HAWKER SIDDELEY NIMROD MR.1

By MICHAEL WILSON

"We search and strike." The one-time unofficial motto of Coastal Command is nowhere more applicable than in the field of anti-submarine warfare. It is probably not too much to say that the implementation of an effective ASW system is the greatest problem which military aviation technology faces today. It is also one to which Britain, dependent as she is upon maritime trade routes, must give unremitting attention. The bitter experiences of the Atlantic war in 1941 and 1942 must never be allowed to recur.

Such considerations as these have led to the development of the Hawker Siddeley 801 Nimrod MR.1, the world's first pure-jet ASW aeroplane. Its equipment for detecting, tracking and killing submarines is as comprehensive and advanced as any known to be flying today. It is also the fastest, if not the largest, aircraft to be designed for these duties. Transit time and endurance on station are the basic prerequisites of maritime reconnaissance aircraft, coupled with good load-carrying ability. In all these respects (and particularly in that of transit time) the Nimrod will be superior to anything flying now or planned for the immediate future. Compared with the Tracker S.2 or similar aeroplane, for example, one Nimrod operating at short range is equivalent to two or three smaller aeroplanes at the same range. As the distance to the search area increases, the increasing divergence of transit times and endurance on station for the two aircraft requires probably five or six S.2s or equivalent. Eventually, after about 700 miles, the smaller aircraft runs out of range entirely and there is thus no equivalent.

The basic mission of the Nimrod, whether in peace or war, remains the same: the security of ships. The flight out to the target is initiated either as part of a regular patrol or in response to a signal from a vessel at sea that has detected the presence of a submarine. In the latter case a quick reaction time is essential. In round figures the difference of 100kt-odd between Nimrod and its fastest piston or turboprop predecessors over 500 n.m. reduces by 20 per cent the time to reach the search area, and this can cut down the search area (in which the submarine is known to be) by nearly 40 per cent. With nuclear submarines travelling at between 35kt and 40kt underwater, the benefits of high-speed cruise are obvious.

The origin of Nimrod goes back a decade. In 1958 the Air Staff began to formulate Air Staff Requirement 381 for a Shackleton replacement to undertake the following tasks: to detect, fix and destroy surfaced and submerged submarines, both conventional and nuclear; to detect and shadow enemy surface units and forces; to conduct wide-area surveillance; to make limited air-to-surface strikes against individual vessels; to perform search and rescue; and to undertake emergency trooping. The Nimrod will, incidentally, replace only the Shackleton 2s. The -3s, with supplementary Viper 11s in the outboard nacelles, will continue in service until about 1978.

A close and continuing study of a number of projects was undertaken by the British Government. These included both new projects and modification of existing aircraft and design proposals included ASW versions of Vanguard and VC10 from BAC and Trident and Comet from Hawker Siddeley. Evaluation of projects was made over a long period and it was not until 1964, when serious discussion on costs got under way, that the Comet derivative began to emerge as the likely contender.

Whereas in 1958 development of a brand new aircraft might have been expected to absorb a fair amount of money, the long period of indecision over a Shackleton replacement saw a gradual tightening of Treasury purse-strings and it became increasingly clear that the sum of money likely to be made available would not buy a completely new airframe design as well as a weapon system.

Of the design submissions made by the various firms, the Comet emerged as the most cost-effective solution: all the R&D work on the airframe was valid (except in a few cases described later) the jigs existed for the most part, the airframe

Continued on page 890, after cutaway drawing of Nimrod

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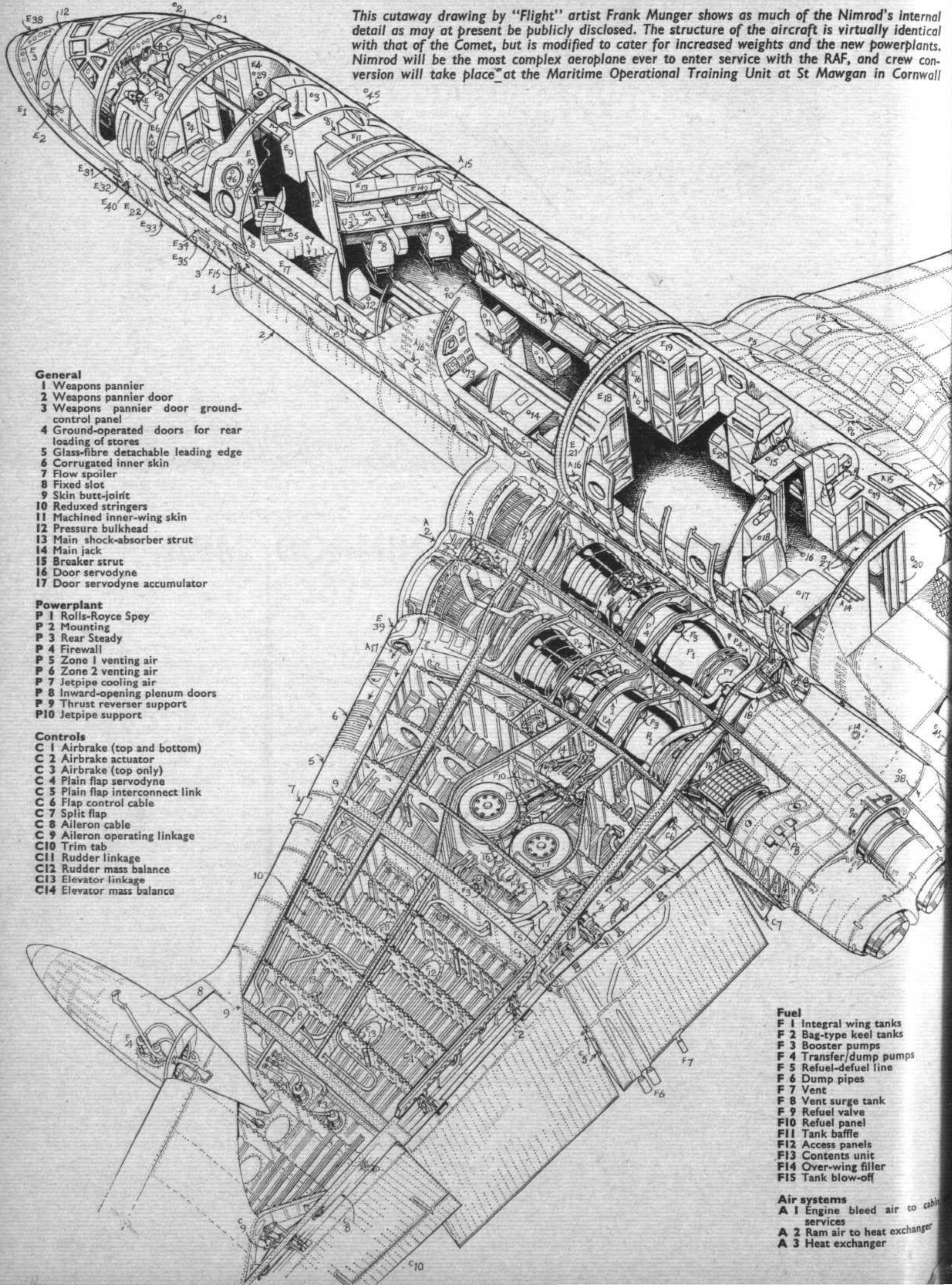
This cutaway drawing by "Flight" artist Frank Munger shows as much of the Nimrod's internal detail as may at present be publicly disclosed. The structure of the aircraft is virtually identical with that of the Comet, but is modified to cater for increased weights and the new powerplants. Nimrod will be the most complex aeroplane ever to enter service with the RAF, and crew conversion will take place at the Maritime Operational Training Unit at St Mawgan in Cornwall



