PROFILE PUBLICATIONS

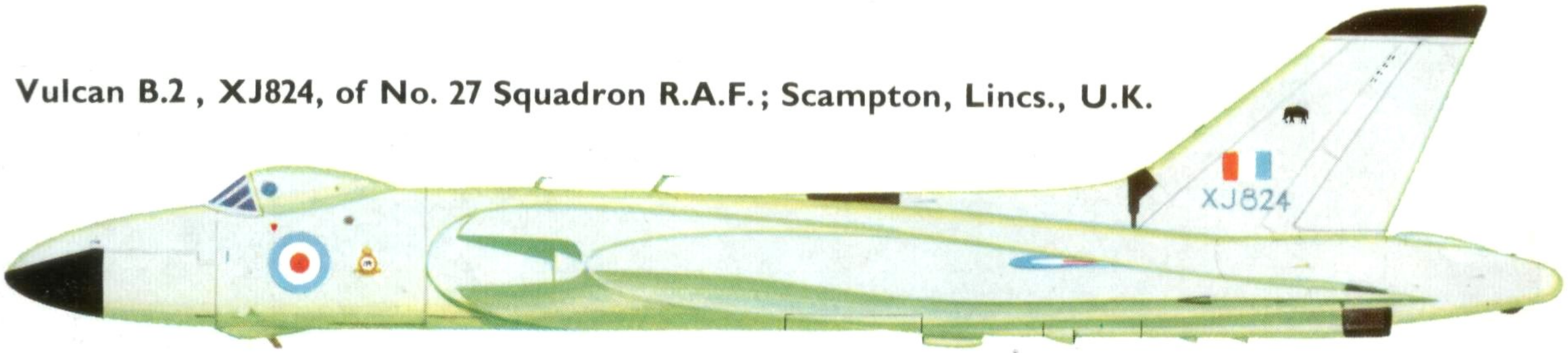
The Avro Vulcan

NUMBER 162

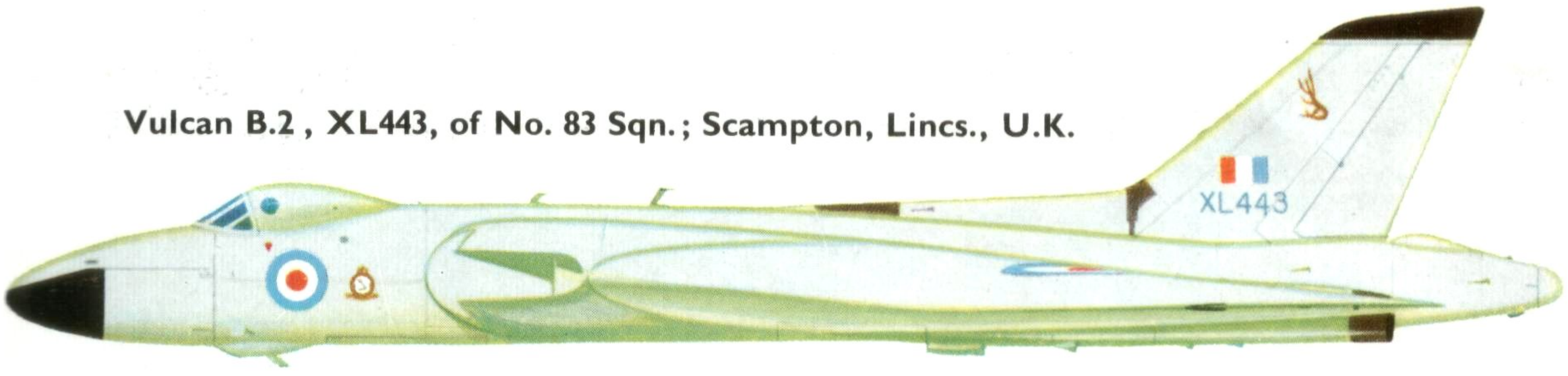
RETAIL PRICE
UNITED KINGDOM TWO SHILLINGS
UNITED STATES AND CANADA 50 CENTS

Vulcan B.I, XA890; Royal Aircraft Establishment, Farnborough, Hants., U.K.

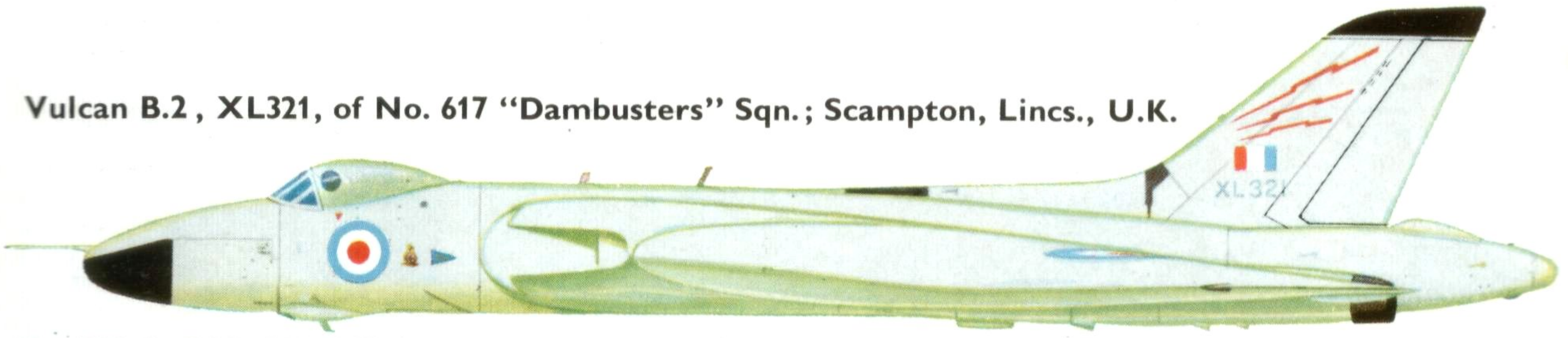
Vulcan B.2 , XJ824, of No. 27 Squadron R.A.F.; Scampton, Lincs., U.K.



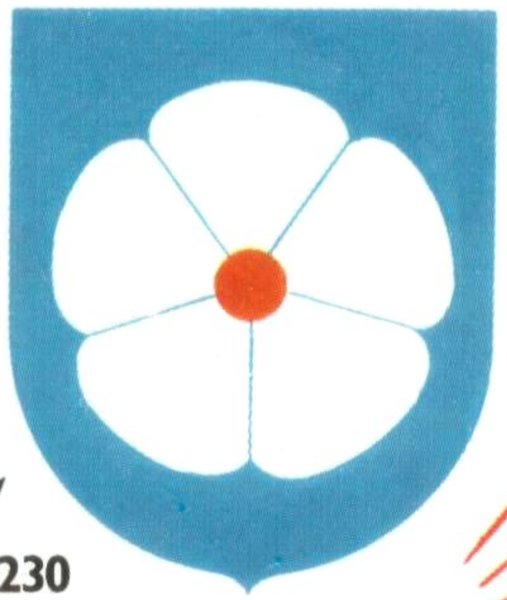
Vulcan B.2 , XL443, of No. 83 Sqn.; Scampton, Lincs., U.K.



Vulcan B.2 , XL321, of No. 617 "Dambusters" Sqn.; Scampton, Lincs., U.K.



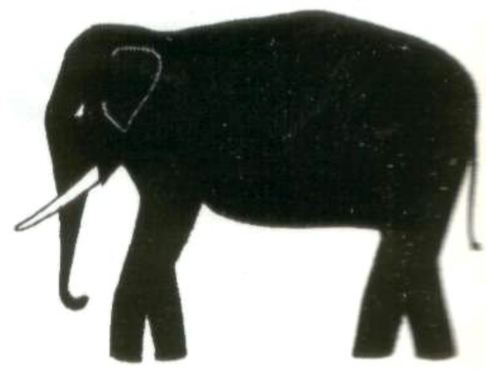
No. 230 O.C.U., Waddington, 1961.



No. 230

No. 617 Sqn.

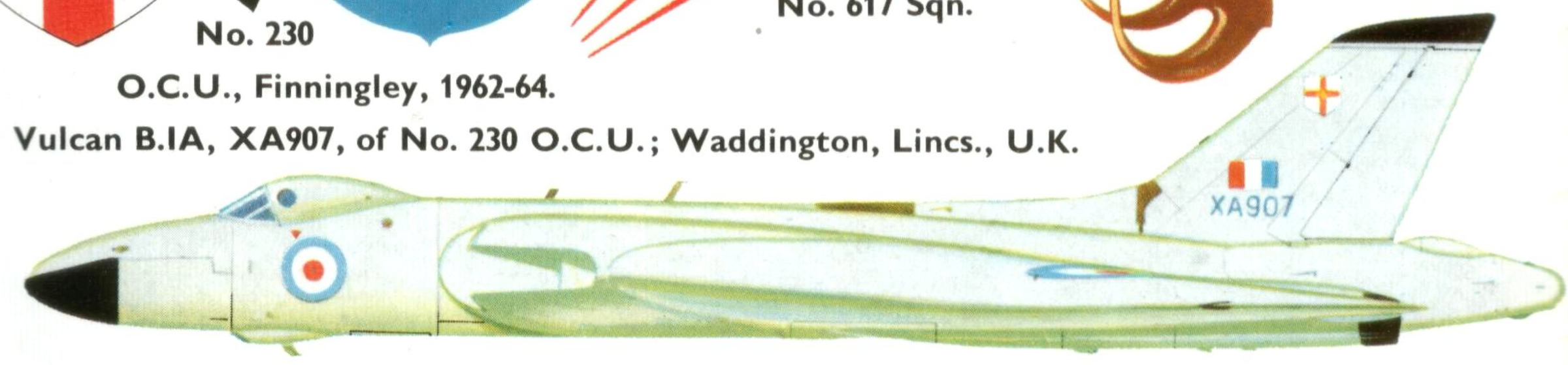
No. 83 Sqn.



No. 27 Sqn.

O.C.U., Finningley, 1962-64.

Vulcan B.IA, XA907, of No. 230 O.C.U.; Waddington, Lincs., U.K.



The Avro Vulcan

by John W. R. Taylor

A Vulcan B.2 seen just after unsticking, showing details of the tail cone which contains radar countermeasures equipment.
(Photo: S. P. Peltz)

To the ancient Romans, Vulcan was the god of fire and inventor of the thunderbolt. No more appropriate name could have been found for the mighty delta-wing bomber with which Avro's late, great technical director, Roy Chadwick, proposed to meet Air Ministry Specification B.35/46, issued on 1st January 1947.

Not much more than a year had passed since World War II had ended in victory, and the Royal Air Force was still regarded, rightly, as second to none in the world in terms of quality of equipment. Britain's aircraft industry, too, was setting the pace—profiting from its experience as the pioneer of jet-propulsion to follow the Allies' only combat-tested jet-fighter with the world's first jet and turboprop airliners. Behind the scenes British scientists, who had contributed so much to America's atomic bomb, were developing improved weapons of their own.

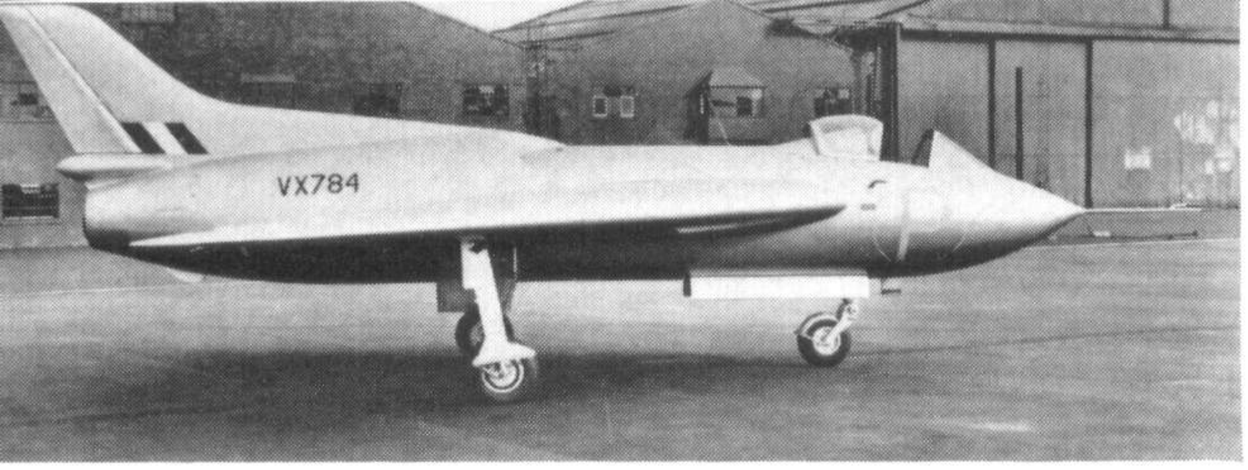
It was against this background of unprecedented British prestige and technological leadership that the Air Staff conceived a generation of strategic bombers as important as the Halifax and Lancaster that were end products of Specifications it had drawn up just ten years earlier. Even these wartime heavy bombers had not represented such a dramatic advance over their predecessors as did the aircraft that the same design teams now projected to satisfy Specification B.35/46—the Handley Page Victor and the Avro Vulcan.

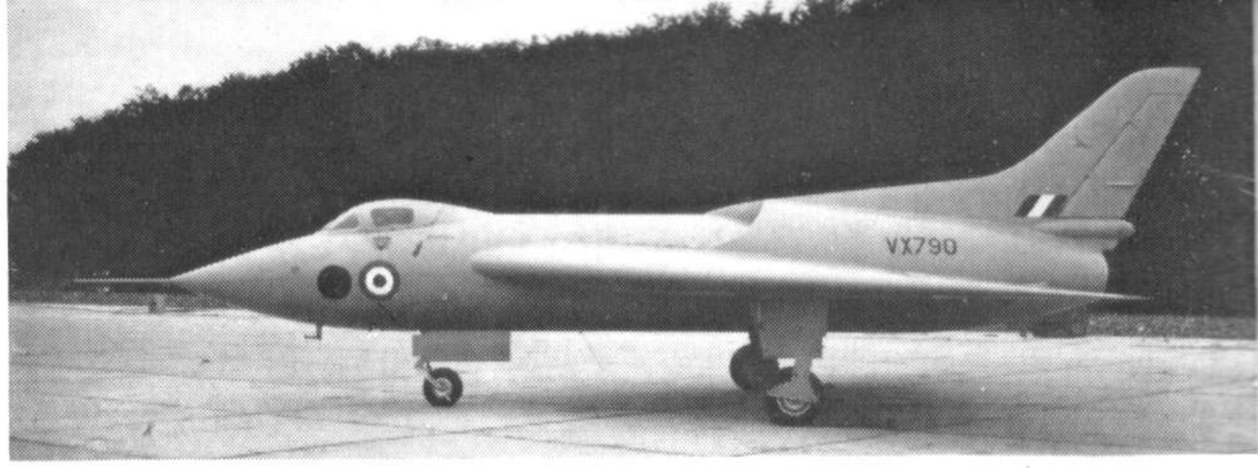
Both introduced new aerodynamic forms. The Victor's crescent wing represented an attempt to gain most of the advantages of a high angle of sweepback without too many of the disadvantages. Roy Chadwick went for less of a compromise, by combining extreme simplicity with the high potential performance and load-carrying capability offered by a delta wing. It was a courageous choice, as no powered delta had flown at that time and there was no shortage of critics predicting gloomily the control and stability problems that would result from the planned deletion of a tailplane and conventional elevators.

