a full-scale service evaluation, batches of the Athena and Balliol were built to a revised Specification with two seats (side-by-side) and Merlin engines. The Balliol was eventually chosen as the new advanced trainer and was put into production, entering service in 1951, but another change in training policy reduced the production run to

(Above) The advent of the jet fighter in the RAF brought with it a need for jet-powered advanced trainers. Eventually, training versions of both the first two fighter types were put into service as the Meteor T Mk 7 and Vampire T Mk 11. (Below) The largest aircraft produced for the RAF specifically for training use was the Vickers Varsity T Mk 1, a relative of the Viking and therefore a descendant of the Wellington.

Airspeed Oxford Mk II Cutaway Drawing Key

1 Nose cone
2 Course setting bomb sight
3 Nose compartment glazing
4 Bomb release switch
5 Bombardier's prone position
6 Height and speed computer stowage
7 Nose compartment framing
8 Pilot's footwell
9 Rudder pedals
10 Elevator control cables
11 Control cable access panels
12 20-lb (9-kg) practice bomb
13 Cockpit floor level
14 Control column
15 Compass
16 Elevator trim wheel
17 Instrument panel
18 Seat adjusting lever
19 Control column handwheel
20 Pilot's seat
21 Folding chart table
22 Navigation instrument stowage case
23 Direct vision side window panel
24 Instructor, navigator or bombardier's seat
25 Instrument panel shroud
26 Curved windscreen panels
27 Cockpit roof glazing
28 Armstrong Siddeley Cheetah X radial engine
29 Propeller reduction gearbox
30 Propeller hub fixing
42 Split trailing edge flap
43 Cabin roof escape hatch
44 Parachute stowage
45 Fire extinguisher bottles
46 Signal pistol cartridges
47 Wing centre section carry-through
48 Radio operator's seat
49 Radio aerial mast
50 D/F loop aerial rotating handle
51 Folding D/F loop aerial
52 H/F aerial mast
53 D/F loop aerial housing
54 Upper navigation light
55 Aerial lead-in
56 Radio transmitter
57 H/F receiver
58 Radio operator's table
59 Morse key
60 Radio equipment rack
61 Trailing aerial winch
62 Oxygen bottle stowage
63 Battery
64 Cabin entry door
65 Plywood covered spruce frame fuselage construction
66 Cabin roof framing
67 Control locking gear stowage
68 Document case
69 Gun turret mounting ring (only Mk I aircraft operated with gunnery training turret fitted)
70 Rear cabin roof hatch
71 Cabin aft bulkhead
72 Marker beacon receiver
73 Dorsal frame and stringer construction
74 Starboard tailplane
75 Starboard elevator
76 Rear fuselage/tailfin main frame
77 Rudder control cables
78 Tailfin construction
79 Rudder horn balance
80 H/F aerial cable
81 Fabric-covered rudder construction
82 Sternpost
83 Tailcone fairing
84 Ground manoeuvering handgrip
85 Tail navigation light
86 Elevator trim tab
87 Fabric-covered elevator construction
88 Tailplane construction
89 Elevator cable controls
90 Tailplane root fillet
91 Tailwheel leg strut
92 Castoring tailwheel
93 Fuselage lower longeron
94 Internal walkway
95 Control cable runs
96 Parachute flare launchers
97 Rear bulkhead door, folded for access
98 Built-up cabin floor
99 Fuselage spruce framing
100 Parachute stowage
101 Wing root trailing edge fillet
102 Inboard flap housing
103 Nacelle tail fairing
104 Oil cooler air outlet
105 Hydraulic flap jack

only 162 aircraft and attention was switched instead to the use of jet aircraft for advanced training.

Meantime, other developments had been taking place. A replacement had to be found for the Tiger Moth in the University Air Squadrons and the Reserve Flying Schools which would be cheaper and less sophisticated than the Prentice. This requirement was simply met by ordering, from the de Havilland company in the UK, a production version of the attractive Chipmunk trainer just developed by de Havilland Canada. No fewer than 735 were built for the RAF and even though the Reserve Flying Schools have long since closed down and the UASs have moved on to something more up-to-date, the Chipmunk is still serving the RAF in 1982, flying in the Air Experience Flights which give air time to the Air Training Corps and CCF cadets in the UK. It was also used for some time at Cranwell and at the time of writing serves at the Flying Selection Squadron at Swinderby, which provides early elimination from the training pipeline of those who do not have sufficient aptitude for piloting an aircraft.