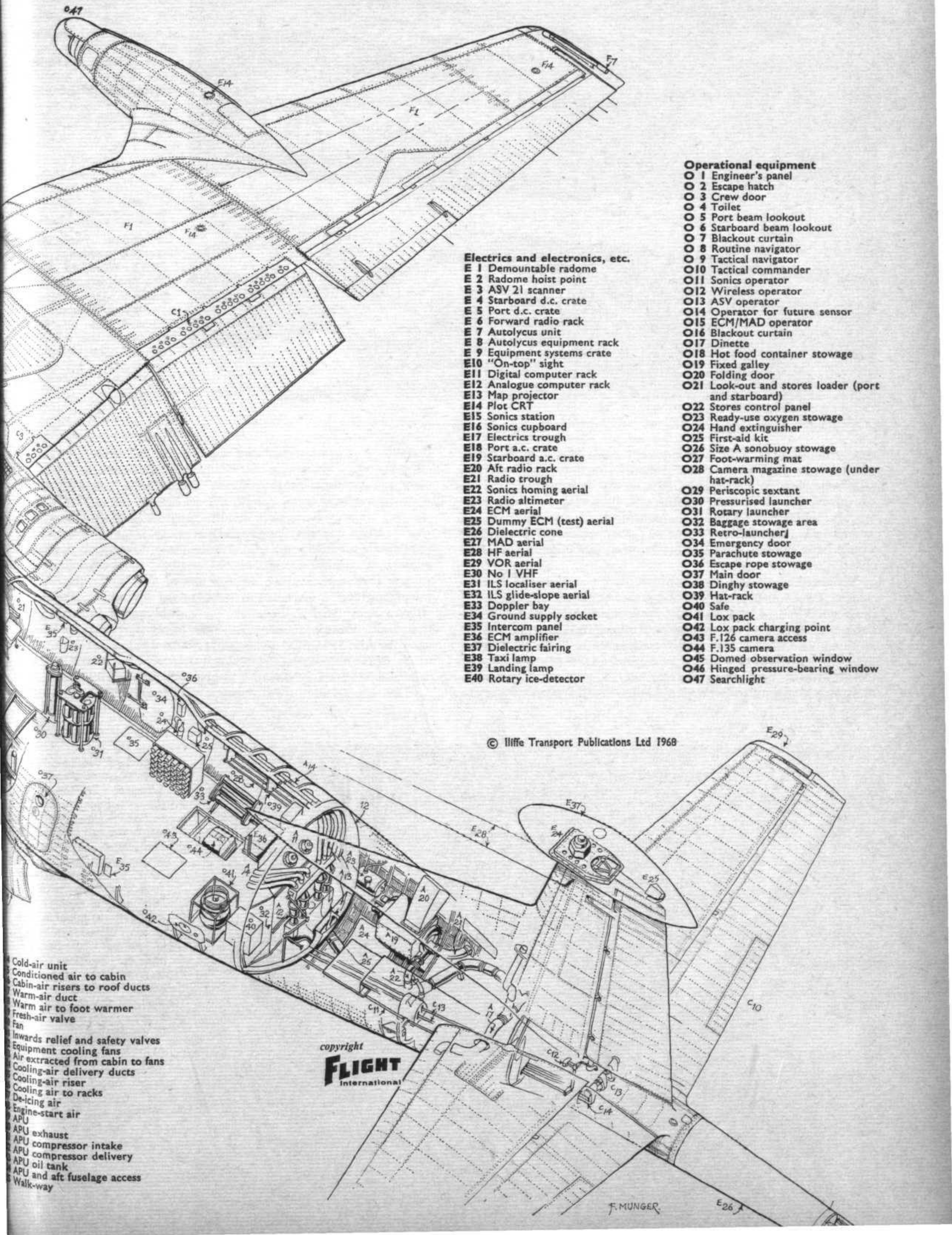
General
- **1** Weapons pannier
- **2** Weapons pannier door
- **3** Weapons pannier door ground-control panel
- **4** Ground-operated doors for rear loading of stores
- **5** Glass-fibre detachable leading edge
- **6** Corrugated inner skin
- **7** Flow spoiler
- **8** Fixed slot
- **9** Skin butt-joint
- **10** Reduxed stringers
- **11** Machined inner-wing skin
- **12** Pressure bulkhead
- **13** Main shock-absorber strut
- **14** Main jack
- **15** Breaker strut
- **16** Door servodyne
- **17** Door servodyne accumulator