It seemed only common sense to flight test the delta configuration first on a small scale. So, while design study and wind tunnel work on the bomber continued, Avro built a series of small research aircraft of basically similar outline. The first of these was the Avro 707 (*VX784*), a single-seat all-metal mid-wing delta, with a dorsal air intake for its 3,500 lb.s.t. Rolls-Royce Derwent 5 turbojet. To speed construction, it utilised a Meteor cockpit canopy and the main undercarriage of an Avro Athena trainer. The 707 flew for the first time on 4th September 1949, piloted by S. E. 'Red' Esler, who took it to Farnborough two days later for static exhibition at the Tenth S.B.A.C. Display. Few who saw it there realised its true significance. *The Aeroplane* commented: "Whether the flying triangle becomes eternal remains to be seen." Sadly, this particular "triangle" proved far from eternal. On 30th September, before it was one month old, it crashed near Blackbushe and Esler was killed.

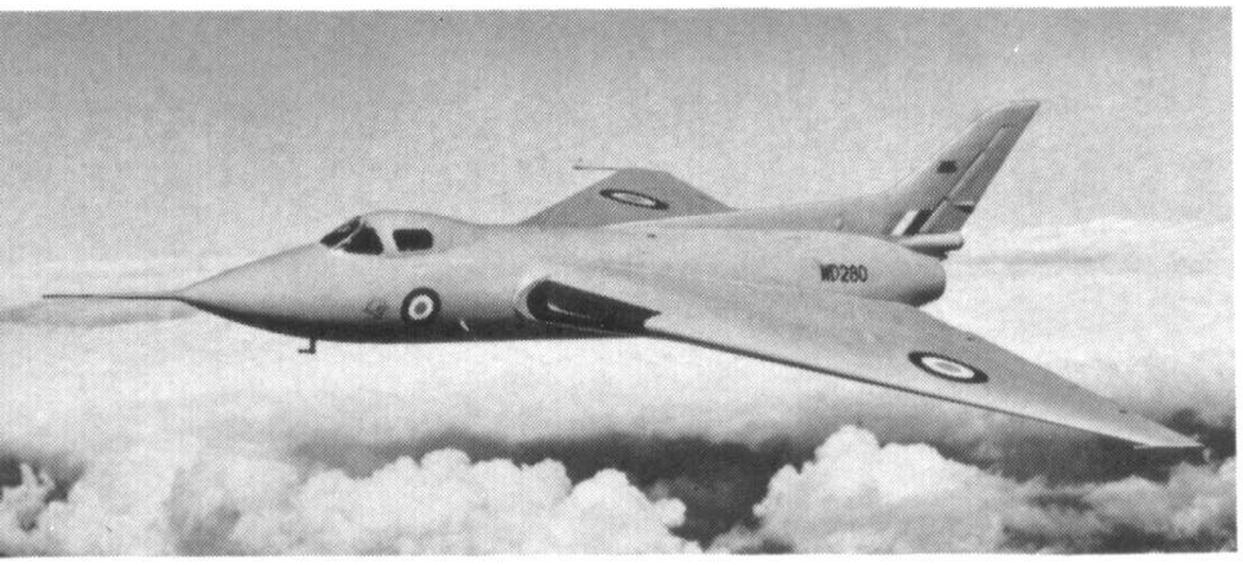
One year and two days after *VX784*, on 6th September 1950, the Avro 707B (*VX790*) was flown for the first time by R. J. Falk. Apart from a slightly longer nose and new cockpit canopy, there was little to distinguish it externally from its predecessor. The wings had a leading-edge sweep of 51 degrees, and a 9 in. longer nose-wheel leg (designed originally for the Hawker P.1052 fighter) was fitted to give them an increased angle of attack for take-off.

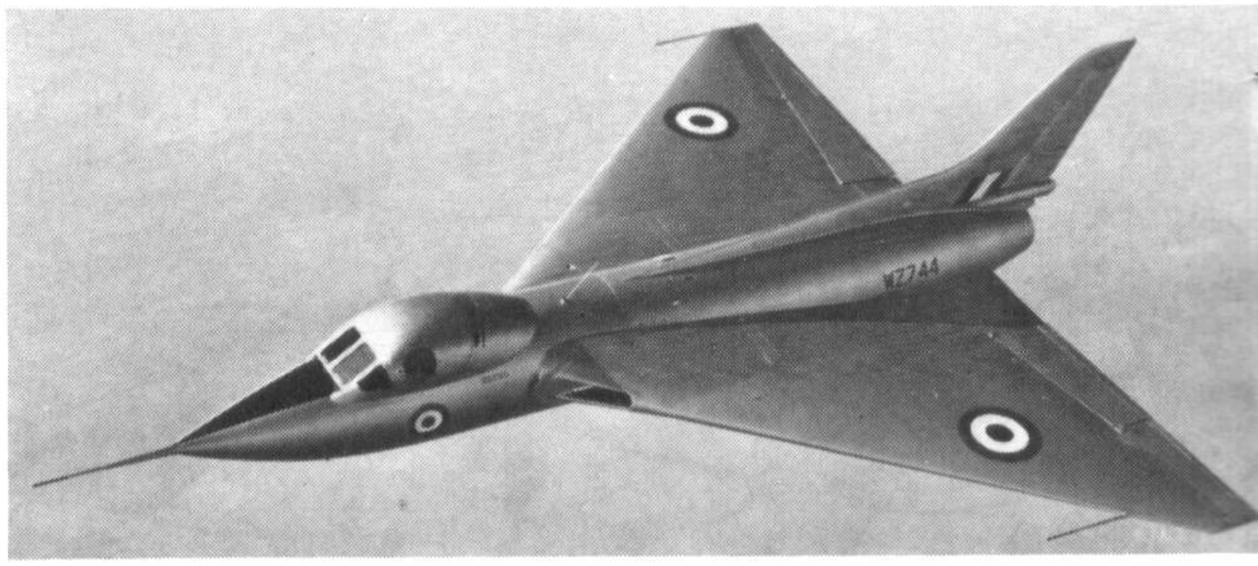
VX790 took part in the 1950 S.B.A.C. Display and then embarked on a lengthy and successful programme of research into the stability characteristics of the delta wing at comparatively low speeds. The first 100 hours of flight testing showed it to be so docile that many civilian and Service pilots were allowed to fly it, including Air Marshal J. N. Boothman, who had won the Schneider Trophy outright for Britain 20 years earlier.





Left: *The original Avro 707 prototype*, VX784, *which crashed on 30th September 1949, less than one month after its first flight, killing the pilot, S. E. Esler.* Right: *The Avro 707B*, VX790, *covered by Air Ministry Specification E.15/48, in its original form with a divided air intake for the Rolls-Royce Derwent turbojet.* (Photos: Ministry of Supply)





(Left) *The third machine*, WD280, *the first Avro 707A, which was later joined by a second 707A*, WZ736, *and* (right) *the last of the series, the side-by-side two-seat Avro 707C*, WZ744. (Photos: Avro)

Although nominally not a high-speed machine, the 707B was fast enough to run into problems when turbulence set up by its canopy, in front of the dorsal intake, caused air starvation of the engine. Redesign of the intake, with an open Vee-strake instead of the original divided entry, eased matters. A better solution was to switch to wing-root intakes and this was done on the third machine (*WD280*). Designated Avro 707A and intended for high-speed tests, this was flown for the first time, by Roly Falk, on 14th June 1951.

No attempt was made to achieve supersonic speeds with the 707A. This enabled its designers to avoid the necessity for vastly increased engine power and powered controls*: and, in any case, the full-scale bomber was intended to fly subsonically. Modifications to the control system included sealing the ailerons and elevators.

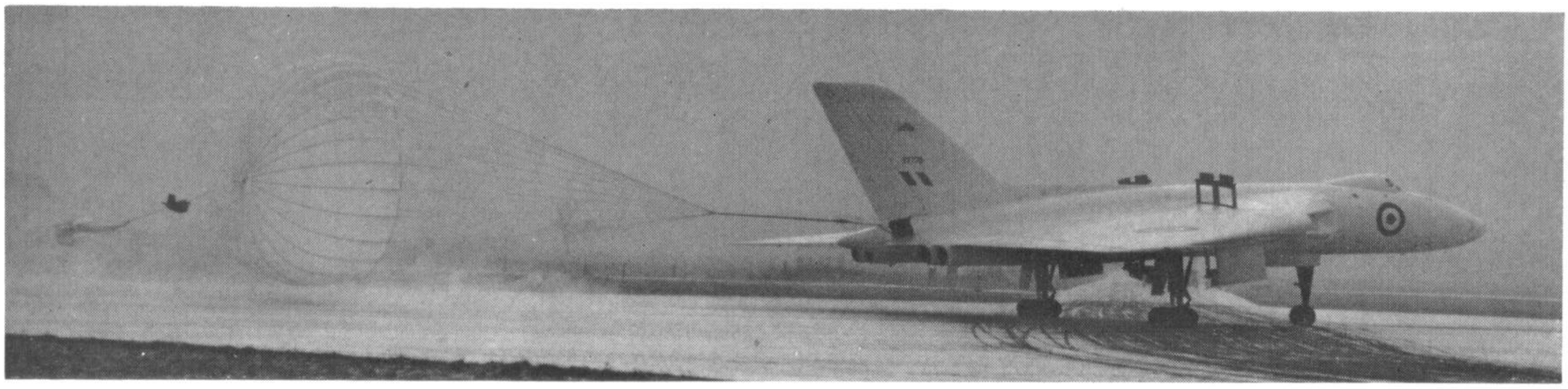
A second 707A (*WZ736*) joined the test programme on 20th February 1953, and was followed later in the year by the side-by-side two-seat 707C (*WZ744*). First flown on 1st July, this aircraft was intended as a trainer to familiarise pilots with the technique of flying a delta.

In its 707A form, the baby delta was virtually a one-third scale model of the Avro B.35/46 bomber. Its excellent performance, coupled with docile handling qualities, indicated that pilots would have little to fear from the latter once they had mastered the peculiarities inherent in a delta. This was made clear in the following description of the 707B's demonstration at the 1951 S.B.A.C. Flying Display, published in *The Aeroplane*:

"The Avro 707B proved a revelation to many

* *Fairey Hydro-booster controls were fitted later to a 707A, as part of the development programme for the Vulcan's powered flying controls. This aircraft was used by the R.A.E. as a research vehicle.*

The first prototype Avro 698 Vulcan, VX770, *showing the initial, undistorted delta wing planform.* (Photo: Avro)

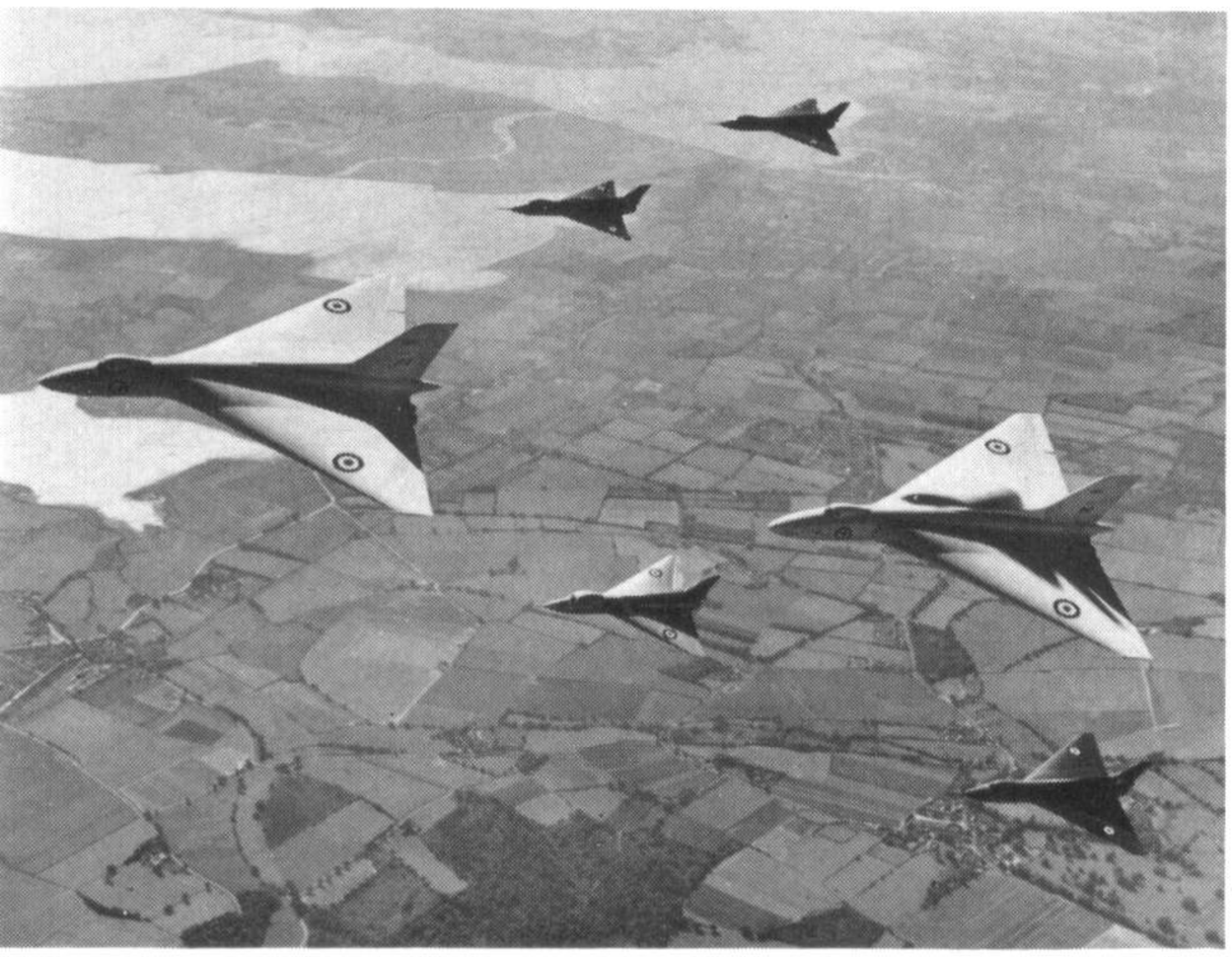


The first prototype deploying its braking parachute; this is the original non-ribbon type. Vulcans now use a ribbon type parachute. (Photo: Avro)

people for its amazing manoeuvrability over a wide speed range. Roly Falk made a prolonged inverted run, and did some of the most rapid rolls yet seen at Farnborough. One of the most effective of his demonstrations consisted of flicking the 707 from one vertical bank to another, showing not only a very high rate of roll, but also a markedly positive aileron control. In contrast, a slow run with dive-brakes extended and the nose right up proved that one of the chief bugbears of delta-wing design can be satisfactorily overcome.