In 1948, in a resurgence of the EATS, training schools were set up in Rhodesia, remaining in use for four years. Pilot training took place at No 4 FTS Heany and No 5 FTS Thornhill, using Chipmunks and Harvards.

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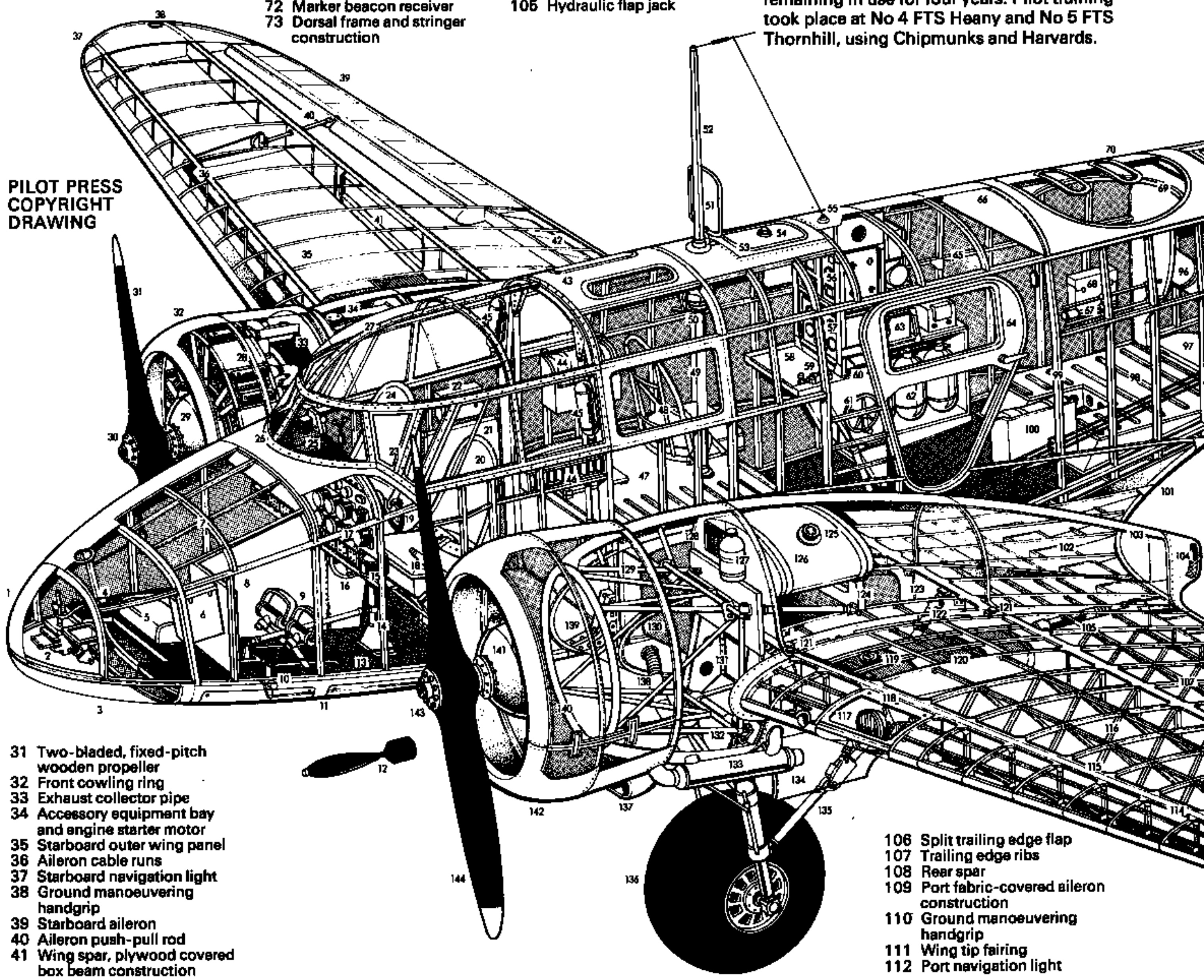
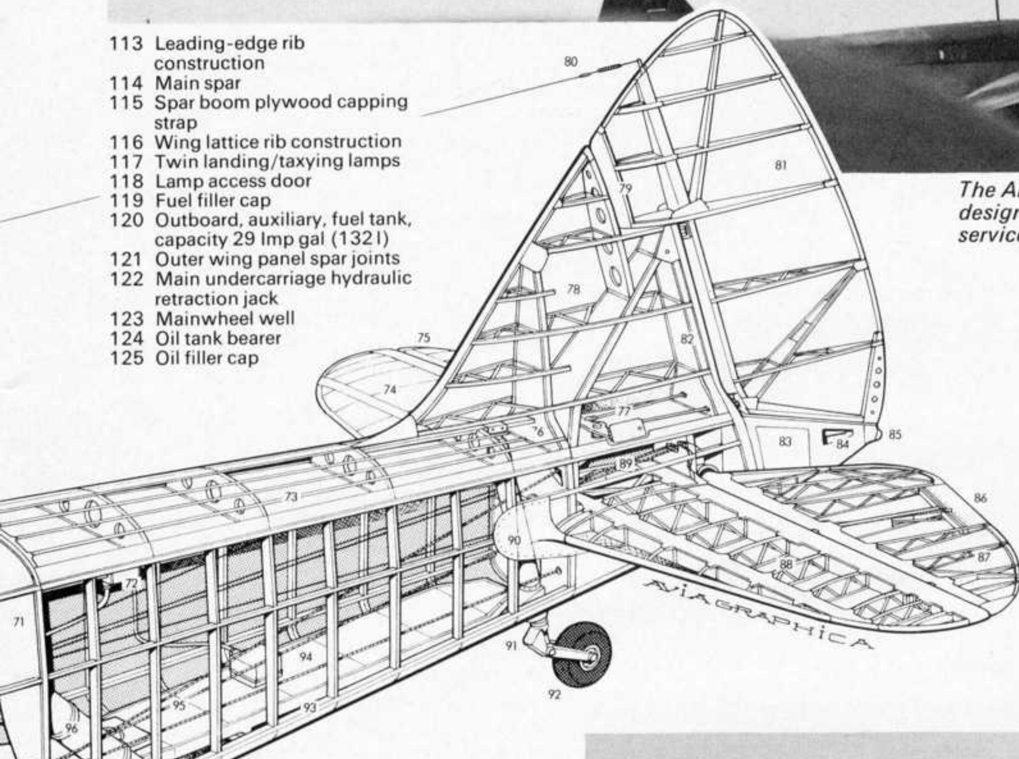