Powerplant
- **P 1** Rolls-Royce Spey
- **P 2** Mounting
- **P 3** Rear Steady
- **P 4** Firewall
- **P 5** Zone 1 venting air
- **P 6** Zone 2 venting air
- **P 7** Jetpipe cooling air
- **P 8** Inward-opening plenum doors
- **P 9** Thrust reverser support
- **P10** Jetpipe support

Controls
- **C 1** Airbrake (top and bottom)
- **C 2** Airbrake actuator
- **C 3** Airbrake (top only)
- **C 4** Plain flap servodyne
- **C 5** Plain flap interconnect link
- **C 6** Flap control cable
- **C 7** Split flap
- **C 8** Aileron cable
- **C 9** Aileron operating linkage
- **C10** Trim tab
- **C11** Rudder linkage
- **C12** Rudder mass balance
- **C13** Elevator linkage
- **C14** Elevator mass balance

Fuel
- **F 1** Integral wing tanks
- **F 2** Bag-type keel tanks
- **F 3** Booster pumps
- **F 4** Transfer/dump pumps
- **F 5** Refuel-defuel line
- **F 6** Dump pipes
- **F 7** Vent
- **F 8** Vent surge tank
- **F 9** Refuel valve
- **F10** Refuel panel
- **F11** Tank baffle
- **F12** Access panels
- **F13** Contents unit
- **F14** Over-wing filler
- **F15** Tank blow-off

Air systems
- **A 1** Engine bleed air to cabin services
- **A 2** Ram air to heat exchanger
- **A 3** Heat exchanger