"On his first landing, Roly Falk used the high lift and high angle characteristic of the delta-wing to bring the 707 in at a walking pace, at an angle of about 32 degrees, and without varying the attitude he opened up for another take-off. On his second landing he came at a rather flatter attitude, and released his tail parachute about 20 ft. above the runway, settling gently and pulling up in a very short space."

By this time, the prototype of the full-scale bomber was beginning to take shape, under the designation Avro Type 698. Roy Chadwick had not lived to see it. On 23rd August 1947, he had been killed when the prototype Tudor 2 airliner crashed during take-off from the company airfield at Woodford, Cheshire, due to incorrect assembly of the aileron controls. Chief designer S. D. Davies survived the accident and had the satisfaction on 27th November of learning that the Avro tender to meet Specification B.35/46 had been accepted.



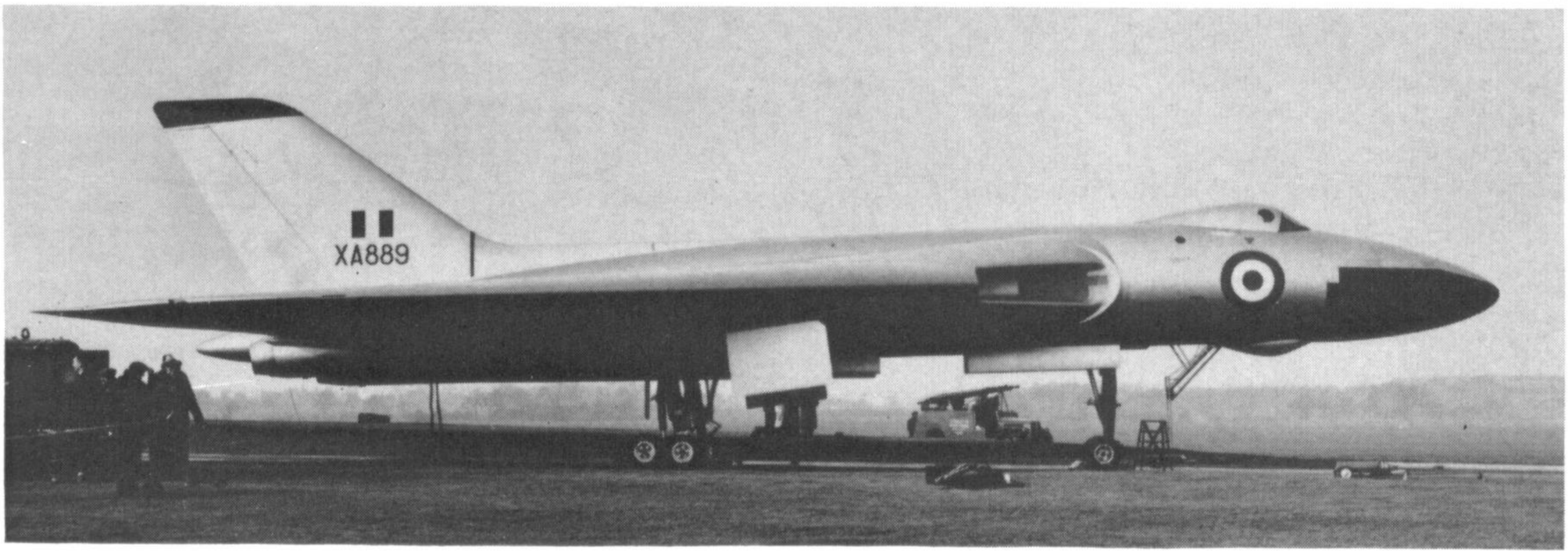
This famous photograph was taken at Farnborough in 1953 and shows all four surviving Avro 707's and the first two Vulcans, VX770 *and* VX777. (Photo: Avro)

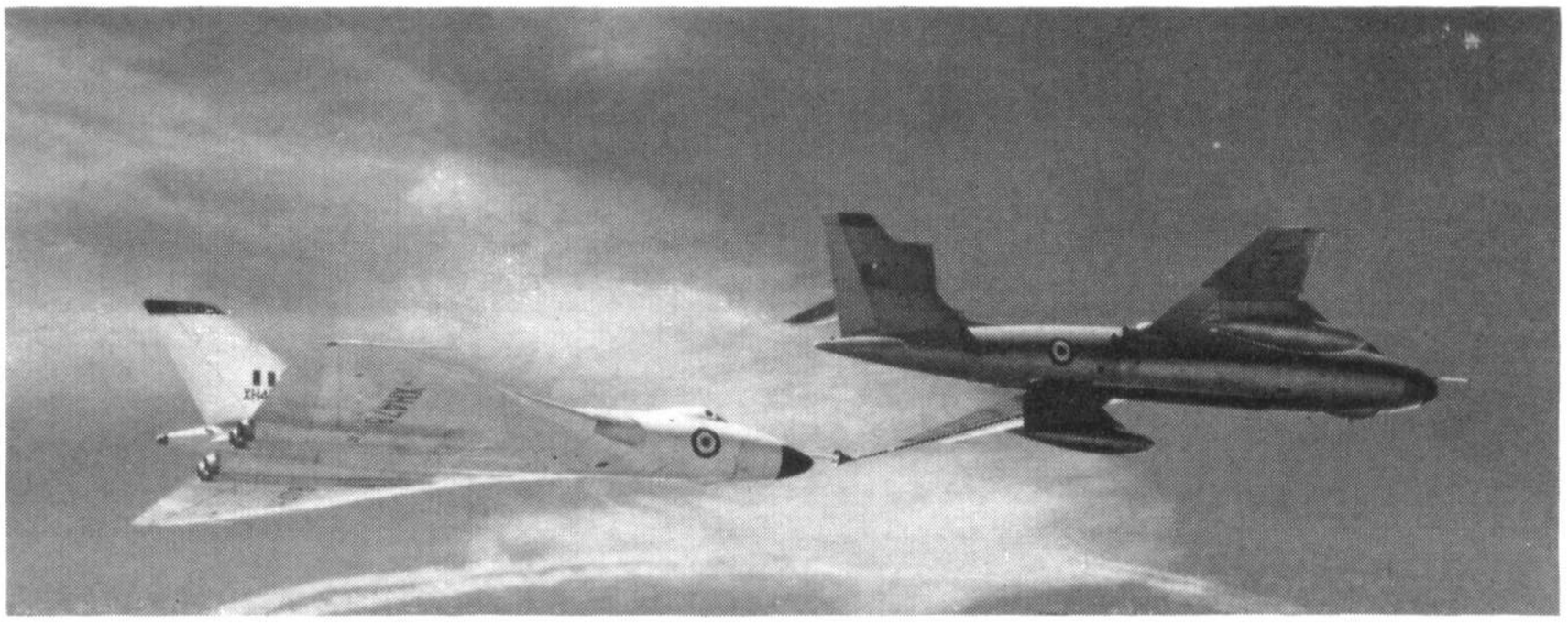
PROTOTYPE FOR A FIRE-GOD

The basic design of what was to become the Vulcan was completed in the following September, and an order for two prototypes was placed in January 1948. Despite a hotting up of the "cold war", exemplified by the Berlin blockade and Air Lift that started a few months later, and the Korean War that began in June 1950, the British government continued to show little interest in re-equipping first-line R.A.F. squadrons with really modern aircraft. Instead of taking the bold step of ordering the V-bombers into production while they were still on the drawing board, it let four years slip by and eventually had to accept 87 ex-U.S.A.F. B-29 Superfortresses of World War 2 vintage to supplement its equally-outdated Lincolns, in order to maintain even a semblance of a strategic bomber force.

A third strategic jet-bomber, the Valiant, had been developed as an "insurance policy" against failure

The first production Vulcan B.1, XA889. (Photo: Avro)





Vulcan B.1, XH478, *being flight-refuelled by a Valiant.* (Photo: Hawker Siddeley Aviation)

of the more advanced Avro and Handley Page designs. This was ordered into production in April 1951. By June of the following year, the international situation was such that production contracts for the two B.35/46 types could be delayed no longer and Avro received an initial order for the Vulcan B. Mk.1. This was not much of a gamble, as the prototype (*VX770*) was within two months of its first flight and, in any case, the series of small-scale 707s had proved the soundness of the basic configuration.

Nothing like *VX770* existed anywhere else in the world. The Specification to which it had been designed called for twice the speed and operating height of the piston-engined Lincoln, combined with longer range and greater weapon-carrying capacity. Nobody doubted that the weapons would eventually include atomic bombs; but the V-bombers were required to offer also a capability for conventional, non-nuclear warfare and Avro built into their design a bomb-bay large enough to house twenty-one 1,000 lb. high-explosive bombs, or mines for an anti-shipping rôle.

One of the advantages inherent in a delta-wing layout is that it offers a vast internal volume in which to pack fuel, engines, undercarriage and equipment. Even when using a comparatively high-speed aerofoil section, with a thickness/chord ratio of 10% at the centre-section/outer wing joint, the great chord of the Vulcan's wing ensured a depth of up to 7 ft. at the root. As a result, only the tail-pipes of the four turbojets protruded beneath the wing, reducing drag to a minimum, while the huge area of wing ensured a low wing loading, giving promise of good high-altitude performance.

Construction, generally, was conventional, with an all-metal two-spar stressed-skin wing and circular-section semi-monocoque fuselage. Even the controls were orthodox on the prototypes and Mk. 1 production aircraft, with two ailerons (outboard) and two elevators (inboard) on each wing and a normal rudder. Boulton Paul power units were fitted to all control surfaces, with Avro-designed artificial feel units.

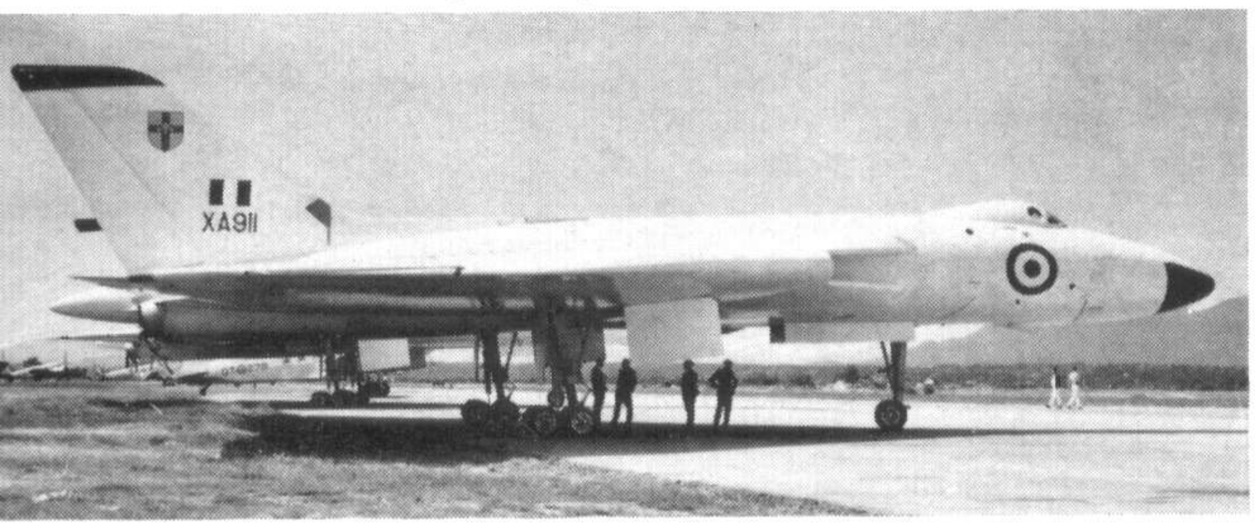
The braking effect of the wing at the high angle of attack assumed during landing made trailing-edge flaps unnecessary; but novel gate-type air-brakes (first tested on the Avro 707B) could be extended above and below the wing centre-section and a GQ parachute-brake was standard equipment.

A rather stalky undercarriage was fitted, to facilitate bomb loading. Of Dowty design, it consisted of a rearward-retracting twin-wheel nose unit and two four-wheel bogie main units, with two tyres per wheel, which retracted forward into the wings.

The front fuselage, forward of the wing-roots, consisted primarily of a pressure-cabin for the crew of five, with an under-belly entry hatch immediately forward of the nose-wheel leg. Pilot and co-pilot were seated side-by-side on Martin-Baker ejection seats, under a blister canopy. The air electronics officer, navigator and radar operator also sat side-by-side, facing rearward, on a lower level. No bombing radar was fitted in the prototype; nor was there provision for visual bomb-aiming.

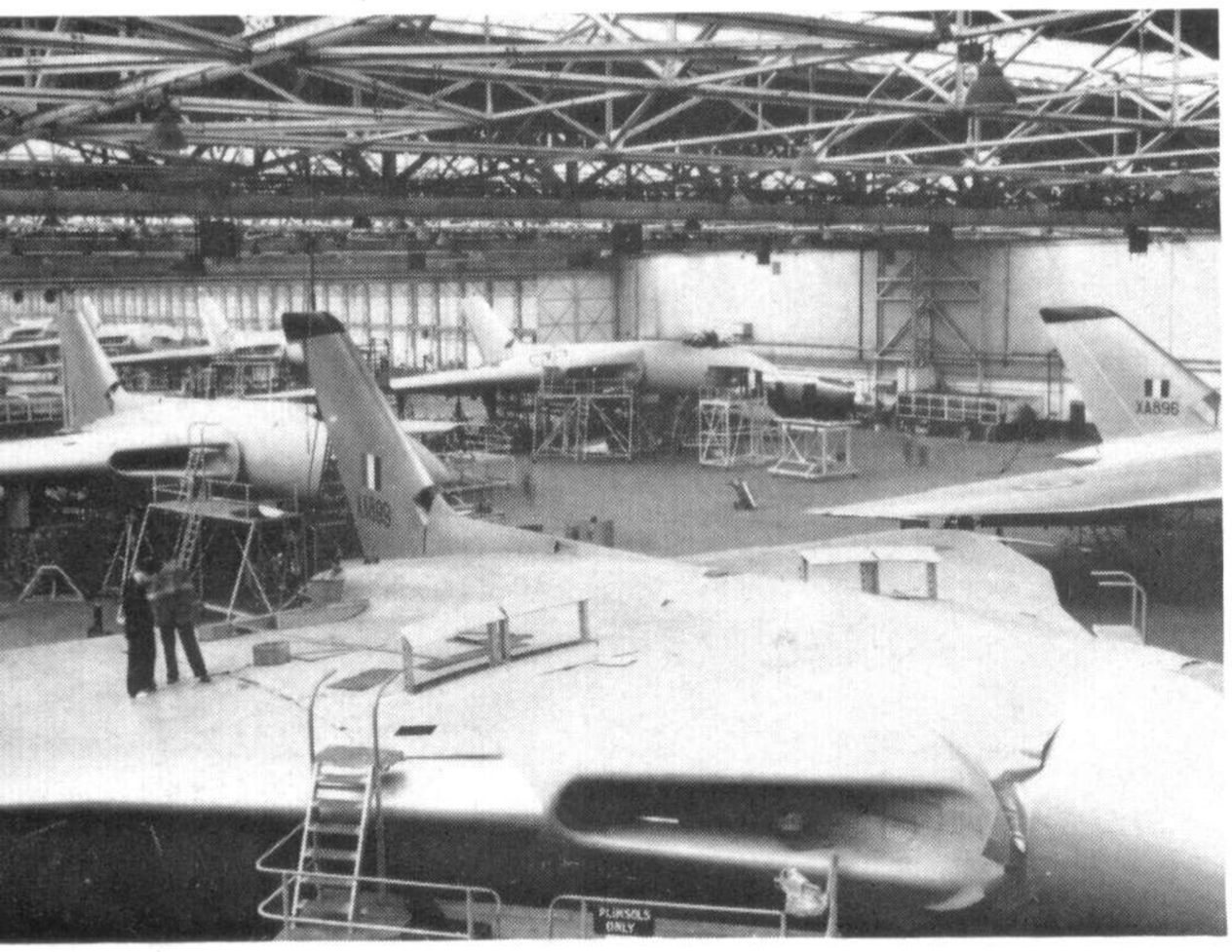
VX770 was ready for flight in advance of the Bristol B.E.10 (Olympus) two-spool turbojets around which it had been designed. As a result, when it flew for the first time on 30th August 1952, piloted by Roly Falk, it was powered by four 6,500 lb.s.t. Rolls-Royce Avon R.A.3s. When the 13th S.B.A.C. Display opened a few days later, the question on everyone's lips was whether the new bomber would put in an appearance. Once again, *The Aeroplane* summed up the answer in its Farnborough report:

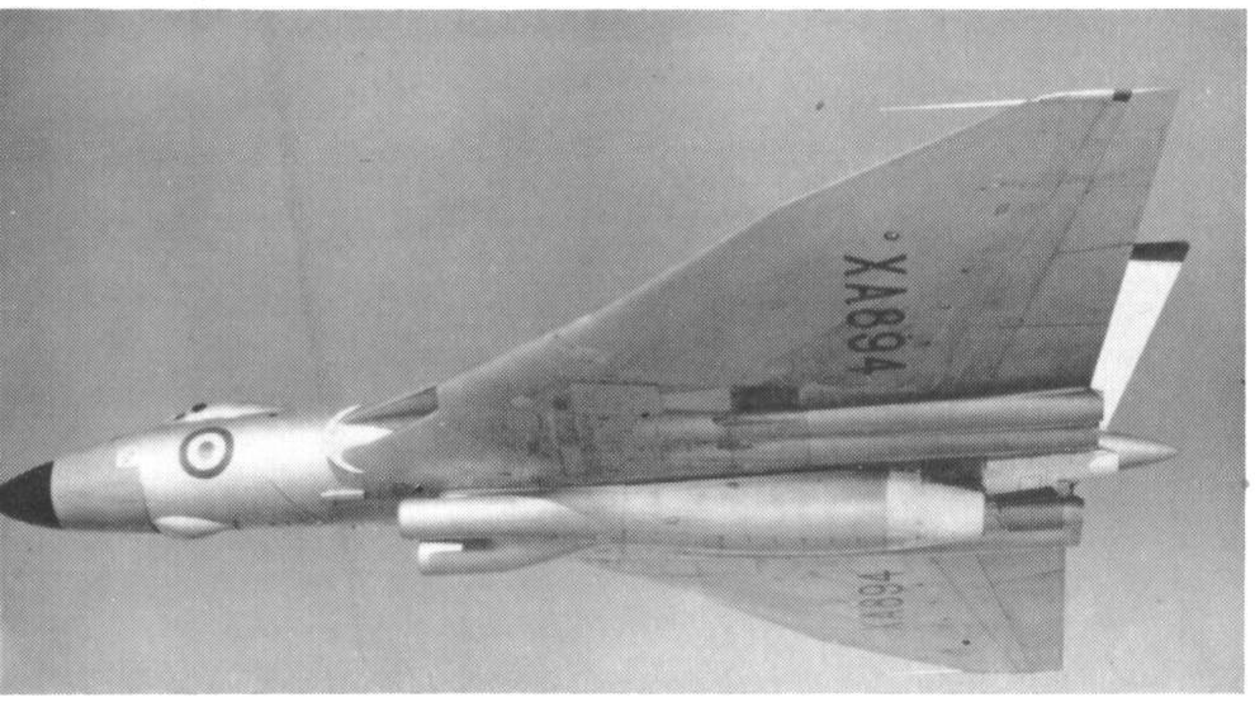
> "For a considerable time while the Hunter and Swift were in the circuit holding the public eye, it was possible to discern futuristic shapes circling on the horizon a few miles away. These shapes, which, despite the knowledge that they were terrestial, gave rise to eerie sensations and a feeling

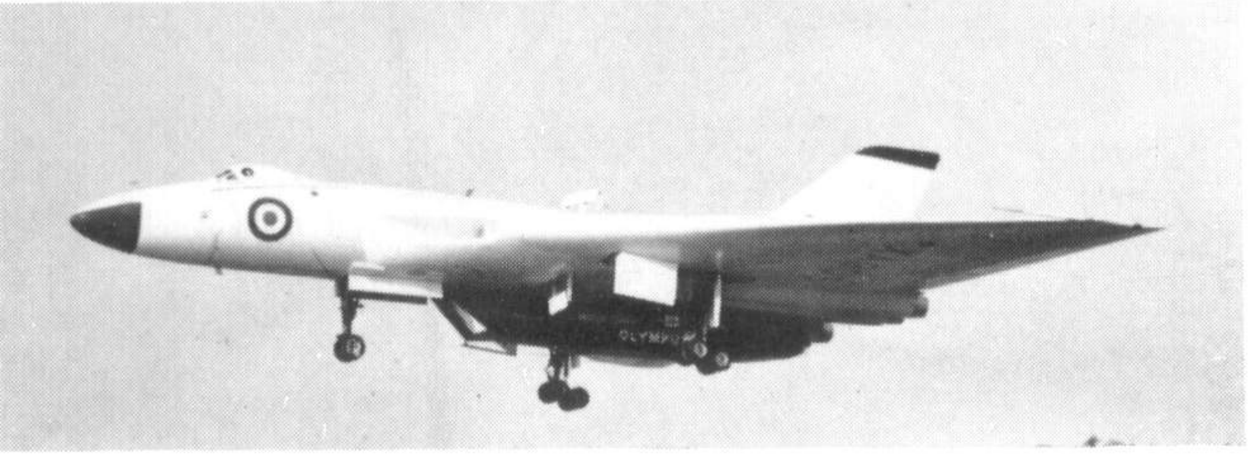


A Vulcan B.1 of No. 230 O.C.U. photographed in Canada. No. 230 O.C.U. loaned four aircraft to No. 83 Sqdn. in May 1957 before the latter unit received its own aircraft in July 1957. (Photo: via the author)

Part of the first batch of Vulcan Mk. 1's in production at Avro's Woodford factory. (Photo: Avro)







Above: *The ill-fated T.S.R.2 Olympus-Vulcan test-bed* XA894. Below: *The Olympus 593-Vulcan test-bed landing at Filton after its first test-flight.* (Top photo: Bristol Siddeley Engines)

that they were extra-terrestial, manned by species hitherto unknown to man.

"These shapes, at least the largest of the three, were the highlights of the 1952 exhibition; and when their turn came to display themselves they approached in patriotic formation, the majestic Avro 698 delta bomber (the name "Vulcan" had not then been announced) finished in glossy white, holding place of honour in the centre of the formation, flanked by the red Avro 707A on the one side and the blue 707B on the other.

"In view of the 698's vast size and unorthodoxy, it was remarkable to learn that Roly Falk was the sole occupant of the new bomber which, when viewed in the circuit . . . . resembled a giant stingray so common in tropical waters. Although the 698 had done less than three hours' flying when it first appeared at Farnborough, Falk handled it with what may be termed abandon."

This was but the first of several years in which Falk and the Vulcan earned star billing at Britain's then-annual air show. By the time *VX770* appeared at the 1953 Display it had been re-engined with four 8,000 lb.s.t. Armstrong Siddeley Sapphire A.S.Sa.6 turbojets. Nor was it alone, for visitors were able to watch the incomparable spectacle of six deltas—made up of two Vulcans and four of the 707s—take off in quick succession and sweep over the airfield in a "delta of deltas" in tight and perfect formation.

This finale to the flying programme was made possible by the first flight of the second prototype (*VX777*) on 3rd September, less than a week before the Show opened. This aircraft was fitted from the start with 9,750 lb.s.t. Olympus 100 Series turbojets. Also, although this was not readily apparent, its front fuselage was made slightly longer to avoid the necessity for shortening the nose-wheel unit prior to retraction.

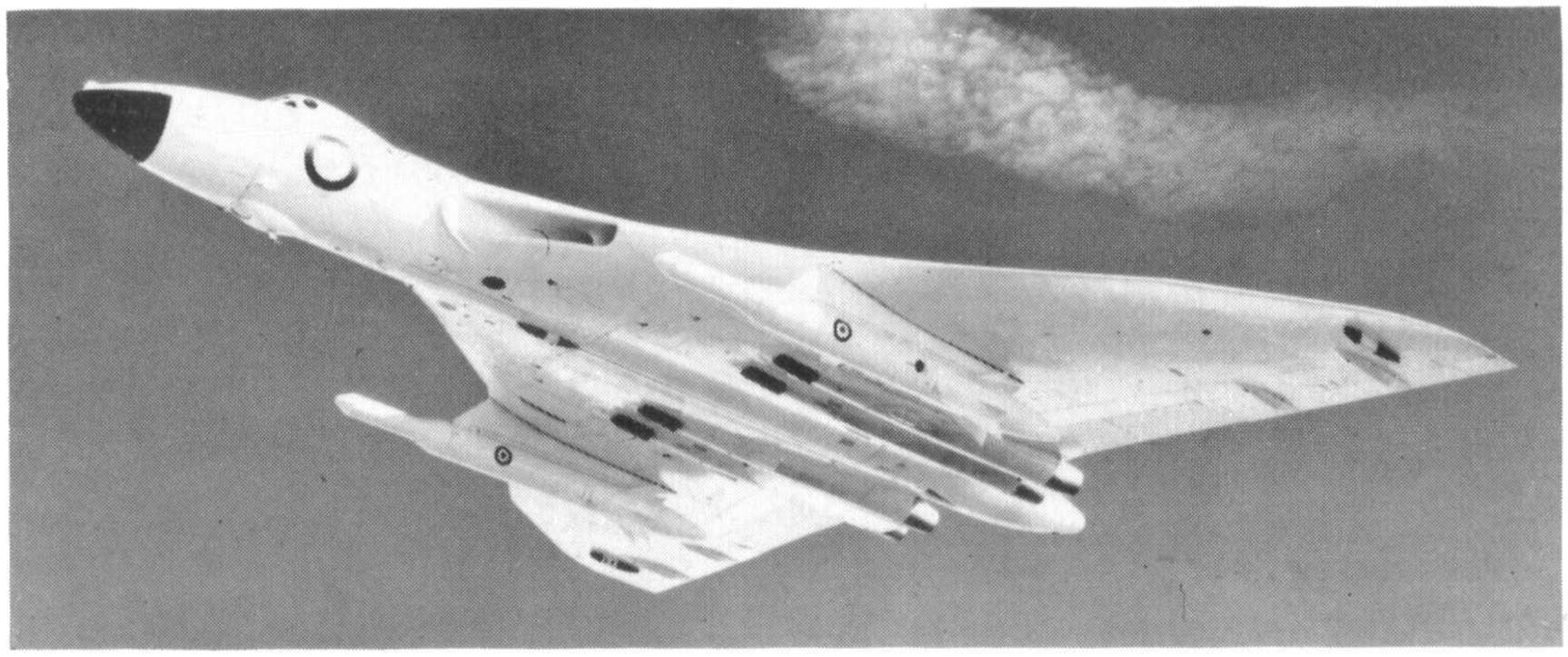
It was followed on 4th February 1955 by the first production Vulcan B. Mk. 1 (*XA889*), with 10,000 lb.s.t. Olympus 101s, and Roly Falk eclipsed even his earlier headline-making successes at Farnborough that year by slow-rolling the second production model (*XA890*). After that, nobody disputed the sturdiness, manoeuvrability or handling qualities of the bomber that was claimed to fly faster, higher and further, with a bigger load, than any of its predecessors.

Up to this time, the general appearance of the aircraft had undergone little change. *VX777* had introduced a small blister fairing under the nose, incorporating an optically-flat window panel for visual bomb-aiming. *XA889* had the lower part of its nose-cone made of double glass-fibre/Hycar sandwich, to house a navigation and bombing radar scanner.

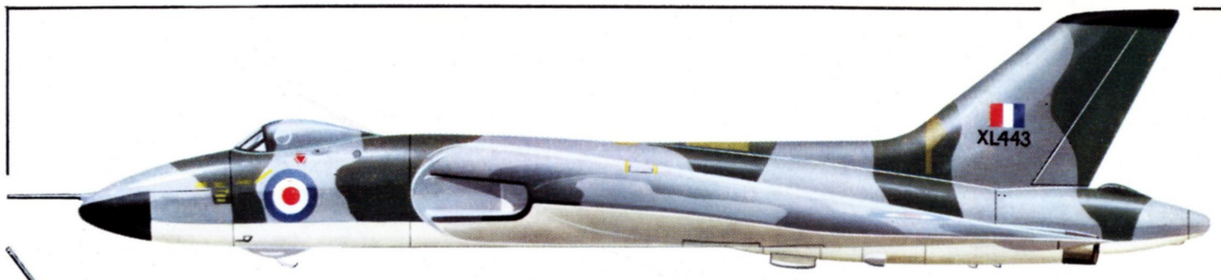
A far more obvious modification was flight tested for the first time on *VX777*, on 5th October 1955. Up to that time, all aircraft had been fitted with a simple delta wing with straight leading-edges, swept back at 52 degrees. Trials at the official Aeroplane and Armament Experimental Establishment, Boscombe Down, had shown that application of *g* at high altitude tended to initiate slight buffeting which might lead to fatigue failure of the outer wings.