31 Two-bladed, fixed-pitch wooden propeller
32 Front cowling ring
33 Exhaust collector pipe
34 Accessory equipment bay and engine starter motor
35 Starboard outer wing panel
36 Aileron cable runs
37 Starboard navigation light
38 Ground manoeuvering handgrip
39 Starboard aileron
40 Aileron push-pull rod
41 Wing spar, plywood covered box beam construction

106 Split trailing edge flap
107 Trailing edge ribs
108 Rear spar
109 Port fabric-covered aileron construction
110 Ground manoeuvering handgrip
111 Wing tip fairing
112 Port navigation light

The Airspeed Oxford was the first twin-engined trainer designed and produced as such for the RAF, and it saw service throughout and beyond World War II. These two were serving with No 3 FTS in 1938.

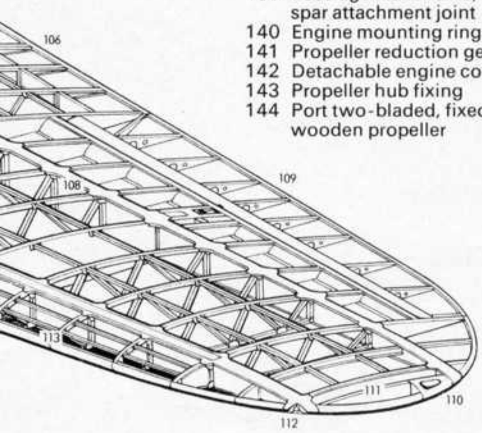


113 Leading-edge rib construction
114 Main spar
115 Spar boom plywood capping strap
116 Wing lattice rib construction
117 Twin landing/taxying lamps
118 Lamp access door
119 Fuel filler cap
120 Outboard, auxiliary, fuel tank, capacity 29 Imp gal (132 l)
121 Outer wing panel spar joints
122 Main undercarriage hydraulic retraction jack
123 Mainwheel well
124 Oil tank bearer
125 Oil filler cap

By this time it had been found that the gap between gaining one's "wings" on a Harvard/Balliol sequence and then stepping into a single-seat Meteor, or a large Lincoln, Shackleton or Hastings, at the Operational Conversion Unit, was far too large for safety and a new intermediary form of school came into existence. This was the Advanced Flying School, the first of which appeared in 1947. No 201 AFS was formed at Swinderby, at first with Wellington T Mk 10s but then from October 1951 with the first Vickers Varsities to enter RAF service. The Varsity had been developed, to Specification T.13/48, as an all-purpose advanced trainer, based on the Viking transport and differing from that type notably in having a tricycle

126 Engine oil tank
127 Hydraulic reservoir
128 Oil radiator
129 Engine bearer struts
130 Inboard, main, fuel tank, capacity 49 Imp gal (223 l)
131 Main undercarriage bearers
132 Main undercarriage leg pivot fixing
133 Exhaust muff heat exchanger
134 Mainwheel door
135 Retraction strut
136 Port mainwheel
137 Carburettor air intake scoop
138 Cabin heating air duct
139 Fuselage main frame/wing spar attachment joint
140 Engine mounting ring
141 Propeller reduction gearbox
142 Detachable engine cowlings
143 Propeller hub fixing
144 Port two-bladed, fixed-pitch, wooden propeller

Towards the end of World War II, the concept of the three-seat pilot trainer influenced the design of first the Percival Prentice (above) and then the more advanced Boulton Paul Balliol (below). In practice, carrying a second student in the rear of the cockpit proved valueless.



(Above) A pair of Jet Provost T Mk 5s of the Gemini aerobatic team from RAF Leeming demonstrate "mirror" flying.

undercarriage and a long extended bomb-bay under the fuselage with a bomb-aimer's window in the front. The RAF received 160 Varsities and the type remained in service in a number of training rôles until the late 'seventies. In its ubiquity, it had been more than matched by "Faithful Annie", the Avro Anson of pre-war origin but continued post-war development and production. The final three Anson variants to be built were, in fact, specialised trainers, including the T Mk 20 for service in Rhodesia, the T Mk 22 to train Air Signallers and, most importantly, the T Mk 21 for use at Nos 1 and 2 ANSs. But for all its diversity and longevity, the Anson saw very little service in the rôle of a pilot trainer, and the training of other aircrew categories, which with the passing years has called for ever more specialisation of training aircraft and curricula, is largely outside the scope of the present article.

(Above) De Havilland Chipmunk T Mk 10 and (below) Scottish Aviation Bulldog T Mk 1, as in service in 1982.

To revert to the Advanced Flying Schools: No 202 AFS also started with Wellingtons but lasted only seven months. In 1951 it was re-formed as a jet AFS at Valley, following the formation of No 203 at Driffield which, after a short time at Chivenor with Spitfires in 1948-49, now flew Meteors and Vampires. No 204 AFS formed at Cottesmore with Mosquito T Mk 3s, the training version of the famous "Mossie" that had appeared in the early 'forties. One or two examples of these dual trainer versions of the early Mosquitoes had been allocated to each operational Mosquito unit for instrument rating and continuation training; No 204 AFS was given a sizeable complement of them for advanced training duties.