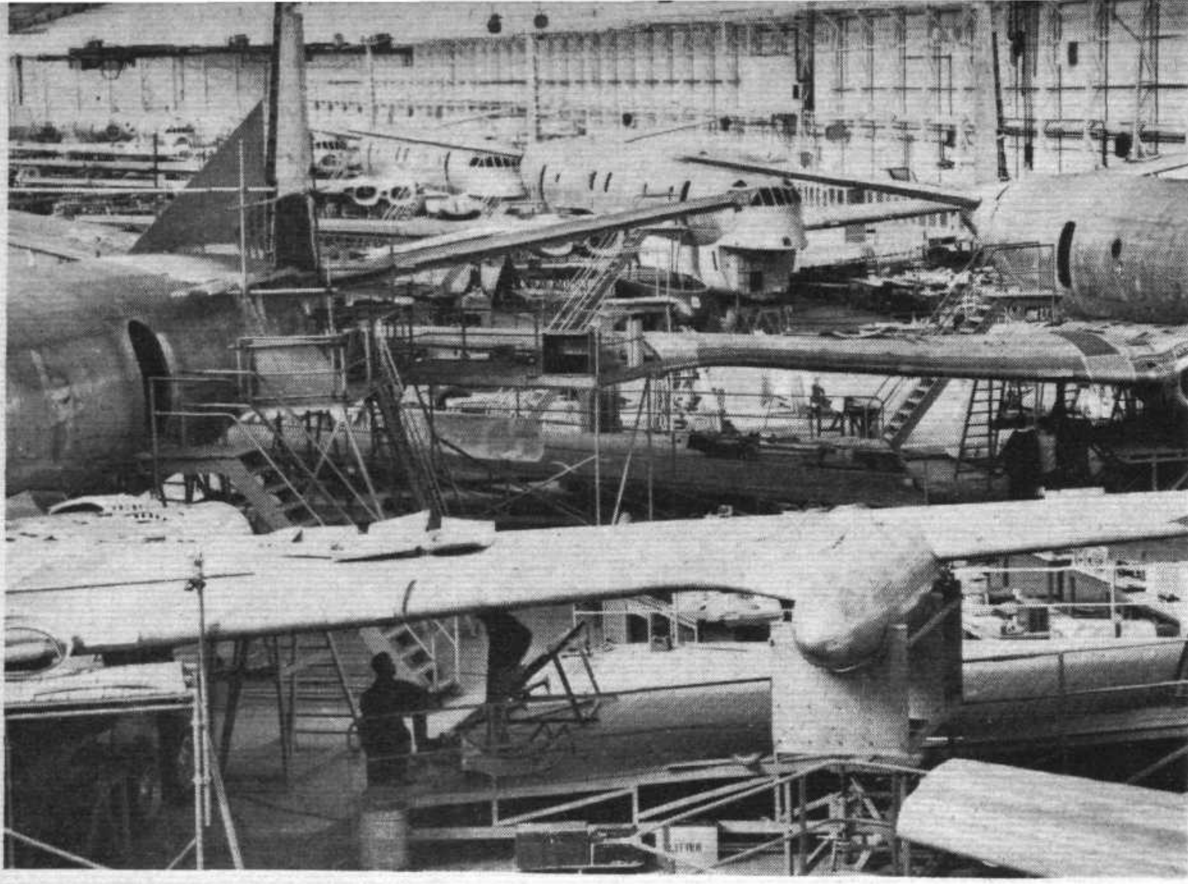
Operational equipment

O 1 Engineer's panel
O 2 Escape hatch
O 3 Crew door
O 4 Toilet
O 5 Port beam lookout
O 6 Starboard beam lookout
O 7 Blackout curtain
O 8 Routine navigator
O 9 Tactical navigator
O10 Tactical commander
O11 Sonics operator
O12 Wireless operator
O13 ASV operator
O14 Operator for future sensor
O15 ECM/MAD operator
O16 Blackout curtain
O17 Dinette
O18 Hot food container stowage
O19 Fixed galley
O20 Folding door
O21 Look-out and stores loader (port and starboard)
O22 Stores control panel
O23 Ready-use oxygen stowage
O24 Hand extinguisher
O25 First-aid kit
O26 Size A sonobuoy stowage
O27 Foot-warming mat
O28 Camera magazine stowage (under hat-rack)
O29 Periscopic sextant
O30 Pressurised launcher
O31 Rotary launcher
O32 Baggage stowage area
O33 Retro-launcher
O34 Emergency door
O35 Parachute stowage
O36 Escape rope stowage
O37 Main door
O38 Dinghy stowage
O39 Hat-rack
O40 Safe
O41 Lox pack
O42 Lox pack charging point
O43 F.126 camera access
O44 F.135 camera
O45 Domed observation window
O46 Hinged pressure-bearing window
O47 Searchlight

Electrics and electronics, etc.

E 1 Demountable radome
E 2 Radome hoist point
E 3 ASV 21 scanner
E 4 Starboard d.c. crate
E 5 Port d.c. crate
E 6 Forward radio rack
E 7 Autolycus unit
E 8 Autolycus equipment rack
E 9 Equipment systems crate
E10 "On-top" sight
E11 Digital computer rack
E12 Analogue computer rack
E13 Map projector
E14 Plot CRT
E15 Sonics station
E16 Sonics cupboard
E17 Electrics trough
E18 Port a.c. crate
E19 Starboard a.c. crate
E20 Aft radio rack
E21 Radio trough
E22 Sonics homing aerial
E23 Radio altimeter
E24 ECM aerial
E25 Dummy ECM (test) aerial
E26 Dielectric cone
E27 MAD aerial
E28 HF aerial
E29 VOR aerial
E30 No 1 VHF
E31 ILS localiser aerial
E32 ILS glide-slope aerial
E33 Doppler bay
E34 Ground supply socket
E35 Intercom panel
E36 ECM amplifier
E37 Dielectric fairing
E38 Taxi lamp
E39 Landing lamp
E40 Rotary ice-detector

Cold-air unit
Conditioned air to cabin
Cabin-air risers to roof ducts
Warm-air duct
Warm air to foot warmer
Fresh-air valve
Fan
Inwards relief and safety valves
Equipment cooling fans
Air extracted from cabin to fans
Cooling-air delivery ducts
Cooling-air riser
Cooling air to racks
De-icing air
Engine-start air
APU
APU exhaust
APU compressor intake
APU compressor delivery
APU oil tank
APU and aft fuselage access
Walk-way



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A general view of the Nimrod production line at HSA's Woodford factory. The final assembly shed is possibly the largest in Europe and apart from Nimrod has an HS.748 production line, while other aircraft (Shackletons, Vulcans, and so on) also find their way here for refurbishing

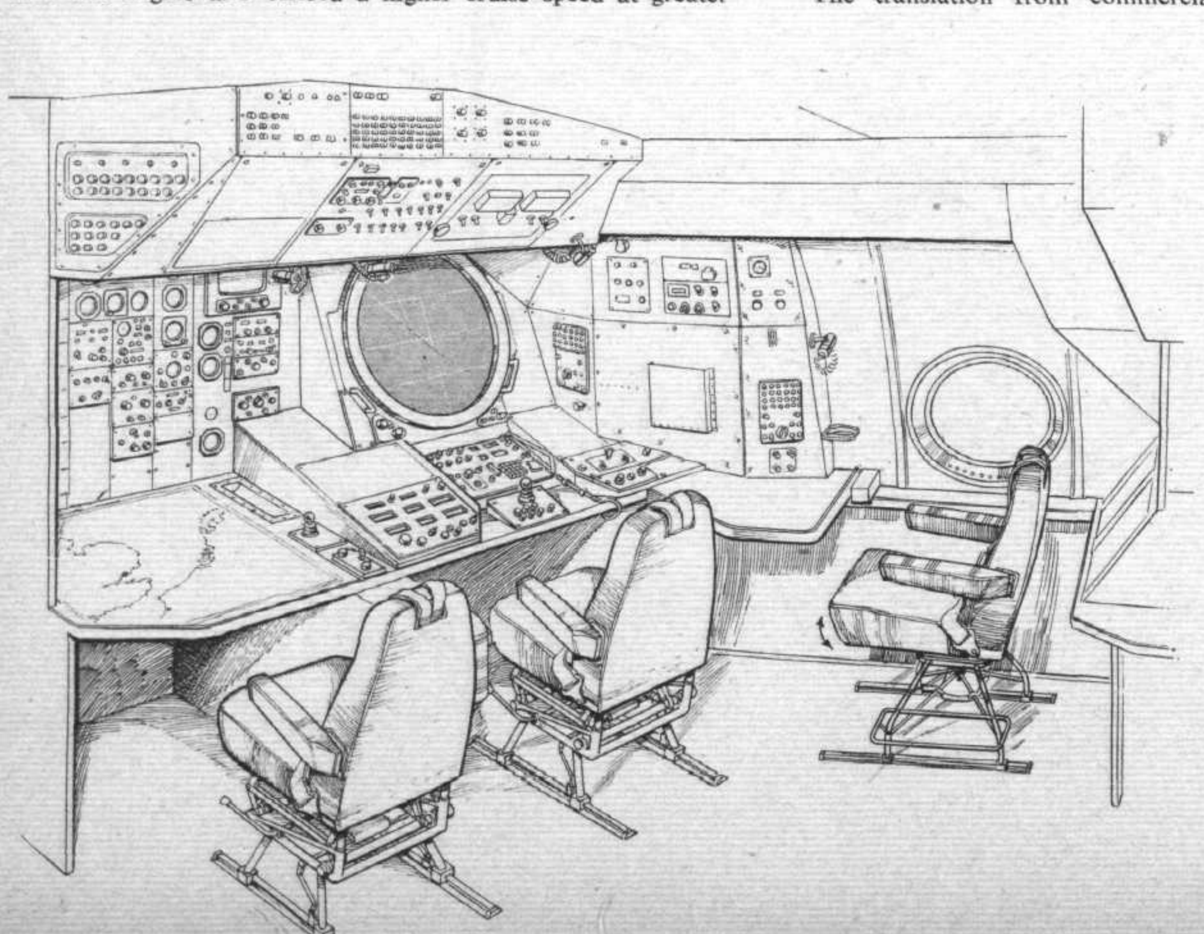
was a familiar exercise to many of the Hawker Siddeley personnel and there was spare capacity in the factories. The relatively high cost of the VC10 and the three-engined layout of the Trident militated against the two big civil jet contenders, while turboprops were considered to be too complex and to lack the necessary speed. Also, adoption of the Trident would have needed a second production line with its attendant cost.