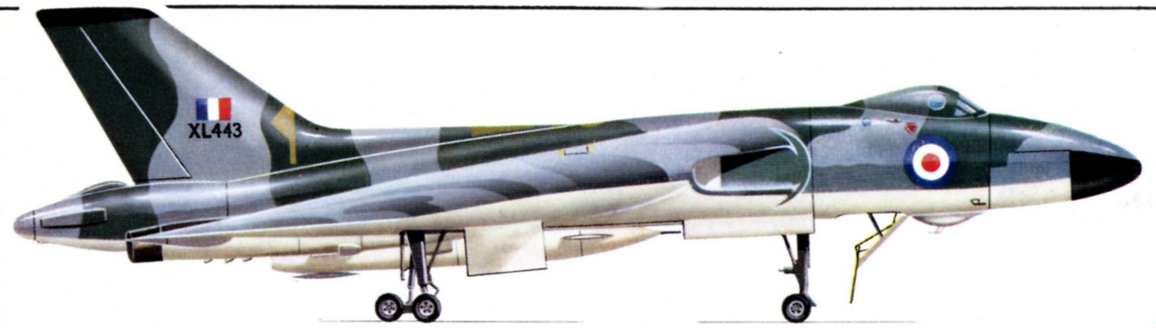
The remedy, although comparatively simple, changed the clean-cut lines of the wing and, if anything, made the Vulcan look even more sinister. It entailed decreasing the angle of sweep by 10 degrees at mid-span but restoring it again further outboard. The resultant compound sweep gave a 20 per cent. increase in chord from 78% span to the tip and delayed the onset of buffeting. The extension had a distinct droop and was accompanied on early production machines by a row of vortex generators above the wing to re-energise the boundary layer.

The handful of Vulcans that had been completed by then were modified to have the new wing-shape. When more powerful versions of the Olympus became available, they were introduced progressively without difficulty, as the design had allowed for considerable "stretch". Thus the B. Mk. 1 began life with 10,000 lb.s.t. (later 11,000 lb.s.t.) Olympus 101s, progressed (from engine set 14) to 12,000 lb.s.t. Olympus 102s and ended with 13,500 lb.s.t. Olympus 104s, to which standard the earlier engines were converted. With these, it had a maximum speed of around 625 m.p.h. (Mach 0·95) at 50,000 ft. and

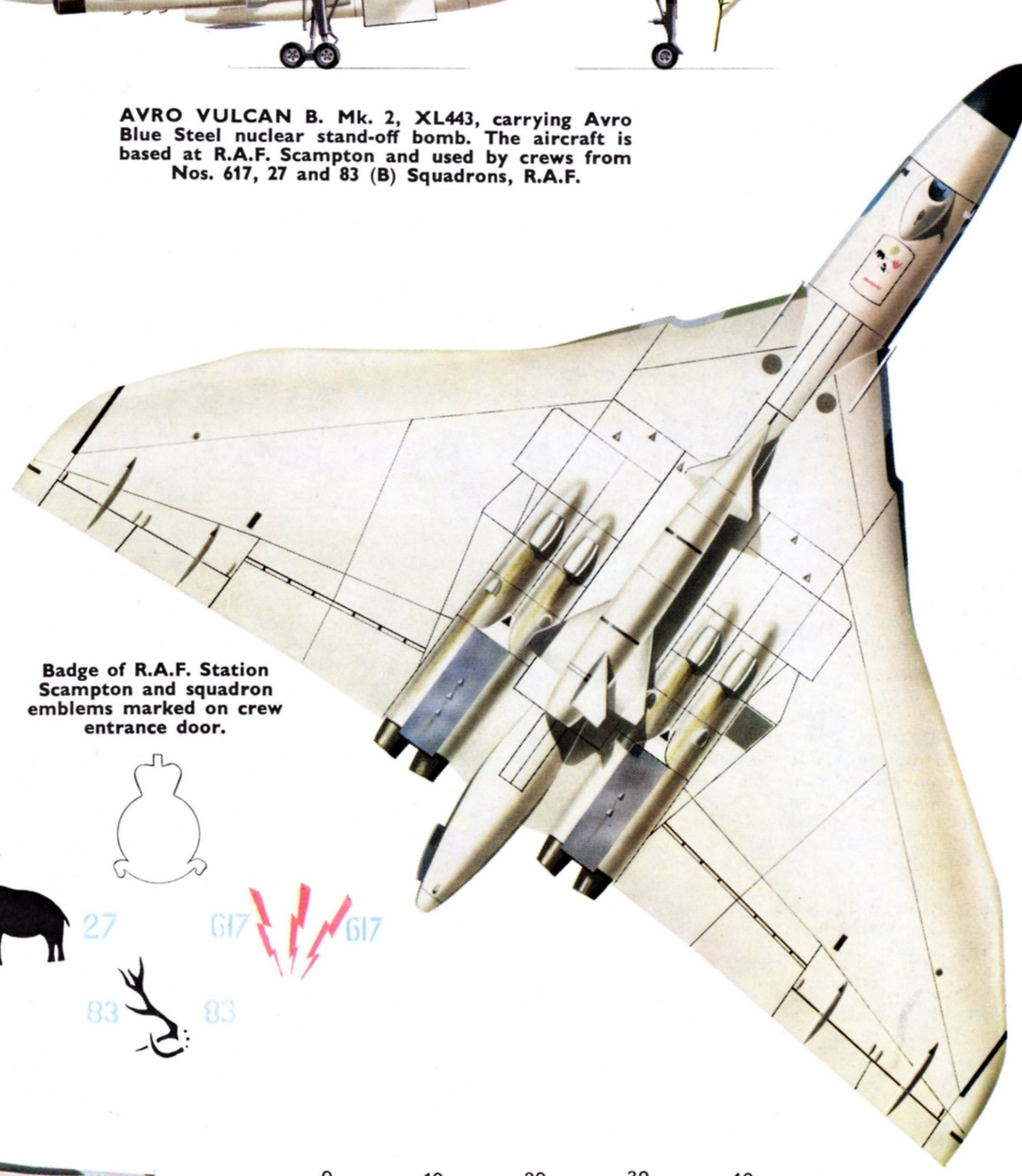


A Vulcan carrying two Douglas Skybolt aerodynamic test vehicles. (Photo: H.S.A.)



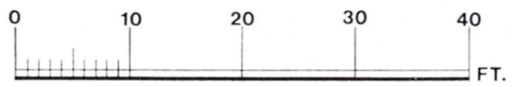


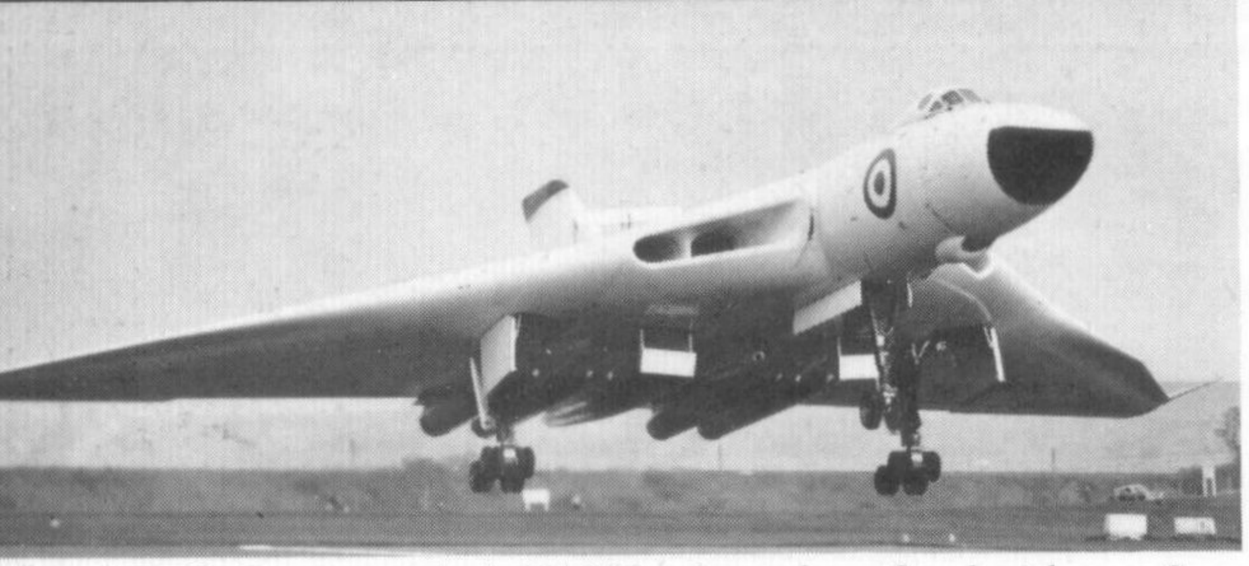
AVRO VULCAN B. Mk. 2, XL443, carrying Avro Blue Steel nuclear stand-off bomb. The aircraft is based at R.A.F. Scampton and used by crews from Nos. 617, 27 and 83 (B) Squadrons, R.A.F.



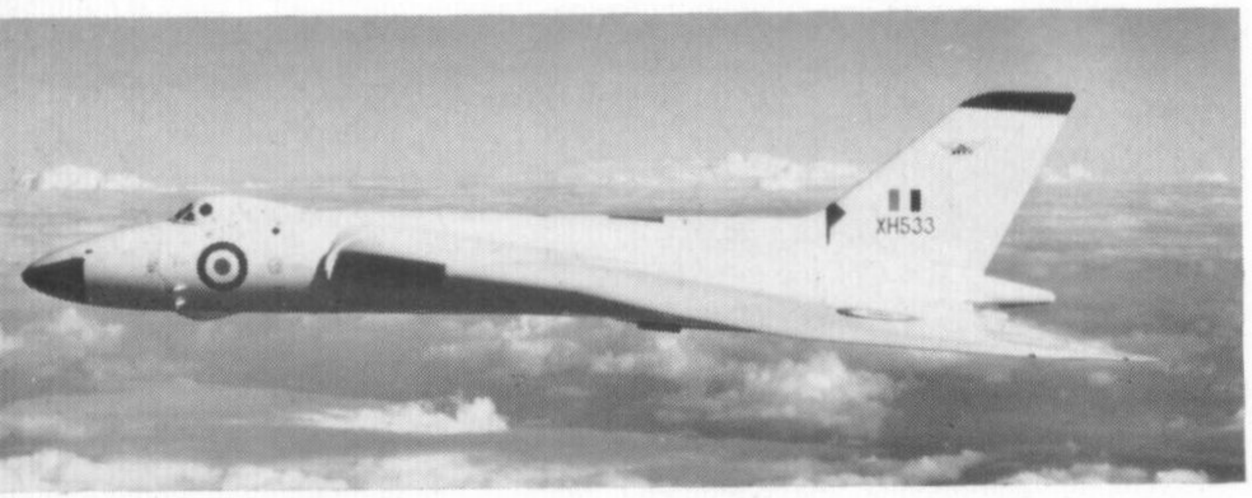
An enlarged view of the station badge.

Badge of R.A.F. Station Scampton and squadron emblems marked on crew entrance door.





Rolls-Royce test-bed, XA902, *shown here fitted with two Spey engines.* (Photo: Rolls-Royce)



XH533, *the first production B. Mk. 2.* (Photo: H.S.A.)

could cruise at 607 m.p.h. (Mach 0·92) at that height.

This made it virtually impossible to intercept, as attacking fighters would have had to fly at supersonic or transonic speed, at heights where they were difficult to control, and attempt to fire their guns or launch their missiles whilst doing so. In the light of such performance, it was considered unnecessary to fit any form of defensive armament. Little wonder that the R.A.F.'s V-bombers began to be regarded as a corner-stone of the Western deterrent force—particularly after the first live test of a British atomic bomb had been made from a Valiant, over Maralinga, South Australia, on 11th October 1956. Only seven months later, on 15th May 1957, Britain's first H-bomb was also dropped successfully from a Valiant in the Pacific. Clearly, whatever a Valiant could carry would fit easily into the larger Vulcan and Victor.

INTO SQUADRON SERVICE

After completion of acceptance trials in the Spring of 1956, Vulcan B. Mk. 1s entered service officially with No. 230 Operational Conversion Unit, at Waddington, on 22nd February 1957. No. 83 Squadron, the first operational Vulcan unit, also formed at Waddington, on 11th July 1957. It was joined subsequently by Nos. 101 and 617 ("Dambusters") Squadrons and the planned re-equipment of three Bomber Command squadrons with the Mk. 1 version was stated to be complete by the beginning of 1960.

It can hardly be said that the Vulcan got off to an auspicious start in its service career. Anxious to show off its new equipment, the R.A.F. despatched aircraft number *XA897* on a goodwill flight to Australia on 9th September 1956, with no less a person than the A.O.C.-in-C. of Bomber Command, Air Marshal Sir Harry Broadhurst, as co-pilot. At first all went well. Flying via Aden and Singapore, the aircraft linked Boscombe Down with Melbourne in less than a day, the actual time from take-off to touchdown being 23 hr. 9 min. Unfortunately, as it approached London Airport at the end of the return journey on 1st October, under ground control in poor visibility, the Vulcan touched down several hundred yards short of the runway. The pilot, Sqn. Ldr. D. R. Howard, managed to climb away but realised that he could not retain control and ordered the crew to bale out. Only Sqn. Ldr. Howard and Sir Harry Broadhurst survived.

The enquiry showed that there was no fault in the aircraft or its engines, and no reason to delay its deployment. But development progressed at such a pace that, in the event, only 45 Mk. 1 Vulcans were built.

The two factors which, more than any others, influenced this rapid development were the ever-increasing power of the Olympus engine and the necessity of providing a vehicle for the Blue Steel rocket-powered stand-off bomb, which was also an Avro product. Availability of the more powerful 200-Series Olympus and the greater deterrent potential offered by Blue Steel's thermonuclear warhead justified a major redesign of the bomber airframe and led to the Mk. 2 version.