Training on jets

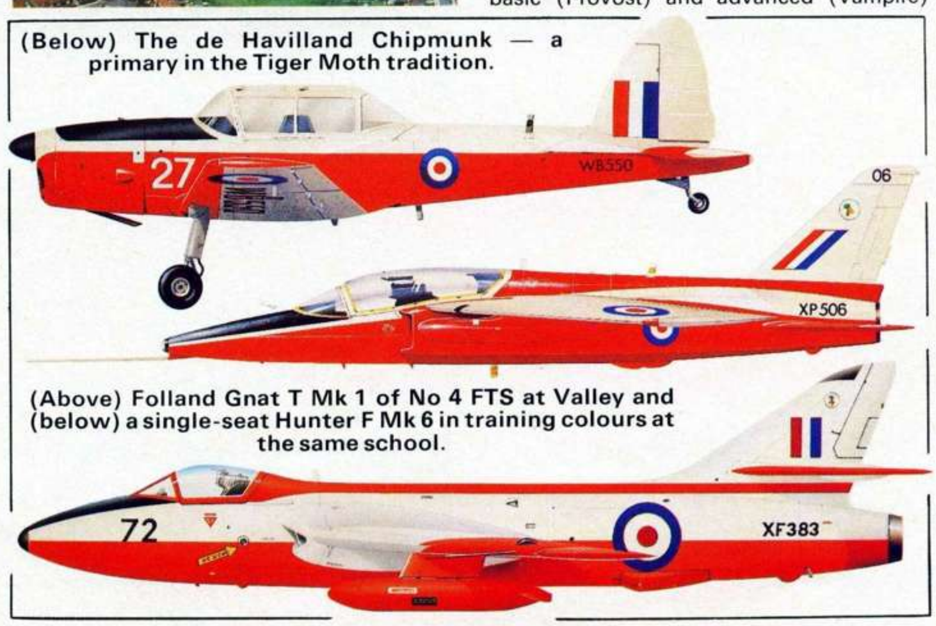
It had become clear early in the life of the Meteor jet fighter, that a two-seater training version would be necessary, and Gloster produced the T Mk 7 which went into service at the end of 1948. Not only did each operational Meteor unit have one or two, but this aircraft became a major tool at the jet AFSs and at the OCUs, 634 Meteor T Mk 7s being produced.

The pattern only recently established for pilot training was now seen to be unsatisfactory and wasteful. The Prentice was found to be far from an ideal basic trainer for the RAF of the 'fifties and, with the advent of the Canberra jet bomber, it was generally agreed that jet flying should be brought into a pilot's training at a much earlier stage. The Air Ministry set about finding a new basic trainer with "punchier" characteristics which would fill in the first part of the Harvard/Balliol type of flying, to be followed with a docile jet trainer, more amenable to student flying than the Meteor.

For the basic trainer, Specification T.16/48 led in due course to the Hunting Percival P.56, after comparative trials with the competing Handley Page HPR.2. The P.56 was ordered into production as the Provost T Mk 1, the last piston-engined pilot trainer in the RAF. The Provost had exceptional flying qualities, with a 550 hp engine, well-harmonised and crisp controls, and excellent aerobatic qualities; 387 were built, the first entering service in 1953 with the CFS and then the RAF College, Cranwell.

The aircraft to complement the Provost in this new training sequence was produced by the Airspeed Division of de Havilland. Already the Vampire single-seat, single-engined jet fighter had been turned into a side-by-side two-seat night-fighter, so it required little further modification to install two pilots' seats with dual controls, remove the AI radar and increase the fin and rudder area to eliminate directional control problems. A new canopy was fitted and the Vampire T Mk 11 became the first aircraft in the trainer sequence up to "wings" standard to be fitted with ejection seats. The Vampire Trainer, of which production totalled 534, first entered service at the AFSs alongside Meteors and single-seat Vampires, but the advent of this new type made it possible to eliminate the Advanced Flying School stage and to bring the Vampire into the training sequence before "wings" standard was reached: the T Mk 11 was therefore issued in due time to several of the Flying Training Schools and No 1 FTS (at Linton-on-Ouse) eventually became the first FTS at which basic (Provost) and advanced (Vampire)

(Below) The de Havilland Chipmunk — a primary in the Tiger Moth tradition.



(Above) Folland Gnat T Mk 1 of No 4 FTS at Valley and (below) a single-seat Hunter F Mk 6 in training colours at the same school.