Almost the greatest lesson which had been learned by the design team while examining progress in aircraft design since the Second World War was the impressive reduction of turbine-engine specific fuel consumption. It became clear that, even at the low altitudes and speeds required for a large part of the ASW mission, the turbofan engine was preferable to any other form of propulsion. During the flight out to the search area this engine also offered a higher cruise speed at greater height. A turbofan-powered Comet was therefore attractive. Finally, the Comet was backed by 1.5 million flying hours and fell not far short of the original operational requirements.

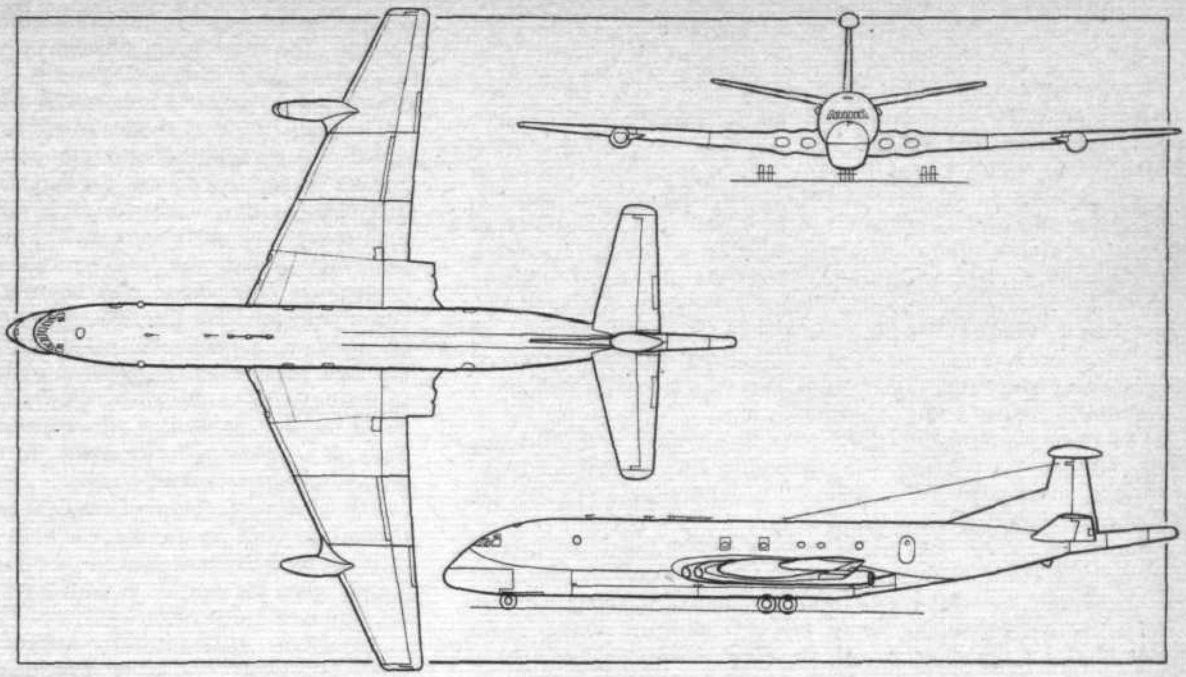
Four engines were considered to be essential. The aircraft is able to cruise on station with progressively three and then two engines (as the weight decreases) at a high power setting and consequently good s.f.c. Under these conditions the design case is a failure of one of the engines, when the remaining engine or engines must be capable of sustaining the aircraft until another is started and brought up to power. The Rolls-Royce Spey RB.168 turbofan was suitably sized for the Comet and was, therefore, adopted. The particular variant selected was the Mk 250, rated at about 11,500lb thust each.

In May 1965 approval was given for initial work to begin and the Ministry go-ahead was given in January 1966.