NEW WING, NEW ENGINES, NEW MISSION

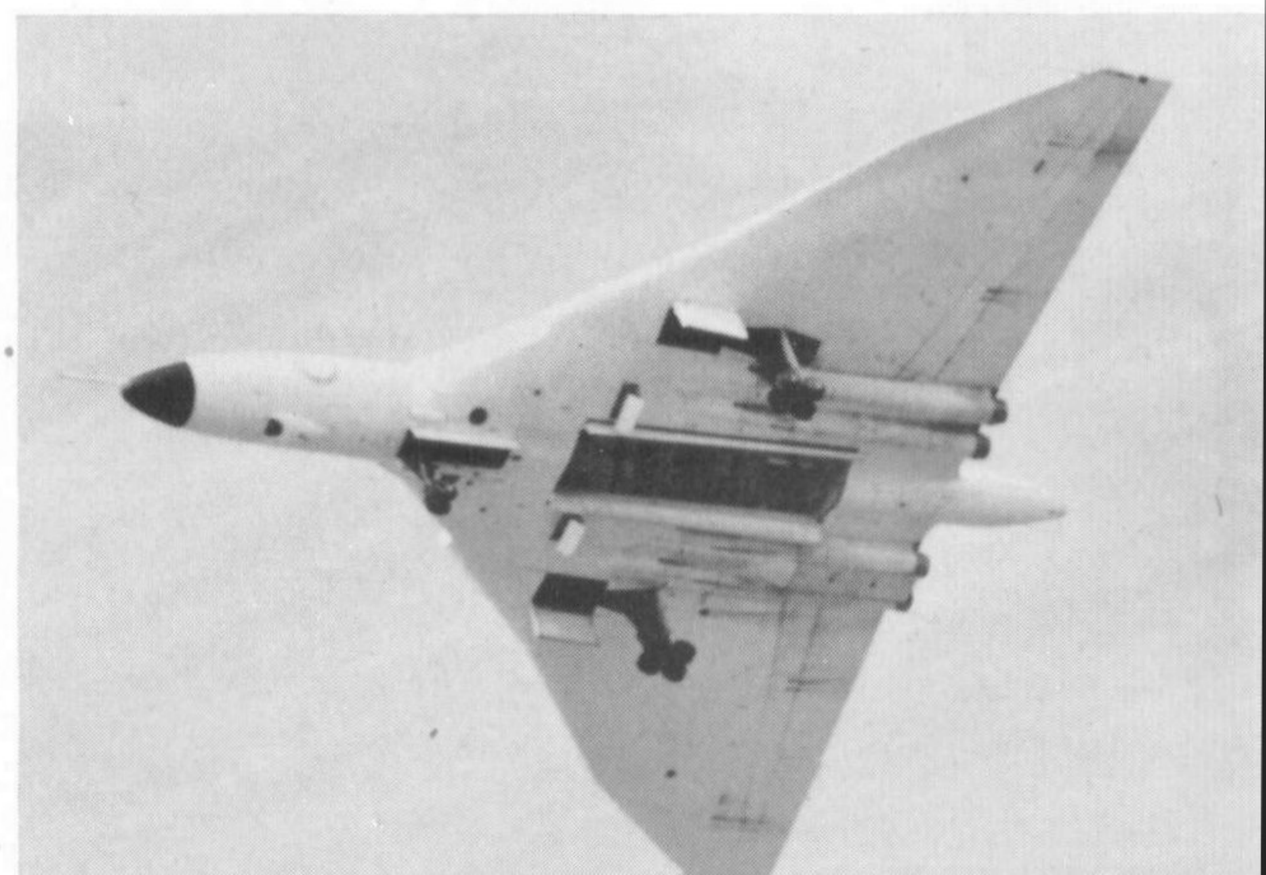
Even in its production form, with compound sweep, the Mk. 1 wing would not have permitted full advantage to be taken of the increased engine thrust. So a new wing was evolved, with an increase in span from 99 ft. to 111 ft. and with a substantially reduced thickness/chord ratio on the outer panels. It also switched to full-span elevon controls in place of the former ailerons and elevators.

As a first step, the larger wing was fitted to the second prototype Vulcan (*VX777*), which began flight trials in its new form on 31st August 1957. It was soon clear that, when allied to 200-Series Olympus engines, the wing would offer a still higher cruising speed and ceiling and would make higher *g* loads acceptable at height without fear of buffeting. So the Mk. 2 replaced the Mk. 1 on the assembly line, with the increased-span wing and 17,000 lb.s.t. Olympus 201 turbojets. A major change in the electrical system was also introduced on the Mk. 2, with a constant frequency 200-volt A.C. system replacing the Mk. 1's 112-volt D.C. system.

The first production Vulcan B. Mk. 2 (*XH533*) flew on 30th August 1958 and took part in the 1958 S.B.A.C. Display, together with a standard B. Mk. 1 (*XA891*), the second prototype (*VX777*) fitted with the Mk. 2 wing, and another B. Mk. 1 (*XA903*) which flew over the airfield without landing, with a Blue Steel development round clasped under its belly.

Initiation of the Blue Steel project implied recognition of the fact that Soviet defence systems were

Yawning gap: a view of the Vulcan's capacious bomb-bay. (Photo: via the author)



Right: *The third Vulcan B.2*, XH535, *flying in company with a U.S.A.F. Stratofortress over the U.S.A.* (Photo: via the author)

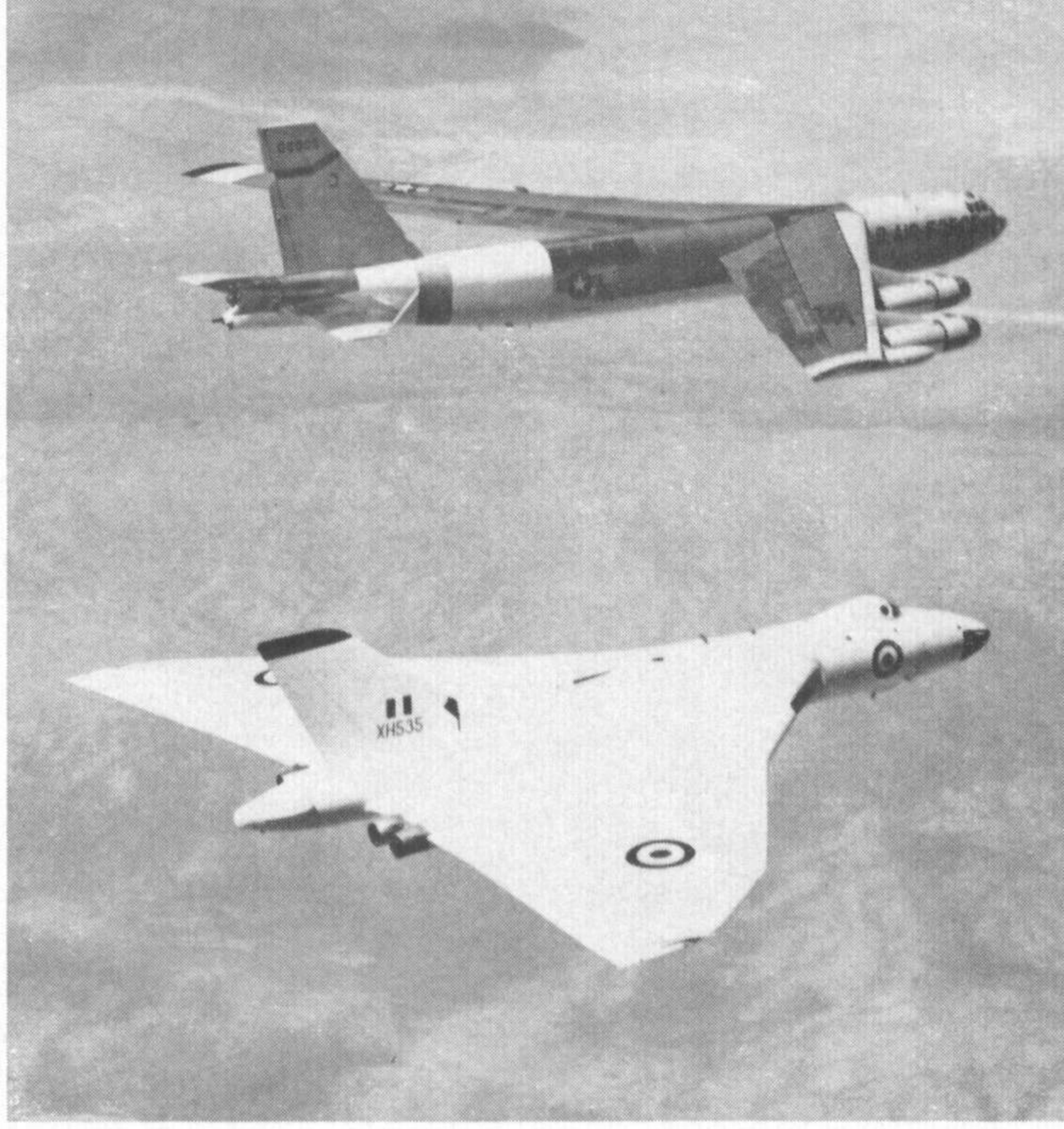
improving at a rate that, eventually, might rule out penetration to a target with conventional free-fall weapons. Further proof of Bomber Command's determination to stay one jump ahead of the opposition was given when the second production Vulcan B.Mk. 2 (*XH534*) was seen to have an extended and bulged tail-cone containing electronic countermeasures equipment and other devices to aid penetration of enemy defences. Even today, full discussion of such equipment is not permissible, but it has been stated that if a V-bomber flew across England with its countermeasures devices switched on, all radio and TV reception would be blanked out as it passed overhead. The effect on enemy early-warning radar and radar-guided interceptor aircraft and missiles can be imagined. Equally effective countermeasures against infra-red heat-seeking missiles are also carried.

First Squadron to receive Mk. 2 Vulcans, on 1st July 1960, was again No. 83, followed by No. 617. Their Mk. 1 aircraft were passed on to No. 44 and 50 Squadrons which, with No. 101, continued to fly this version in 1966. The planned major improvement in the operational capability of the Vulcans was brought nearer in the Summer of 1962, when genuine production Blue Steel missiles were delivered to No. 617 Squadron for operational development trials. All went well and in February 1963 Blue Steel was declared operational with this unit, at R.A.F. Scampton. The other two Vulcan Mk. 2 squadrons at that station, Nos. 27 and 83, were stated to be well advanced with their training in the operation of the missile at that time.

Other squadrons known to be equipped with the Vulcan B. Mk. 2 at the beginning of 1967 include Nos. 9, 12 and 35. No. 50 is also reported to have exchanged its Mk. 1s for the newer version. Late production Mk. 2s have 20,000 lb.s.t. Olympus 301 turbojets and early models are being retrofitted with these engines, which enable the maximum possible performance to be extracted from the airframe. Precise figures are secret, but there is good reason to believe that the Vulcan B. Mk. 2 has a maximum speed of 645 m.p.h. (Mach 0·98)—which is about as near to Mach 1 as one can get without going supersonic—and can cruise at 620 m.p.h. (Mach 0·94) at 55,000 ft. Its normal combat radius is 2,300 miles when delivering an attack at high altitudes, or 1,725 miles when it has to descend to low altitudes for the final stages of an attack. A single flight refuelling, for which all Mk. 2 Vulcans are equipped, increases the maximum combat radius to 2,875 miles.

In practical terms, this made possible the claim a few years ago, that Bomber Command could, by itself, wipe out 70 per cent. of the worthwhile targets in the Soviet Union with a single raid.

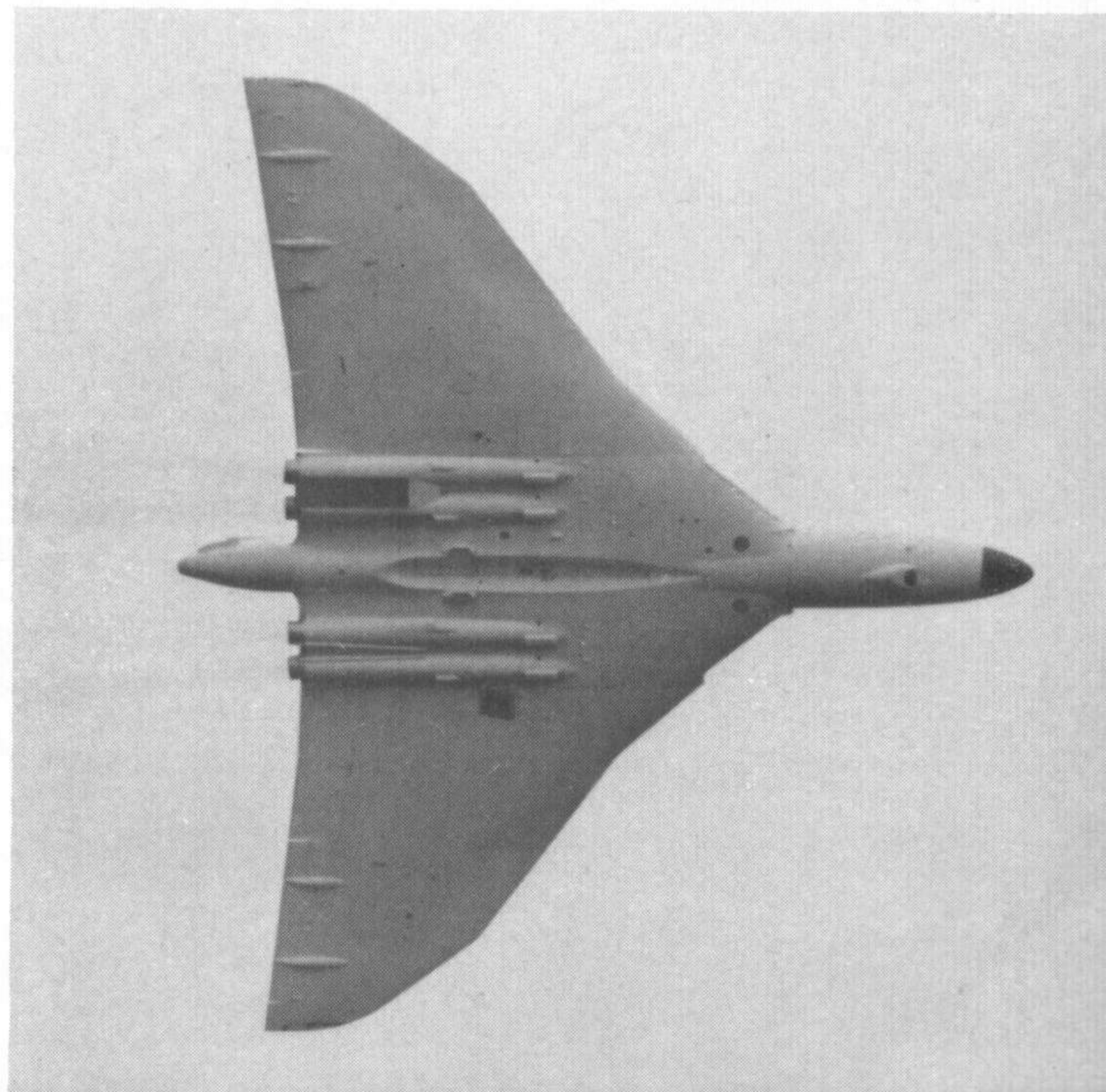
Following cancellation of the Blue Streak long-range ballistic missile in April 1960, it was planned to extend the capability of the Vulcan B. Mk. 2 by adapting it to carry a Skybolt air-launched ballistic missile under each wing. An aircraft from No. 83 Squadron went to the U.S.A. early in 1961 for non-flying compatibility tests with mock-up Skybolts. In England, *XH538* flew with ballistic dummies, which were dropped during test flights, and also carried an instrumented round on flight trials. But yet another change of policy in December 1962 led to cancellation of the Skybolt programme in favour of the submarine-launched Polaris.



In the face of the growing effectiveness of Soviet surface-to-air missiles, it became necessary in 1964 to extend the versatility of the Vulcan B. Mk. 2 and the Blue Steel, to permit penetration of enemy territory and launching of the missile at extremely low altitudes. After modification, the aircraft were given a coat of camouflage over their upper surfaces to make detection by defending interceptors more difficult.

Nor have the surviving Mk. 1s been allowed to become outmoded. In 1961, they were fitted with a countermeasures tail-cone similar to that of the Mk. 2, in which form they were redesignated B. Mk. 1A.

Production of the Mk. 1 ended with the delivery of aircraft No. *XH532* in April 1959. The last Mk. 2 was delivered in late 1964. But this last great R.A.F.



Right: *The underside of a Vulcan B.2 equipped to carry the Blue Steel stand-off bomb.* (Photo: S. P. Peltz)

An impressive line-up of B. Mk. 2's of the Scampton Wing. (Photo: Ministry of Defence)

long-range bomber is likely to remain an effective weapon well into the 1970s, although its rôle will be primarily tactical after about 1969.