(Right) Percival Provost T Mk 1, the last of the RAF's piston-engined basic trainers and (below) the Jet Provost T Mk 5A, final derivative of the same design, here in the colours of the RAF College. (Bottom) Vickers Varsity T Mk 1 multi-rôle trainer, also here in RAF College colours.

(Left) A Scottish Aviation Jetstream T Mk 1 multi-engine pilot trainer. (Above) Westland/ Bell Sioux HT Mk 2 of the CFS at Ternhill.

flying training to jet wings standard was conducted on the same station.

In the early 'fifties, with the Korean War and consequent heating up of the international scene, there came a great expansion of the RAF which involved calling on some of the RAFVR. As a result, some temporary units appeared to give Advanced Flying Training and to serve as Flying Refresher Schools, and into these were pressed all types of aircraft — Airspeed Oxfords were pulled out of storage, Harvards flew their swan song with the RAF and the FRSs had a variety of types including both Vampires and Spitfires. Basic Air Navigation Schools at Hamble and Usworth were equipped with Anson T Mk 21s as national service aircrew were pressed into this rapid expansion of the RAF in the early 'fifties. This, however, was a mushroom-like growth and, with the passing of national service aircrew, these units disappeared once more into oblivion.

All-through jet training

The logical step, after introducing the Vampire early in the training sequence, was to go "all-jet". Hunting Percival responded to RAF ideas by, basically, taking a Provost, installing an Armstrong Siddeley Viper jet engine in place of the Leonides and giving the aircraft a tricycle undercarriage. An initial batch of 10 Jet Provost T Mk 1s was delivered to the RAF for No 2 FTS at Hullavington and used for comparative trials in 1955, one course flying all-jet, alongside

(Above right) Wessex HU Mk 5 advanced helicopter trainers at No 2 FTS and (below) the same unit's Gazelle HT Mk 3, of the type used to equip the British Tri-Service Team for the 1981 Helicopter Championships.

(Above) The Vickers Varsity T Mk 1 remained in service for multi-engined pilot training at No 5 FTS, RAF Oakington, until replaced by Jetstreams in 1973. (Below left) The Folland Gnat — outgrowth of a lightweight fighter design — gave long service as the standard advanced trainer for the RAF, until eventually replaced by the even better Hawk T Mk 1.

others carrying on the normal courses on piston Provosts. After much discussion and deliberation it was decided to adopt all-through jet training, and the much-modified Jet Provost T Mk 3 entered service with No 2 FTS (now at Syerston) in June 1959. This very successful basic jet trainer was followed into service by the T Mk 4 with a 40 per cent thrust increase, thus providing a basic and advanced trainer within the same airframe. The 201 Jet Provost T Mk 3s and 185 T Mk 4s provided the bulk of the RAF's pilot training for over a decade. However, because the Jet Provost was a very docile aircraft as jet aircraft go, as the RAF moved into the realm of sonic and supersonic jets with delta and swept-wing planforms, some type of trainer on which the "fast jet" pupil could cut his compressibility teeth now became necessary. The RAF found this need could be met by a two-seat training version of the Folland Gnat. A pre-production batch was evaluated by CFS, which encouraged the go-ahead for production by Hawker Siddeley of a batch of 105 Gnat T Mk 1s; these served solely at the CFS and No 4 FTS from November 1962 until 1979, providing pupils trained on Jet Provosts with an introduction to the world of high-speed flight.

Until the 'sixties, there had been no specific helicopter training unit within the RAF, for the requirement had been relatively small and CFS with its complement of current helicopter types, had been able to fulfil the necessary training rôle. However, with the expansion of helicopter flying within the RAF in the early 'sixties, a separate branch of CFS was established at Tern Hill and equipped with Whirlwind HAR Mk 10s and, from 1965 onwards, an elementary training aircraft in the shape of the Westland/Bell 47G Sioux AH Mk 1. Fifteen Sioux HT Mk 2s, specifically built for the RAF, subsequently served in this rôle for ten years.