The translation from commercial transport to maritime



Details of the routine and tactical navigators' compartment. On the left is the routine navigator's station with charts on which may be plotted "en route" fixes from an overhead projector. On his right is the tactical navigator's station with the 24in tactical display. The toggle on the panel in front of him allows symbols to be moved over the CRT and fix positions to be inserted into the computer. The third position is that for the tactical commander, which post is now to be deleted



Although the ancestry is clear in plan view, the side elevation disguises the Nimrod's background effectively by the devices of a capacious weapon bay, a dorsal fin and the ECM fairing

Leading data

Span, 114.8ft; length, 126.75ft; height, 29.7ft; wing area, 2,121 sq ft; fuselage depth, 13.25ft; weapon bay length, 50ft approx

reconnaissance was relatively straightforward. The airframe is based on that of the Comet 4C (although the fuselage length is that of the Comet 4) and the main and obvious change is the addition of a capacious skirt attached to the underside of the fuselage in segments that they are free to move relatively to one another. By this means, structural loads in the bomb-bay are not transmitted back to the fuselage to threaten the integrity of the pressurised hull. The weapon carriers pick up at the strong points used to mount the floor and no strengthening of the basic Comet fuselage was needed.

This extensive weapons bay—most of it ahead of the c.g.—lessened the directional stability to an extent not offset by the beneficial end-plate effect of the ECM aerial fairing mounted atop the fin. Thus a rather prominent dorsal fin was added to make up the deficiency and gives the Nimrod a characteristic appearance.

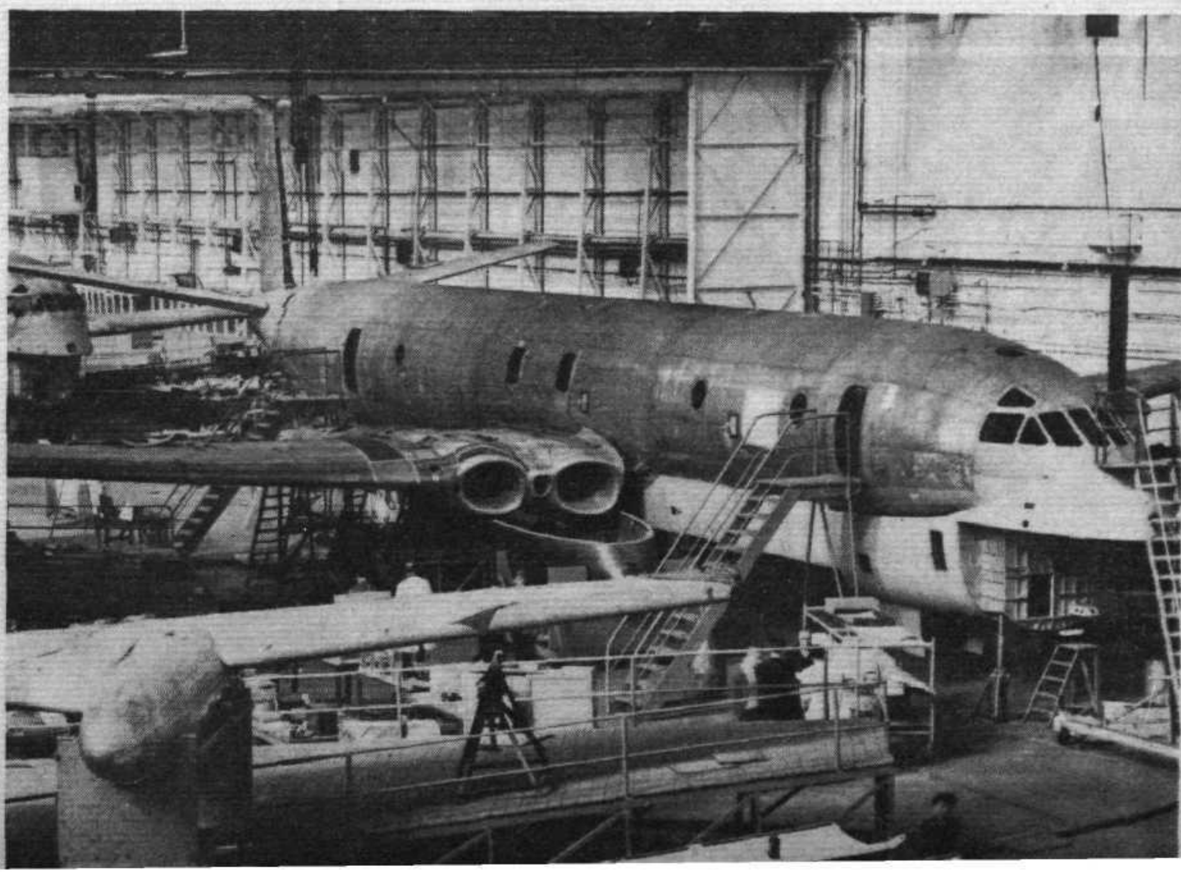
The other noticeable external difference applies to the engine intakes. The greater mass flow and diameter of the Spey engine over that of the Avon has resulted in an increase in the size of the inlets and exhausts, which has meant some redesign in the wing centre-section.

The pilots' windscreens have been deepened to confer better visibility during search, and two eyebrow windows (one each side) have been added in order to enable the crew to look into the turn when the aircraft is banked during ASW manœuvres at low altitude.

Extra fuel tanks have been fitted in the weapons bay. Other changes include the strengthening of two wing ribs to carry pylons for external stores; the installation of a searchlight in the starboard external wing tank; and strengthening of the undercarriage to cope with what is now a considerably heavier aeroplane. A Rover APU is carried to provide high-pressure air for engine starting.

Surprisingly, the fact that the flight profile is rather different from that of the Comet 4 has brought no airframe problems. Comet experience has read directly across to Nimrod and test work has been done on the aircraft only where structural changes have occurred: for example, the eyebrow window cut-outs were pressure-tested. The MoD has made an assessment of the Comet under appropriate conditions, and the handling and ride were found to be quite acceptable. In particular, no unpleasant yaw modes—a trial in some ASW

Another view of the Woodford assembly line. Sub-assemblies are built as far as possible at the HSA divisions responsible for similar assemblies on the Comets. Note the large size of the nose radome and the enlarged engine air intakes



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aircraft—were found to exist in low-altitude turbulence.