No Vulcan has ever delivered a weapon in anger, but this is a paradox as the very presence of such a deterrent has played a major part in averting a third World War. The potential of the V-bomber force has been demonstrated frequently, with particular emphasis on its capability of rapid deployment to any spot on earth in under a day. In April 1961, a Vulcan of No. 617 Squadron covered the 8,500 miles between Britain and Karachi non-stop—with flight refuelling—in 17½ hours. Using the same technique, another linked Scampton and Sydney non-stop in 20 hr. 3 min. three months later. A third crossed the Atlantic from Goose Bay to Scampton in 3 hr. 46 min. at an average speed of 656 m.p.h. in 1962.

In "Western Ranger" flights to America, Mk. 2 Vulcans shattered the confidence of the U.S. Defense Department by penetrating the entire U.S. defensive network without interception or even detection.

When it was implied that Bomber Command was outdated in a missile age, a new concept of dispersal and quick reaction was worked out. Under this, the V-bomber squadrons would disperse in flights of four aircraft to a large number of scattered airfields at the first hint of a forthcoming emergency. There, they would be held at instant readiness, with crews on board, weapons loaded and engines ready to start. From such a state of preparedness, the whole V-bomber force could be airborne within about 150 seconds of receiving the order to take off. Such, still, is the effectiveness of this deterrent, for even the highest-performance missile would take at least four minutes to reach Britain and its launching would not go undetected.

PROJECT WORK

So much for the operational career of the Vulcan. Availability of such an airframe has, inevitably, led to its extensive use as a flying test-bed for engines and equipment.

Three Vulcans from Nos. 9, 12 and 35 Squadrons, seen during a fly-past following the granting of the Freedom of Boston, Lincs. to R.A.F., Coningsby in 1963. The leading aircraft from No. 9 Squadron continued the flight to Boston, Massachusetts conveying greetings to the Mayor there.

(Photo: via A. Price)

First machine utilised in this way was the original prototype (*VX770*) which was fitted with four 15,000 lb.s.t. Rolls-Royce Conway R.Co.5 turbofans in 1957. It was one of the very few Vulcans to meet an unhappy end, on 20th September 1958, when it broke up during a high-speed low-level fly-past at the Battle of Britain Day Display at Syerston, after logging more than 800 flying hours as an engine test-bed.

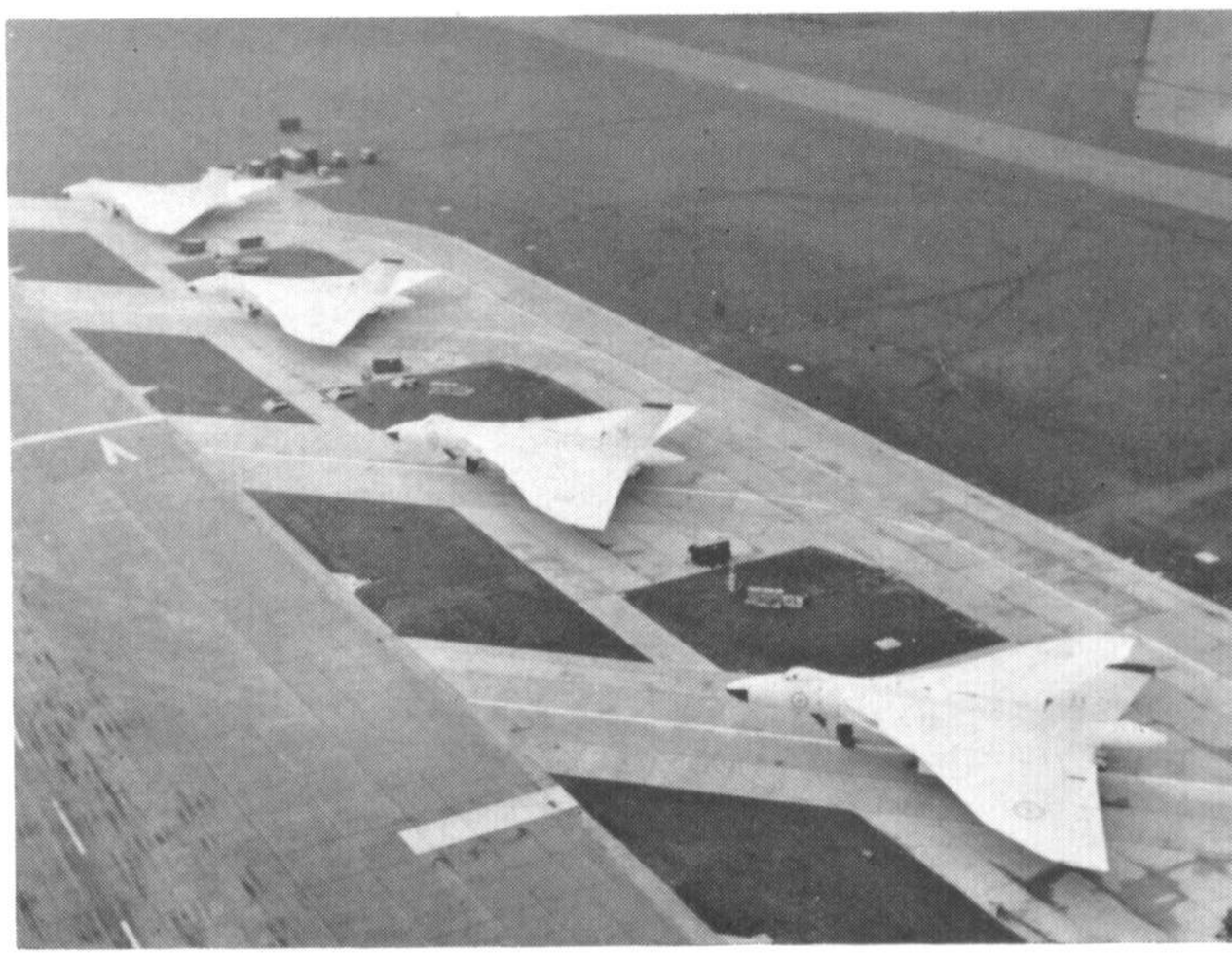
Its successor was a production Vulcan 1 (*XA902*) which completed a 1,000 hr. endurance programme with the Conway R.Co.11. The same aircraft was then used for Spey development, flying for the first time on 12th October 1961 with Conways in the outboard positions and Speys inboard.

Another Mk. 1 was adapted to flight test the supersonic version of the Olympus turbojet that was under development for the TSR.2 tactical strike/reconnaissance aircraft. In doing so, it became the first five-engined Vulcan, as the Olympus was slung under the fuselage in a specially designed pod and was fed through bifurcated air intakes positioned as they would be on the actual TSR.2. After 100 hours of test flying, this aircraft (*XA894*) caught fire on the ground at Filton on 3rd December 1962 and was destroyed.

Yet another Vulcan B. Mk. 1 (*XA896*) was being converted as a flying test-bed to carry the Bristol Siddeley BS100 vectored-thrust turbofan engine specified for the Hawker Siddeley P.1154 fighter, but never flew in this form as the P.1154 programme was cancelled in 1964.

A B. Mk. 2 (*XH557*) has been used by Bristol Siddeley for routine engine development, its ability

A close-up of B. Mk. 2 XL385 *of No. 9 Sqdn. showing the extended tailcone housing R.C.M. equipment.*



Four Vulcan B.2's on their O.R.P.'s (Operational Readiness Platforms) angled into the side of the runway to speed "scrambling". (Photo: M.o.D.)

to cruise just below the speed of sound at extreme heights making it an invaluable tool for research. Nor has the Vulcan by any means reached the limit of its usefulness in this rôle, for a Vulcan B. Mk. 1 (*XA903*) is now serving as a flying test-bed for the Concord's Olympus 593 engine, which is installed in an under-belly replica of one of the engine ducts that will be fitted in this Anglo-French supersonic transport.

Another Mk. 1 aircraft (*XA890*) was employed by the Blind Landing Experimental Unit at R.A.E. Bedford for development work on automatic landing systems, and is still in use for that purpose and for testing allied systems. Some Mk. 2 aircraft are fitted with Autoland systems, although these are not to the triplicated standard installed in civil aircraft such as the Trident. It would be correct to say, however, that *XA890* contributed to perfection of the commercial systems now in use.

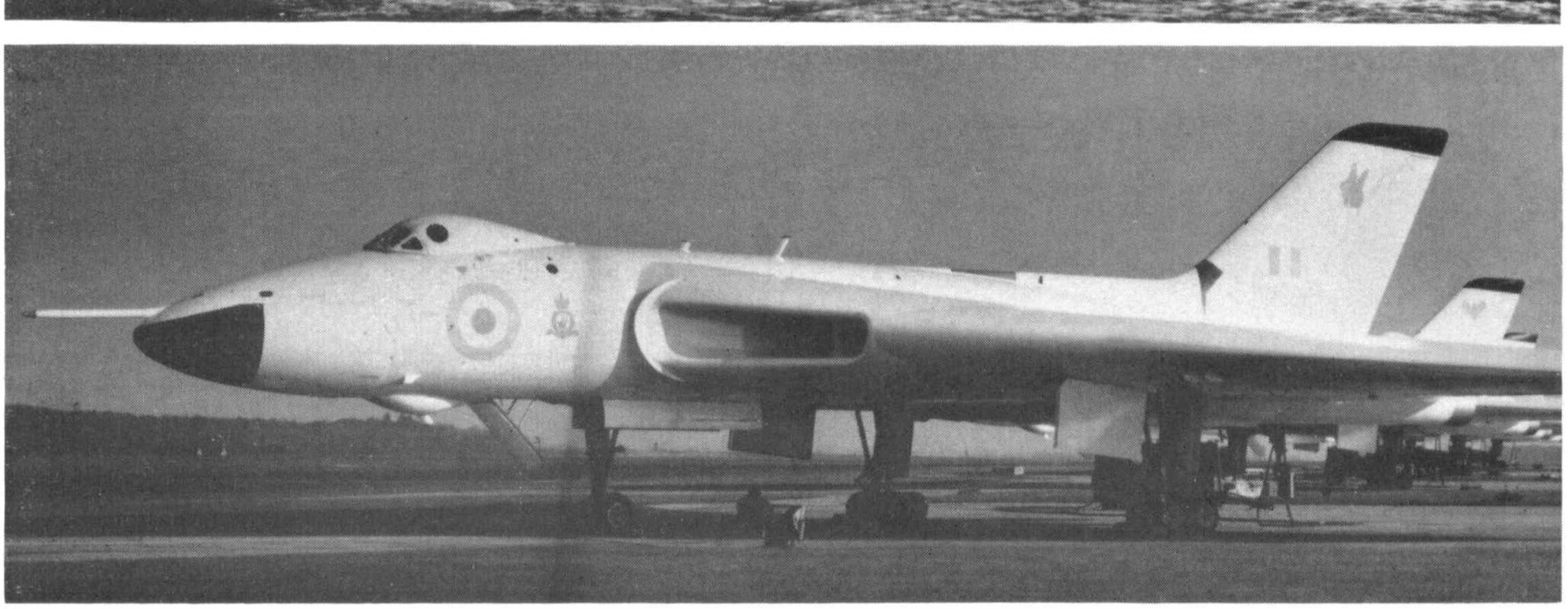
Thus, while remaining the ultimate peak of achievement in subsonic bomber design, the Vulcan is also helping to pave the way for an entirely new era of airline flying. For better or worse, it has also outlived the supersonic bombers that were once intended to replace it.

SERIAL NUMBERS

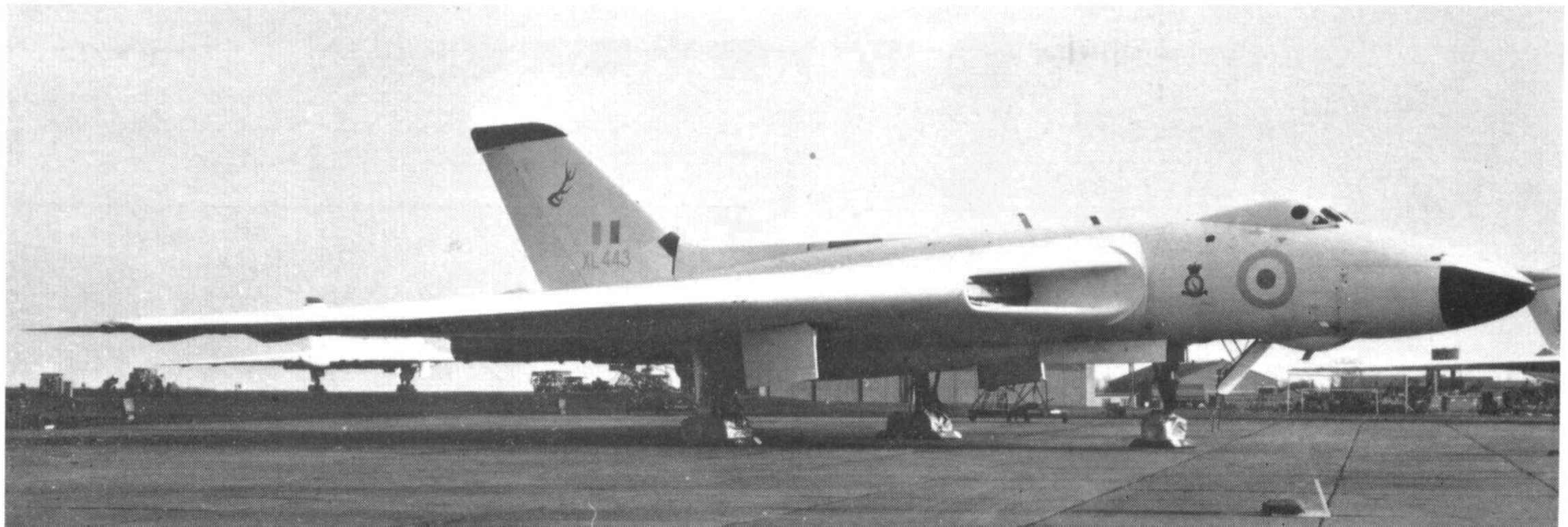
Prototypes: *VX770* and *VX777*
B. Mk. 1/1A: *XA889–XA913*, *XH475–XH483*, *XH497–XH506*, *XH532*.
B. Mk. 2: recorded serials include *XH533–XH538*, *XH554*, *XH557–XH563*, *XJ780–XJ783*, *XJ823–XJ825*, *XL317*, *XL361*, *XL388*, *XL389*, *XL443*, *XL449*, *XM569–XM573*, *XM598*, *XM603–XM611*, *XM635*, *XM645–XM657*.