The trend of building two-seat trainer versions of the principal operational types had continued in the 'fifties and the Hunter and Canberra, the main jet equipment of the RAF fighter and bomber squadrons, had their T Mk 7 and T Mk 4 versions, used principally at the OCUs and on the squadrons themselves. In 1967, some of the Hunter T Mk 7s were added to the complement of No 4 FTS at Valley and worked alongside the Gnats in the training of fast-jet pupils. Although the Jet Provost T Mks 3 and 4 were providing excellent service, the RAF called in due course for a pressurised version, developed initially by Hunting as a private venture. The resulting Jet Provost T Mk 5 had the pressure cabin, an updated instrumentation and increased tankage for longer sorties. Entering service with the CFS in September 1969, it subsequently completely replaced the T Mk 4 version, and now, in 1982, takes the lion's share of RAF pilot training; it has been improved in the T Mk 5A version with updated instrumentation and radio aids, and is in service at CFS, No 1 FTS at Linton-on-Ouse, No 3 FTS at Leeming and No 7 FTS at Church Fenton for pilot training as well as, of course, at RAF

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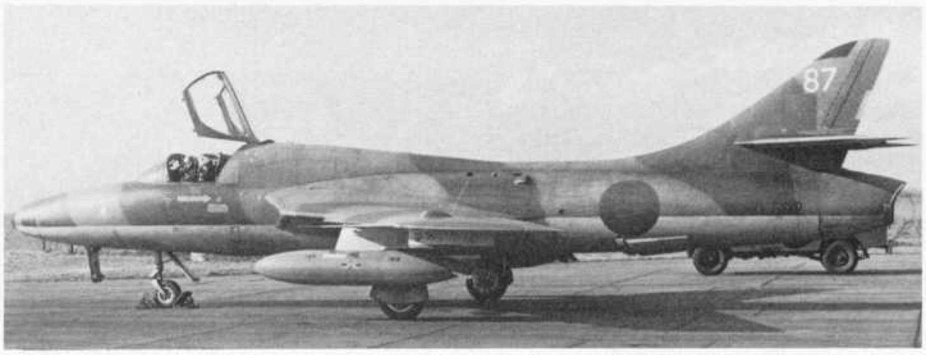
(Above) The Jet Provost, designed by the Hunting company and built by BAC before that company became part of British Aerospace, remains in service as the basic jet trainer on which RAF pilots gain their "wings". Current versions are the T Mk 3A and (illustrated) T Mk 5A.

College, Cranwell.

Into the 'seventies, the training pattern was well established and working well. The next replacement type required was a new primary trainer for the University Air Squadrons. With their emphasis on graduate aircrew, these units assumed a greater importance and to replace the Chipmunk, choice fell on the Beagle Bulldog, which became the responsibility of Scottish Aviation before production could commence. The RAF order was for 132 aircraft; the first entered service with CFS in April 1973, and also served with the Primary Grading Squadron of No 2 FTS, then at Church Fenton and later at Leeming. The Bulldog T Mk 1 also serves, of course, with all fourteen UASs. With the Varsity also beginning to belong to a previous era as far as pilot training was concerned, another new type was ordered for the multi-engine pilot training rôle. This was the Jetstream, which had been designed by Handley Page as a third-level airliner/business aircraft, powered by two Turboméca Astazou engines. Scottish Aviation built 26 for the RAF and in June 1973 these began to replace the Varsities at No 5 FTS at Oakington, the final Varsity pilot-training unit. Almost at the same moment, however, Defence cuts reduced the requirements for multi-engined pilots so much that the RAF decided that no further pilot training would be required for some years; the Jetstream was put into storage for four years, but in 1977 the Multi-Engined Training Squadron was formed (at Leeming), under the umbrella of No 3 FTS, and eight Jetstreams were brought back into service to perform this rôle, the others being transferred to the Royal Navy.

The Sioux helicopter was a very basic type of helicopter for use as a primary trainer and had certain shortcomings, so a replacement was selected in the Westland/Aérospatiale Gazelle, 14 examples for the RAF being designated HT Mk 3s. They were delivered to Tern Hill from 1973 onwards and shortly afterwards the helicopter training pattern was regularised by the establishment of No 2 FTS at Shawbury, to which the Gazelles and Whirlwind HAR Mk 10s moved in October 1976; very recently, the Whirlwinds have been phased out, the advanced helicopter training rôle have been taken over by a small number of Westland Wessex HU Mk 5s



(Above) A Hunter T Mk 7 serving at No 1 Tactical Weapons Unit, RAF Brawdy — hence its operational style camouflage. Hunters used hitherto by No 4 FTS, RAF Valley, were painted in the standard red and white finish (below) before finally being retired.