Crew comfort has been given much thought and the improvement over that of the Shackleton is very great indeed. This factor, which has not always been given due regard as a vital adjunct to effective ASW, stems from several aspects. First, the absence of vibration and noise and the ability to fly out at high altitude, in air-conditioned comfort, removes a major source of crew fatigue while the increased cruising speed cuts down the transit period, so reducing the total airborne time. Sorties will thus be much shorter than those of the Shackleton, and the Nimrod therefore has no crew rest facilities as such (the Shackleton has two bunks) although a "dinette" provides comfort while eating.

The roomy fuselage further adds to comfort and efficiency and, because of the low wing position, the main-spar carry-through structures (quite literally a stumbling-block in the Shackleton) are under the cabin floor.

Construction of the aeroplane is distributed extensively through the Hawker Siddeley organisation, so that the divisions of the company which had built Comet sub-assemblies also build the corresponding units for the Nimrod. Only where assemblies are peculiar to 801 is construction undertaken at Chadderton. Thus, the wing centre-section is built at Chester, which is now also responsible for fuselage sections and outer wings, production of which has been transferred from Portsmouth. The tailplane and engine intakes are made at Hatfield. Final assembly takes place at Woodford, which is also the base for development flying.

The two prototypes were the last two Comet 4s on the production line and were suitably modified up to Nimrod (or, in the case of the second prototype, quasi-Nimrod) standards. The first of these is a handling and performance aircraft, powered by four Speys, and was flown for the first time on May 23 last year. The second aircraft, fitted for reasons of economy and time with Avons, flew on July 31 and will be used for the development of the ASW system.

While HSA are responsible overall for the electronics, Elliott-Automation Advanced Military Systems division have been selected as the design co-ordinators for the nav-attack systems. The ASW equipment is a logical development of the Shackleton system but the greatly increased performance and space of the Nimrod have allowed more advanced data processing to be employed. In fact, probably the greatest single difference between the two aircraft, regarded as weapons systems, is the application of computer techniques to the prediction of target data.

The crew numbers 11: two pilots, one engineer, two beam lookouts (port and starboard), a routine navigator, a tactical navigator, a radio operator, an ASV radar operator and two sonar operators.

The flight-deck layout is entirely conventional, strongly resembling its civil predecessor, and there is very little evidence of the aggressive nature of the new aeroplane. A Smiths SF.6 flight system is fitted, together with an SEP.6 autopilot. Mach trim is standard and a yaw damper makes for smoother flying when the aircraft is doing the quite violent S-turns which are a feature of ASW work. It is not really until one leaves the flight deck and walks down the cabin that the scientifically warlike aspect becomes apparent. Immediately to the rear of the flight-deck bulkhead are two hemispherical look-out blisters for visual tracking, one each side of the fuselage (a second blister is fitted on the starboard side further aft). Adjacent to these is the side-by-side station for the routine and tactical navigators—the command post of the aircraft—set obliquely against the starboard fuselage side. Further aft again, the next station is that of the radio operator, who faces his radar counterpart across their combined console looking on to the port wing.

The two sonar operators ("sonics" in the vernacular) sit side by side, looking to starboard; and bringing up the rear on the same side is the ECM/MAD (electronic countermeasures and magnetic anomaly detector) station. The last two positions along the rear left-hand cabin are reserved for future sensor equipment. Further aft, but still inside the pressure cabin, is the sonobuoy bay.

As already stated, the basic ASW equipment of the Nimrod is similar to that of the Shackleton, modified in many cases to suit the new-data processing system. It comprises the IC sonar, ASV radar, Autolycus and ECM. These are supplemented by a new long-range sonar system and MAD.

The basic tools of the trade are sonobuoys, active or passive, which are parachuted into the water in a given pattern. The passive buoy listens-out for underwater sound sources and transmits to a surface vessel or aircraft the bearing of any such source which it detects. The active buoy broadcasts low-frequency pulses underwater and any returns are processed to provide both range and bearing information to a ship or aircraft. In practice the two types are complementary and both are used in a particular search area to provide a fix. While the two passive buoys provide a fix on the target in relation to their positions the active buoy determines the range of this fix in relation to itself. One technique then is to use the active buoy as a datum for the attack, by beginning a count-down as the aircraft flies over it.

ASV (air/surface-vessel) radar may be used to detect the submarine if it is on the surface, or a periscope or snorkel if it is partially submerged although being an active device it may give the search aircraft away. ECM may also be used for submarine detection.

Autolycus, an ionisation detector or "sniffer," will reveal small concentrations of combustion products from fuel oils. It gives an indication of whether shipping is or has been present, although too long a search in the same area may result in spurious, search-aircraft-induced indications.

MAD is a very sensitive device which has not previously been fitted to British ASW aircraft. The equipment consists of a magnetometer which can detect and measure extremely small local changes of intensity of the Earth's magnetic field from the nominal value. The magnetometer is isolated as much as possible from the effect of the aircraft itself by mounting it on a long boom. Information is displayed as a flat trace representing a uniform magnetic field on a recorder. A blip appears in the trace if there is a change in field intensity such as would be caused by the presence of an iron mass of appreciable size. This aid is very local in operation and is the best method of obtaining a final and accurate fix. It has to be used in conjunction with other sensors, however, since it is non-selective and does not differentiate between, for example, a submarine and a sunken wreck.

Each sensor and its operator may be regarded as an information unit, and its data is assessed by the tactical navigator. In the Shackleton, information was transmitted by means of word or note; but in the Nimrod, co-ordinates of a fix or suspected target are transferred automatically by the sensor operator to the tactical navigator's station, where it appears on a 24in-diameter display.

The tasks of the routine and tactical navigators are complementary. The first man is responsible for the navigation of the aircraft in transit to and from the search area; the job of the second is to conduct the attack.