DIMENSIONS

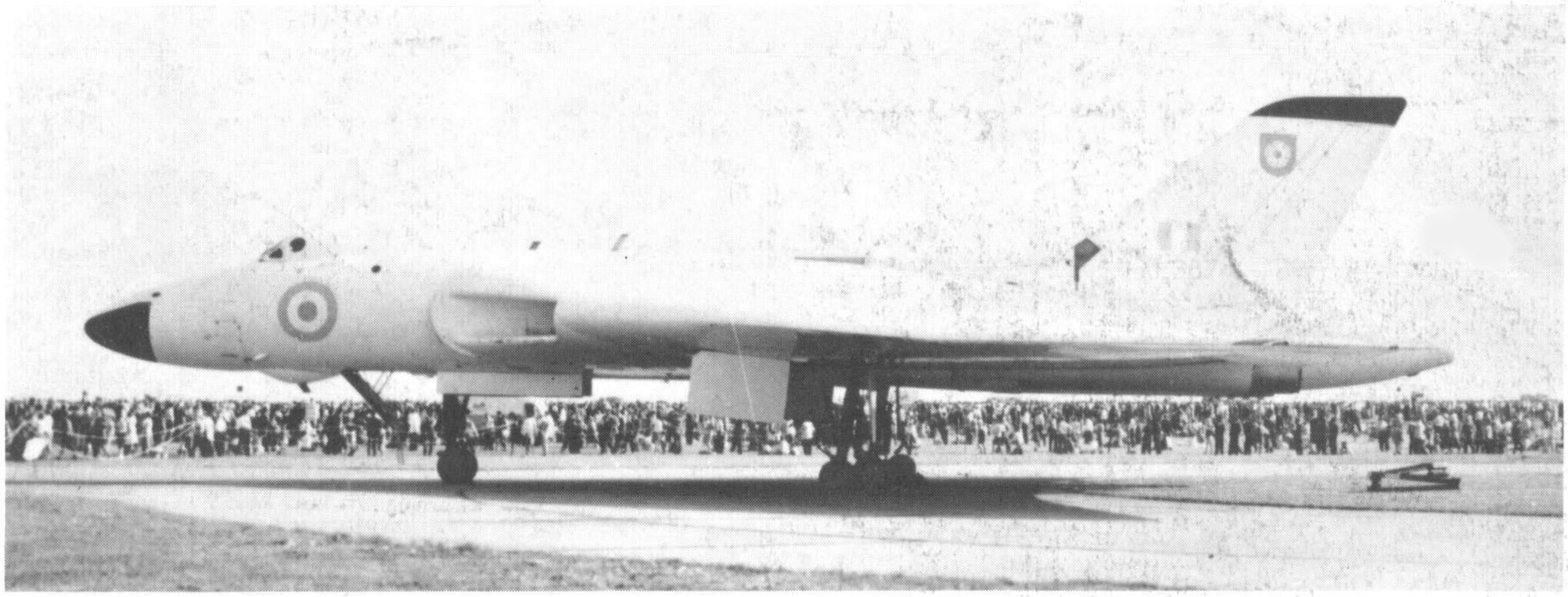
	B. Mk. 1	*B. Mk. 2*
Wing span	99 ft. 0 in.	111 ft. 0in.
Length overall	97 ft. 1 in.	99 ft. 11 in.
Height overall	26 ft. 1 in.	27 ft. 2 in.
Wing area (gross)	3,554 sq. ft.	3,964 sq. ft.
Aspect ratio	2·78	3·1

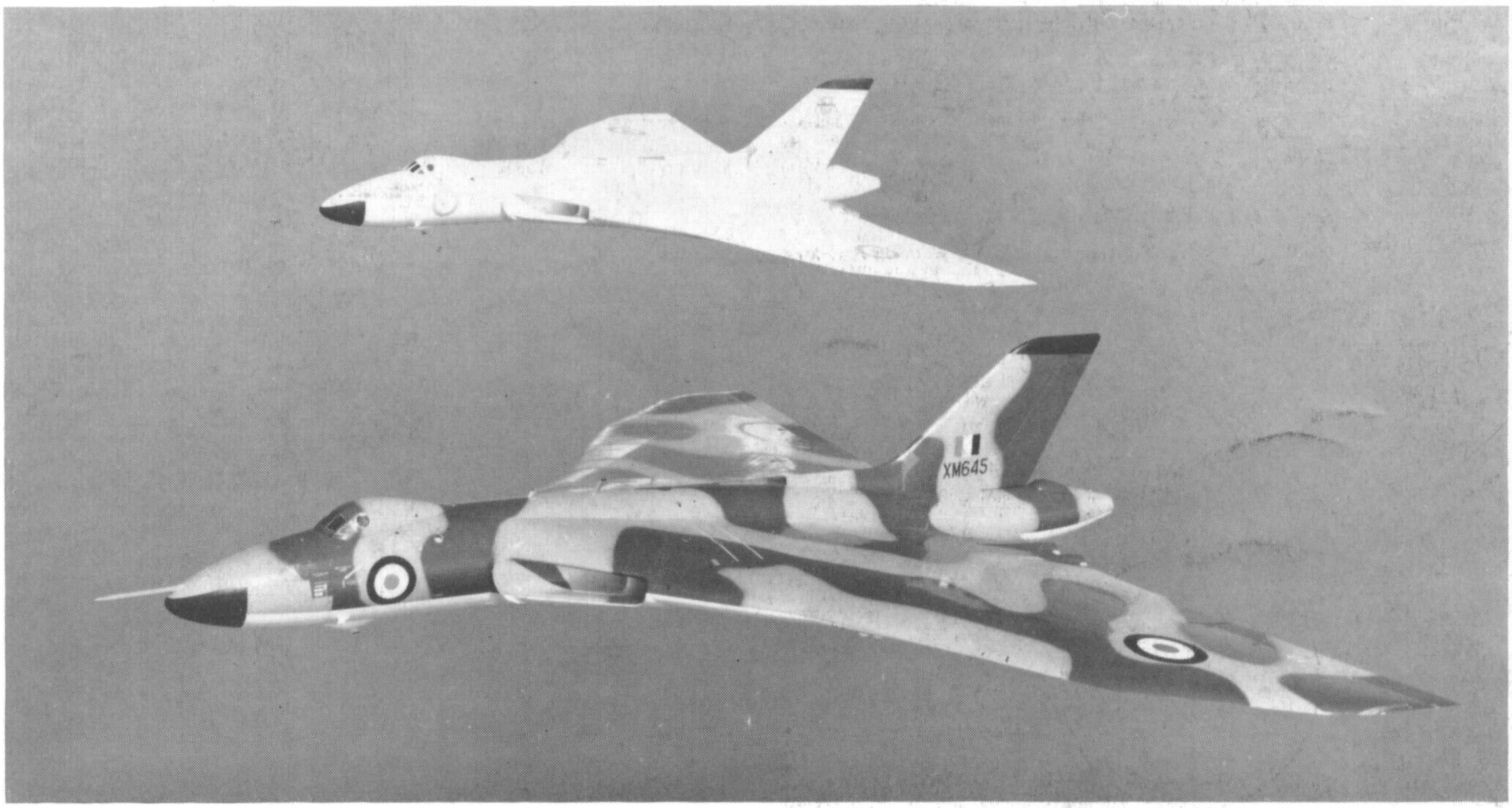


Vulcan B.2's (top to bottom), XM602 *of No. 12 Sqdn.*, XL444 *of No. 27 Sqdn.*, XM604 *of No. 35 Sqdn.*, XL443 *of No. 83 Sqdn.*
(Photos: S. P. Peltz)



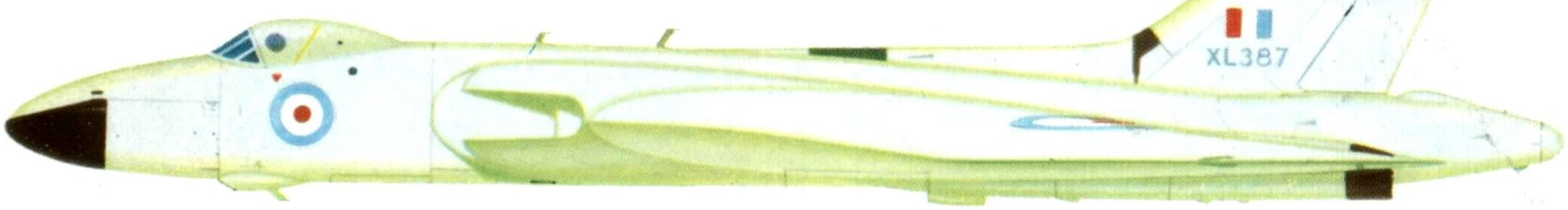
(Above) XL319 *of No. 617 Sqdn., and* (below) XL387 *of No. 230 O.C.U.* (Photos: S. P. Peltz)



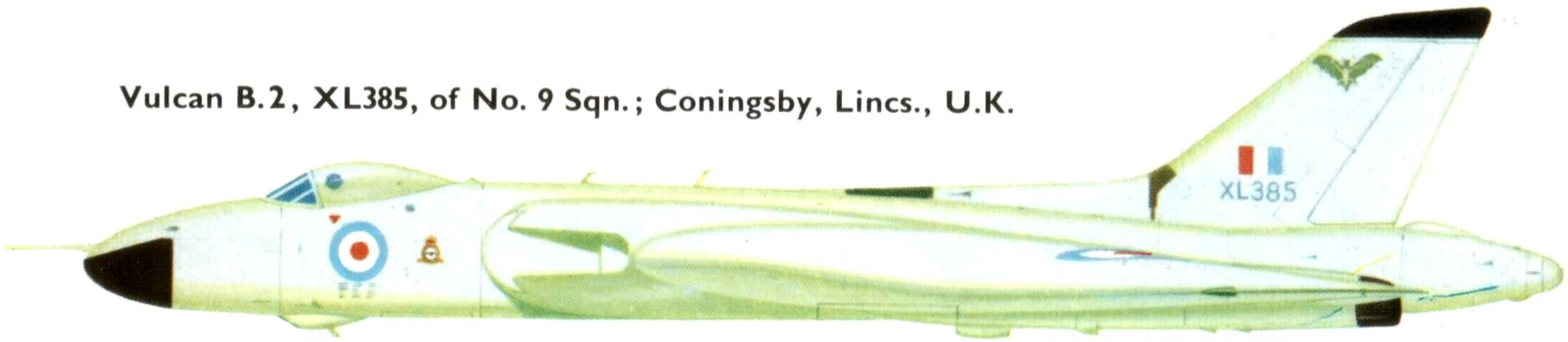


Two Vulcan B.2's: XM645 (nearest camera) *from R.A.F. Coningsby and* XJ824 *from No. 230 O.C.U., Finningley.* (Photo: M.o.D).

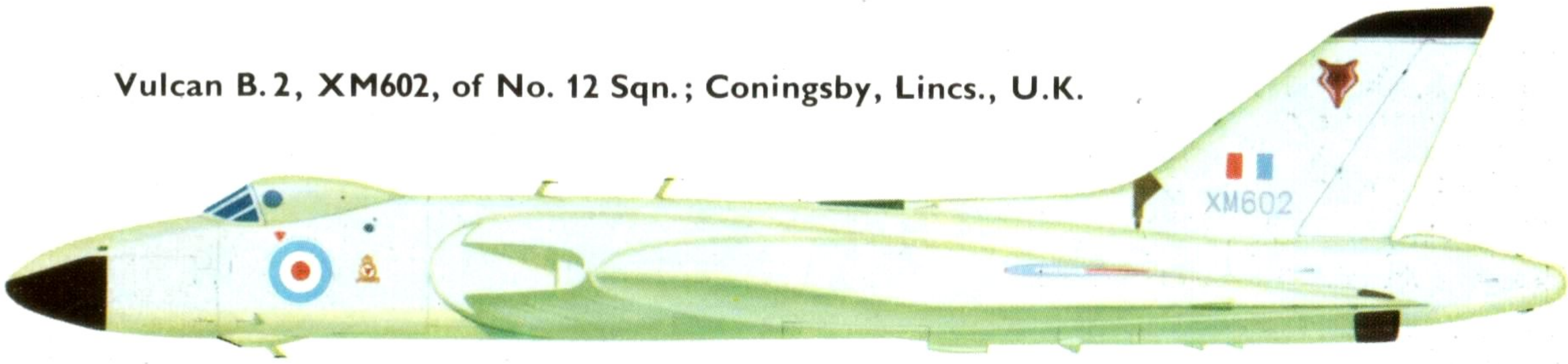
Vulcan B.2, XL387, of No. 230 O.C.U.; Finningley, Yorks., U.K.



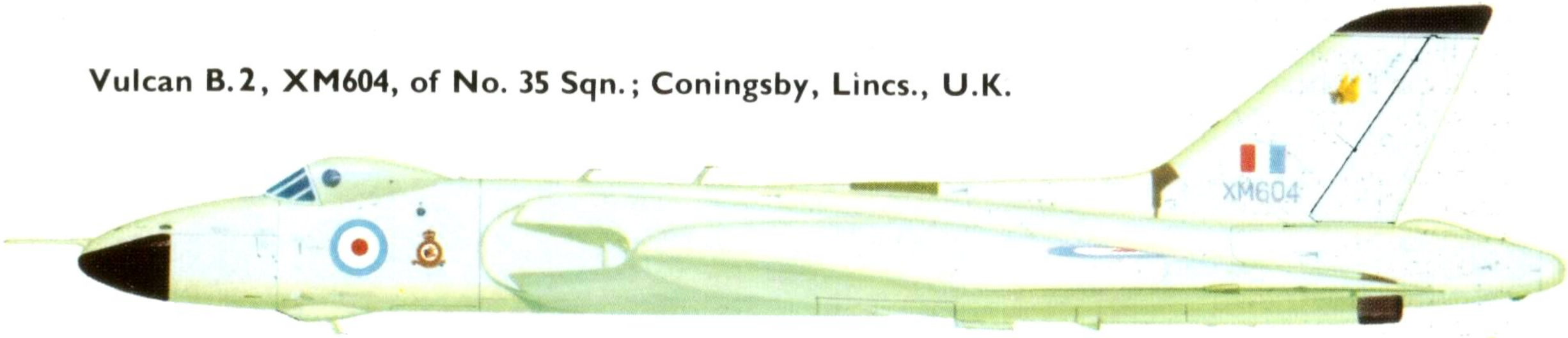
Vulcan B.2, XL385, of No. 9 Sqn.; Coningsby, Lincs., U.K.



Vulcan B.2, XM602, of No. 12 Sqn.; Coningsby, Lincs., U.K.



Vulcan B.2, XM604, of No. 35 Sqn.; Coningsby, Lincs., U.K.



No. 9 Sqn.

No. 35 Sqn.

CAPT	WG. CDR.	K. STEVENS
CO PILOT	FLT. LT.	T. MASON
NAV/RAD	FLT LT	H. CHAPMAN
NAV/PLOT	FLT LT	F. WADDINGTON
A.E.O.	FLT LT.	R. WILSON
A.S.C.	C/TECH.	R. WHITINGTON
A.S.C.	C/TECH.	P. GRANTHAM

No. 12 Sqn.

No. 230 O.C.U.

Detail of nose markings, XL385 above.

Vulcan B.IA, XA898, of No. 230 O.C.U.; Waddington, Lincs., U.K.