(Below) Derived from the Beagle Pup club trainer and tourer, the Bulldog T Mk 1 was produced for the RAF by Scottish Aviation and is now standard issue for the University Air Squadrons; this one serves with the Oxford UAS.

The British Aerospace Hawk, now the RAF's standard trainer at (top) No 4 FTS, (centre) Nos 1 and 2 TWUs and (bottom) for use by the Red Arrows.

acquired from the Fleet Air Arm. These two types now provide a complete helicopter training syllabus for all the RAF's helicopter pilots at No 2 FTS.

Enter the Hawk

Bringing the story of the RAF pilot training up-to-date is one of the most successful of trainers introduced in the whole history of the RAF. By 1977 the Gnat was coming to the end of its life, Hunters had been out of production since 1957 and there were obvious limitations in what the Jet Provost could do, for all its excellence. A new aircraft was required which would take pilot training into the 'eighties, would replace both Hunter and Gnat, and would also relieve the pressure on the Jet Provost. This replacement aircraft was found in the Hawker Siddeley (now British Aerospace) Hawk T Mk 1, 175 examples of which were ordered in the early 'seventies. The type entered service at No 4 FTS Valley in November 1976, and it has bettered all previous records for maintainability, reliability and safety. Gnats and Hunters have been phased out at Valley, making way for an all-Hawk force, the Hunters moving on to other training duties with operational Buccaneer units.

One of the developments in the early 'seventies concerned the introduction into the RAF of a predominantly low-level, tactical strike force, as opposed to the traditional high-level rôle. With Vulcan bombers going over to low-level, the introduction of the Phantom, the Buccaneer, and then the Jaguar into the UK and RAFG squadrons, large numbers of aircrew needed to be trained in low-level attack methods. For this transition to take place at the Operational Conversion level meant the use of highly-expensive operational aircraft on what was basically a training task rather than an operational conversion. So the Hunter Operational Conversion Unit, No 229 OCU at Chivenor, which had become redundant with the replacement of the Hunter by later types in operational service, was moved to Brawdy in Wales and renamed the Tactical Weapons Unit. Its new task was to teach the principles of low-level attack to all aircrew who were going forward into the fast-jet squadrons. So great was the demand that in September 1978 a second TWU was established at Lossiemouth, both units being at first Hunter-equipped. However, with the introduction of the Hawk, the latter type joined No 1 TWU at Brawdy late in 1977 and in 1980 equipped a new No 2 TWU at Chivenor, allowing the Hunter unit at Lossiemouth to disband. At the time of writing, No 2 TWU at Chivenor flies only the Hawk and No 1 at Brawdy is partly Hawk, and partly Hunter, equipped.

This short account of RAF training types has, perforce, been limited to a discussion of those aircraft used in the training of pilots and has largely omitted reference to the types which have been developed for operational conversion purposes, as these properly fit more into an operational scenario. For such rôles over the post-war years many famous types of aircraft have had their training versions — the Shackleton T Mk 4, Canberra T Mk 4, 11, 17 and 19, the Lightning T Mk 4 and 5, Javelin T Mk 3, Hastings T Mk 5, Harrier T Mk 2 and 4 and Tornado GR Mk 1 (T) to name the principals. There have also been a number of esoteric training schools suitably equipped for teaching specialist subjects, such as the Bomber Command Bombing School, the Empire Test Pilots' School and others which also fall outside the scope of this general article; for the most part they have used the types of aircraft mentioned in this text, or variants of operational aircraft — and all have played their part in making the RAF one of the best-trained air arms to be found anywhere in the world. □

(Above) A Hawk carrying Sidewinder AAMs. TWU Hawks — such as the example below — are being modified to have a limited air defence capability in an emergency.

(Below) A Hawk T Mk 1 in the colours of No 4 FTS at RAF Valley, which is now the sole unit providing advanced flying training for the fast-jet pilot stream.

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