Sub-contracting throughout HSA means a lot of roadwork. Here a Nimrod is seen in transit to Woodford for final assembly

The primary, navigation mode uses Doppler with an inertial platform, giving Doppler ground speed and drift and inertial heading. Tactical navigation uses mixed Doppler-inertial velocities and inertial heading. Automatic reversion to inertial data occurs should Doppler fail, and this is satisfactory for short-term work. A further reversion available in the case of failure of both Doppler and the platform is the use of the air-data computer and twin-gyro compass to provide speed and heading. Besides present position data for the two navigators, latitude and longitude are also displayed to the second pilot.

The task of the routine navigator is to navigate the aircraft out to the search area and to plot radar fixes along the route. A Ferranti vertical projector displays aircraft and ship symbols on to his chart table to enable position fixes to be read off. One of four projection scales may be chosen: 2, 1, 0.5 million and 36,000 to 1, to correspond with the tactical display.

The routine navigator is not dependent upon digitally computed information, but uses instead Doppler and platform.

Sitting immediately alongside the routine navigator is the tactical navigator, whose job is to evaluate data from the information units. He may also be responsible for commanding the attack if the first pilot does not elect to do so. Information is processed by an Elliott 920B computer, the primary purposes of which are to relieve the tactical navigator of part of the task of analysing data from the "sonics," and to organise and control the tactical display. Presentation of continuously updated information to this crew member takes place on an Elliott display of 24in diameter. Five scales may be selected to give a converge between 10 n.m. and 160 n.m. The display is north-stabilised and the origin may be chosen at will; it need not represent the instantaneous position of the aeroplane but can be a surface vessel, for example. In the latter case, correlation of information and timing can enable the aircraft to make an attack by using the vessel as datum.

The computer can then feed steering information to the pilots' flight director and will begin a countdown to attack. The actual release of the weapon or weapons is not done automatically, but for safety reasons, is under the direct control of the tactical navigator.

Mounted alongside the main display is the tabular display, a smaller, square tube which is used to note down navigational information such as target and aircraft track, speed and position, sonobuoy selection, next fix point, etc., and is, in fact an *aide memoire*. This display is also driven by the computer.

Nimrod will carry the full range of ASW weapons: mines, depth charges, bombs and torpedoes. In addition, two wing pylons can carry either Martel or AS.12 missiles.

Performance may not yet be disclosed but it is known that the aircraft can conduct a useful search at 1,000 miles from base. This takes into account a 400-mile diversion on return to base (spanning, for example, the range Kinloss to St Mawgan) together with a 30min stand-off and 5 per cent reserves. Because the airframe is aerodynamically similar to that of the Comet, the speed range must be very similar.

Nimrod progress

Up to last April the two prototypes had been accumulating flight hours at the impressive rate of 25hr/month for the first aircraft and 20hr/month for the second. Progress has been very smooth, the only "flats" in the utilisation graph being due to weather or for scheduled maintenance.

The Nimrod has been surprisingly free from the political cut-and-thrust which has laid low other projects. One reason is, perhaps, that the burden of risk falls very heavily on HSA. The contract for most of the programme—design, R&D, production of two prototypes and 38 production aircraft—is worth about £100 million and was negotiated on a fixe-price basis. This means that while HSA will receive an overall maximum profit (closely auditor-scrutinised), there is, theoretically, no limit to the loss which the firm would have to bear if the final cost were greater than the estimated figure. The Nimrod will be quite the most complex aircraft ever to enter RAF service and its design development and production were clearly going to be a major programme. As the existing HSA (Manchester) chief designer, Mr Maurice Brennan, was heavily committed with other projects, the task of leading the 801 programme was given to Mr Gilbert Whitehead. The Manchester division of HSA is probably unique, therefore, in having two chief designers.

A view of the Nimrod which will become increasingly common over the years, especially at St Mawgan and Kinloss. The large bomb-bay doors are slightly open, and the dorsal fin and ECM fairing are distinctive

It is HSA's contention that Nimrod should be designed for at least 20 years' active life and a close watch has been kept at all stages of design to ensure that future improvements may be incorporated with the least possible modification work. For example, the 60 kVA constant-frequency alternators are very conservatively rated, so as to be able to cope easily with future additional loads. Future development in three areas is foreseen: new and more effective weapons, better sensors and new and even more economic engines, to all three of which Nimrod will be adaptable. Probably the greatest improvement will come in the development of powerplants such as the three-spool Rolls-Royce engines. Housing such large-diameter engines within the wings would be a problem and it is possible that podded installations would be the practical solution.

Not a few countries have shown great interest in the aircraft—Holland, Canada and Italy, for example, while South Africa's proclaimed interest in the Nimrod to replace her Shackletons was stamped on by the British Government last year.

While there is no British Operational Requirement for an AEW (airborne early warning) aircraft the Nimrod would obviously be an ideal platform for AEW equipment, since the requirements of the two missions are broadly similar. Cruising at high altitude, it could carry the large scanner essential in this role and would have satisfactory endurance.

Meanwhile, test flying continues apace to meet the in-service date of early 1969, by which time the Nimrod will have been granted an interim operational capability, although it will not yet have been cleared for tropical or arctic flying.

The first prototype has already been transferred to A&AEE at Boscombe Down for an official handling assessment; and the first production aircraft, which is due to fly in a few days' time, will be used for armament and nav/attack development. The second and third production 801s will also go to A&AEE for assessment in all aspects. Production of the present batch is scheduled for completion some time before 1971.

In conclusion, it must be emphasised that the Nimrod is not a Comet in uniform; it is an absolutely brand-new aeroplane at the very beginning of its career but with the birthright of many years' experience built in. It should be second to none in its ability to protect seaborne traffic, be it military or civil.